INDICATORS FOR MEASURING CHANGES IN INCOME, FOOD AVAILABILITY AND CONSUMPTION, AND THE NATURAL RESOURCE BASE

A.I.D. PROGRAM DESIGN AND EVALUATION METHODOLOGY NO. 12
(Document Order No. PN-AAX-223)

by

Krishna Kumar, Senior Analyst
(Bureau for Program and Policy Coordination, A.I.D.)

U.S. Agency for International Development

September 1989

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FOREWORD

The Agency for International Development (A.I.D.), Bureau for Program and Policy Coordination/Center for Development Information and Evaluation (PPC/CDIE), in cooperation with the Bureau for Science and Technology and three regional bureaus, organized a workshop on indicators for measuring changes in income, food consumption and food availability, and the natural resource base. The purpose of the workshop was to identify and discuss a set of simple, practical indicators that can be used by overseas Missions and A.I.D./Washington for monitoring the impact of agricultural and rural development assistance.

The workshop was held on June 20-22, 1988 in Virginia and was attended by 60 development specialists including A.I.D.

staff, consultants, and outside experts. It held 12 plenary and 15 working group sessions in which a wide range of ideas, issues, insights, and recommendations were discussed.

Four background papers were prepared for the workshop; each was presented in a plenary session and was followed by small group discussion(s). Their titles are "Impact Indicators: General Issues and Concerns," "Indicators of Household Income for Use in the Evaluation of Agricultural Development Projects," "Food Availability and Consumption Indicators," and "Indicators for Assessing Changes in Natural Resources in Developing Countries." CDIE is publishing the revised version of each of these papers separately.

This report, which has been prepared for a wide audience, presents the major conclusions and findings of the workshop. It discusses conceptual and methodological issues concerning impact indicators and briefly outlines simple, practical indicators for income, food availability and consumption, and the natural resource base. I am confident that the report will be of great help, not only to A.I.D. staff and contractors, but also to host governments and institutions that are struggling to develop effective and efficient monitoring and evaluation systems for development activities.

Janet C. Ballantyne
Associate Assistant Administrator
Center for Development Information
 and Evaluation
Bureau for Program and Policy
 Coordination
U.S. Agency for International
 Development
September 1989

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Annette Binnendijk, Robert O. Blake, Ernest W. Carter, Roberto Castro, Vincent Cusumano, Tej Pal Gill, Nicolaas Luykx, A. Ralph J. McCracken, John Mason, Donald G. McClelland, Raymond Meyer, Patricia O'Brien-Place, W. Haven North, Nena Vreeland, and Clarence Zuvekas for their comments on the earlier draft of this report.

1. INTRODUCTION

The impact indicators workshop held 12 plenary and 15 working group sessions and covered a wide range of topics. This report is not a comprehensive review of the issues, ideas, insights, and recommendations discussed by workshop participants, because it would be extremely difficult, if not impossible, to capture all that was discussed in the workshop without missing some of the finer points and their implications. Instead, the report focuses on the major conclusions and recommendations that can be drawn from the workshop. The report briefly outlines three sets of indicators that were either proposed in the background papers submitted to the workshop or suggested by the participants. All of the indicators outlined can be used to assess the impacts of agricultural and rural development interventions.

The remainder of this report is organized into four sections. Section 2 focuses on general conceptual and data collection issues related to the selection and use of impact indicators. The remaining three sections focus on the direct and indirect indicators for measuring changes in income, food availability and consumption, and the natural resource base.

2. SELECTING AND USING IMPACT INDICATORS

2.1. The Concept of Indicator

The word indicator is often given different meanings in different contexts. It is often confused with such concepts as data, targets, standards for evaluation, and even modes of data collection. Such confusion is unwarranted given the precise meaning of the term in the literature on monitoring and evaluation. Still, since some confusion does persist, it is important to define the precise meaning of the word for the purpose of this report.

Indicators are defined as variables whose purpose is to measure change in a given phenomenon or process. They are conceptualized as analytical tools that facilitate the measurement of change that may have resulted from development interventions. Further, they can provide summary data that are useful in project/program design, implementation, and evaluation. Ideally, indicators should refer to a specific event and should be objectively verifiable and replicable -- requirements that are usually not fully met in practice.

Indicators must have a point of reference to determine the magnitude of change, if any, over a specified period of time. Ideally, indicator data are gathered at several points in time (before, during, and after an intervention) to reveal change or trends. When time-series data are not available, cross-sectional data can be used to make comparisons. In such situations, the same or similar indicators are used to gather data for comparable groups or regions to determine change. In still other cases, acceptable standards or targets can be used as a point of reference to measure progress or lack of it.

Several general points about the nature of indicators were discussed and clarified during the workshop.

First, participants agreed that indicators can be both direct and indirect. Direct indicators involve the direct measurement of a phenomenon, for example, measuring household income by conducting income surveys that gather data on individual households. However, indirect indicators, also known as proxies, are based on indirect evidence. For example, instead of directly measuring income, evaluators can measure expenditure because expenditure data tend to be more reliable and give a more accurate picture of economic well-being. In fact, in many situations, indirect indicators can be more cost-effective and provide more valid information than direct indicators.

Second, some participants questioned the premise that indicators should be based solely on quantitative data; they suggested that such a conceptualization is unduly restrictive and minimizes the importance of qualitative assessments. For example, to assess the impact of a project on the income of participating farmers, evaluators can solicit the views of farmers, host country officials, and other experts through unstructured interviews. The findings of such a study can give development specialists a reasonable indication of the overall impact of the project without requiring exhaustive quantitative data. In most cases, participants argued with considerable justification, the Agency for International Development (A.I.D.) cannot go beyond such qualitative assessments because of the difficulties and costs of collecting and analyzing rigorous quantitative data.

The participants who preferred the narrow definition of indicators did not question the utility of qualitative assessments. Indeed, they recognized that qualitative data are necessary and should remain an indispensable part of any impact assessment strategy. What they objected to was broadening the word "indicator" to include qualitative information. According to their view, it is better to accept the common usage of the term, which confines it to data that are statistically manipulable, than to define it differently, thus contributing to unnecessary confusion. In any case, the differences voiced were problems in semantics rather than substance, because all stressed the need for qualitative as well as quantitative information.

On a final note, it is important to recognize that in many instances qualitative information can be converted into numerical data for the purpose of constructing indicators. For example, evaluators can use nominal categories to describe variations in the impact of a project on food consumption of the target populations. They can state that 30 percent of the informants indicated that the project very significantly reduced malnutrition, another 30 percent described the project's impact as significant, and 20 percent believed that it did not have any impact. Thus, in practice, qualitative information can be used for constructing indicators.

The second category is composed of the "purpose level" indicators, which are related to the immediate goals of activities or tasks initiated by a project. Some widely used indicators that fall under this category include crop yields, natural resource productivity, and the amount of additional agricultural lands brought under irrigation by a project. Performance indicators can also be referred to as "intermediate" indicators.

Third, indicators can be classified into three categories, depending on the purpose for which they are used. The first category is composed of "performance" indicators, which describe the operational status of an activity or task. Examples of this category of indicators include the amount of fertilizers supplied by a project to farmers, the number of farmers visited by an extension agent, or the number of microenterprises that received technical assistance from a project. In the language of A.I.D.'s Logical Framework, these are essentially input and output indicators.

The last category of indicators is "impact" indicators, which are designed to measure the effects of developmental interventions on people, the economy, society, and the natural resource base. These indicators focus on the long-term goals of development. Examples of such indicators are per capita income, gross national product (GNP), or per capita consumption of calories.

Workshop participants stressed that often intermediate indicators have to be used to assess the impact of an intervention. The reason is that in many cases, the Agency does not have access to reliable impact data, and the only viable alternative is to to infer impacts from immediate results of the tasks performed or activities completed. For example, if there is strong evidence that the farmers have been using the improved variety of maize seed enthusiastically, evaluators can assume that it is profitable to the farmers and consequently that farmers' incomes are rising. However, participants recognized that inferences on impact derived primarily from intermediate indicators might be misleading in some cases. For example, the mere fact that extension staff were successfully organizing meetings attended by a large number of farmers does not imply that farmers actually used the recommended technical packages, even less that they benefited by their use.

2.2 The Problem of Establishing Causal Relationships

The subject of causality -- of whether a specific observed change is caused by a project -- was only briefly discussed during the workshop. Participants recognized that in order to establish causality on the basis of indicator data alone, net impacts would have to be measured; that is, the observed changes resulting from factors and conditions not related to a project would have to be subtracted from the observed gross changes. For example, suppose farmers' real incomes have increased by 40 percent since the implementation of a project that supplies fertilizers to farmers. On the basis of such evidence, evaluators cannot assume that the project has contributed to these increases, because the changes in incomes may have been caused by factors unrelated to and outside the control of the project.

Participants generally agreed that the measurement of net impacts is extremely difficult in cases of agricultural and rural development interventions. Two methodological strategies -- quasi

-experimental designs and statistical controls -- which are traditionally used in the health, education, and population sectors, have not proven practical in agricultural and rural projects. Both these strategies pose major conceptual and methodological problems that are difficult to resolve satisfactorily. Moreover, they require massive data collection efforts conducted over extended periods of time, and their costs, measured in terms of time and resources, tend to be very high.

Participants agreed that causality can be inferred through less rigorous methods and at lower cost by supplementing impact indicator data with qualitative studies. Although qualitative studies cannot measure net changes, they are able to answer, to a reasonable extent, the question of whether a project has contributed to a particular observed outcome. Well-designed qualitative studies can examine underlying assumptions -- the intervention models on which projects or programs are based -- and their relevance to a given setting, the efficiency of activities undertaken to initiate changes, and possible explanations for changes observed. Qualitative studies can also identify unanticipated impacts or shed light on intervening variables that may account for why impacts have or have not occurred.

Participants did not view impact indicator data as an alternative to qualitative case studies or the impact assessments undertaken by A.I.D.'s regional bureaus and the Bureau for Program and Policy Coordination, Center for Development Information and Evaluation (PPC/CDIE). Instead, they felt that such data, if collected and analyzed, would supplement the existing evaluation system and improve the reliability and validity of information about the overall impacts of A.I.D.'s agricultural and rural development assistance.

2.3 Information Needs of Various Users

Workshop participants noted that several groups and organizational entities are interested in and use impact indicator data, including the Congress; private voluntary organizations; international donor agencies; A.I.D.'s Administrator's Office, regional bureaus, country Missions, and project managers; host governments; and target populations.

However, because all these actors have different roles and responsibilities, they often require different types of data and information. For example, the Congress needs impact data aggregated at national and regional levels because its primary concern is to ensure that the Agency is using congressionally appropriated funds to achieve certain agreed-on objectives, and it is interested in determining whether programs are having desired impacts on the developing countries. In most instances, the Congress seeks both statistical data and insightful qualitative studies. However, A.I.D. project management staff at the field level are less interested in gathering and analyzing rigorous impact data. Since they are intimately familiar with projects and have the advantage of directly observing the implementation process, they are likely to have a reasonable idea of the effects of interventions without needing to draw on impact indicator data.

Thus, the same set of impact indicators may not serve all the needs of the various actors involved. Participants generally agreed that specific information requirements of the major users should be carefully examined before information systems for impact indicator data are developed. Only after careful assessment of needs can simple, practical sets of indicators be identifield and a viable information system established.

2.4 Considerations on the Selection of Impact Indicators

Two sets of considerations affect the kinds of indicators selected. The first consideration is dictated by technical requirements, while the second arises from the operational constraints in which investigators operate. Participants agreed that the technical requirements of a good indicator are that it

-- Provide valid measures. The indicator should measure what it is designed to measure. For example, if changes in household assets are used as an indicator of changes in income, evaluators should be certain that the indicator will give them a reasonable estimate of changes in the income levels of the target populations.

-- Be reliable. The conclusions based on indicators data should be the same if measured by different people at different times.

-- Be sensitive to change. Indicators should be able to detect changes in the condition measured.

-- Be replicable. Indicators should be usable for different projects and settings to allow comparative analysis.

-- Have access to data. There is little value in an indicator if the data required for the assessment cannot be gathered.

In addition to the technical considerations that were raised, participants discussed four practical considerations that should influence the selection process.

-- Cost-effectiveness of data collection. Costs vary for different indicators depending on the magnitude of information required, mode of data collection, and scale of operation. Preference should be given to those indicators for which data can be collected at lower costs, subject to minimum standards of reliability.

-- Timeliness. The rapid delivery of data is very important. Other things being equal, indicators for which data can be gathered expeditiously will better serve the needs of the Agency and other parties involved.

-- Ease of communication. Preference should be given to indicators that are simple to understand and that provide information that can be easily communicated. expertise and therefore tend to ignore highly complex indicators. Policymakers and decision-makers often lack technical expertise and therefore tend to ignore highly complex indicators.

-- Availability of technical and organizational resources. Indicators requiring data that can be gathered with local resources are preferable because costs for data collection are reduced and the process of carrying out such efforts strengthens institutional capabilities in host societies.

Participants recognized that the selection criteria and considerations discussed above are not always compatible. For example, ensuring a high standard of validity may require extensive data collection efforts, whereas the concern for cost-effectiveness may dictate choices that reduce the validity of results. In practice, designers and implementers of impact indicator information systems will have to make reasonable compromises to ensure that the information needs of the different users are optimally served.

2.5 Selection of Projects and Programs

Participants agreed that impact indicator data cannot be gathered for all agricultural and rural development interventions. The collection of such data for all or even a majority of projects would require administrative, technical, and financial resources that would overburden individual projects, country Missions, and regional bureaus. Therefore, impact data should be collected for only a cluster of projects with similar objectives at the program level. Participants believed that useful, although not usually statistically valid, generalizations can be made about the overall impacts of development assistance on the basis of a small, carefully selected sample.

The sample of projects included in an impact indicator information system cannot be constructed in a statistically rigorous manner. Instead, the sample is likely to be purposive rather than random. In the course of discussions, participants mentioned several general considerations that may influence the choice of projects for a global impact review. First, selected projects should reflect the emerging agricultural and urban thrust of A.I.D. programs. Second, selected projects should be representative of the major regions of Asia, Africa, South America, and the Middle East. Third, some preference should be given to projects located in countries receiving a relatively large share of A.I.D. funding. Fourth, projects should reflect a range of different social, economic, political, and environmental settings in which projects operate. Finally, the indigenous capabilities of host countries to collect and analyze information should be taken into account.

In addition to these suggestions, participants identified three project characteristics that might also be considered. First, only those projects should be included in an information system that are designed to directly affect one or more of the three impact areas of interest -- income, food availability and consumption, and the natural resource base. Thus, interventions that may not generate direct, observable impacts in one of those areas should be excluded. For example, projects that provide assistance to agricultural universities would be excluded from the study, because the ultimate impacts of such efforts are usually indirect and diffused, thus not easily captured by impact indicators. Second, selected projects should have identifiable target populations on which data can be gathered. Third, preference should be given to innovative projects so that the findings can be helpful in evaluating their replicability.

A country or sector may also find it useful to undertake impact evaluations of some of its projects. Participants agreed that if the Agency decides to gather impact indicator data, it should give careful thought and reflection to the selection of projects.

2.6 Aggregation of Impact Data

An issue that surfaced early and continued throughout the workshop discussions was aggregation. Participants agreed that aggregation of impact data at the national, regional, or worldwide Agency level is not possible for a variety of reasons. Agricultural and rural development projects vary in their design and target populations, and their impacts become visible at different times. Moreover, socioeconomic settings vary from project to project. Therefore the same set of indicators is not valid for all projects studied. For example, in some countries income or expenditure surveys may generate the best information, whereas in others ownership of assets might be the only indicator that can provide relevant results.

Although impact data cannot be aggregated to generate statistically rigorous findings, it is still possible to group the data together to provide a more comprehensive assessment. For example, a country Mission can report that the findings from its three agricultural projects indicated that real incomes of the target populations increased an average of 5 to 10 percent a year during a given period. Or, a regional bureau can simply list the summary findings on its projects. In fact, with a little ingenuity, analysts can group collected data in a variety of ways to draw necessary conclusions and provide useful recommendations.

In any case, participants stressed that even when impact data are not aggregated, they would be useful to the various groups and organizational entities mentioned earlier.

3. MEASURING CHANGES IN INCOME

Participants agreed that one of the primary objectives of development assistance is to increase the income and standard of living of people living in developing countries. Increased agricultural production and productivity, strengthened local development institutions, and the diffusion of appropriate technology are not ends in themselves; they are only a means for improving the living conditions of people suffering from the age-old problems of poverty and deprivation.

Experience shows that, at both the macro and micro levels, increased income contributes in the long run to a better quality of life. Higher income means better food, improved nutrition, better clothing, better educational facilities, declining mortality and illiteracy rates, and more viable social and political institutions. Therefore, income level is usually a good predictor of the social, political, and cultural status of people. Participants stressed that the effects of A.I.D. assistance efforts on income should be carefully examined.

Simply defined, income refers to the monetized value of the flow of goods and services. Income is measured at macro (national) and micro (household or individual) levels. Several indicators are commonly used to measure income at these levels.

3.1 Macro-Level Income Indicators

A.I.D. uses macro-level income indicators to prepare action plans, Country Development Strategy Statements, and congressional presentations and to report the overall impacts of the Agency's development assistance program to its different constituencies. The following indicators were briefly identified and discussed during the workshop:

-- GNP: Measured as the total value of all final goods and services produced in a country calculated at market prices plus all factor income from abroad to the residents of a country.

-- Gross domestic product (GDP): Computed in the same way as GNP but without adding net payments (payments less recipients abroad) to owners of production abroad.

-- Net national product (NNP): Computed the same way as GNP, but adjusted for capital depreciation. In other words, only net investment is included.

-- Contribution of agriculture to GDP: Gross agricultural product at market prices.

-- GDP per capita: Computed by dividing GDP by the total population. This indicator cannot be used to estimate the change at the micro level, because it provides no information about changes in income distribution.

Data for macro-level indicators are available from national and international sources. International comparisons based on national or per capita income data pose many problems because of fluctuations in market prices and exchange rates. A common procedure for addressing the exchange rate problem is to adjust the average exchange rate for the current year and two preceding years to the difference in inflation between the country of interest and the United States. The market price problem can be addressed through various purchasing power-parity adjustments. However, several workshop participants cautioned that even after such adjustments are made, international comparisons can be misleading.

Since the methodology for computing macro-level income indicators is well established and generally the same sources of data are used by all users, participants did not discuss them in detail. Instead, participants focused on micro-level indicators, which are more appropriate for measuring changes at the project level.

3.2 Micro-Level Income Indicators

Micro-level income indicators that focus on the household or an individual can be divided into two categories: direct and indirect (proxy) indicators. The direct measure of income includes cash, as well as the monetized value of goods and services received, with the coverage of the latter partial at best. Indirect measures focus not on the flow of resources but on their use. The most commonly used indirect measures are expenditure, consumption, assets, and standard-of-living indicators.

3.2.1 Household Income

There was a consensus among participants that for well-recognized reasons, a definition of income in terms of cash received is unduly restrictive, especially in rural areas of developing countries. Farmers generally keep a part of their produce for domestic consumption. Farm workers may receive part of their wages in kind. Moreover, rural households may have free access to vegetables, herbs, fruits, wild animals, grazing land, firewood, and building materials. Therefore, an adequate concept of income must include the values of goods and services received in kind, including the imputed rental value (income) of the household dwelling unit. Data for the direct measurement of income are gathered through surveys, which typically do not provide for full coverage of in-kind and imputed income.

Participants examined several advantages of using the direct measurement of income to assess development intervention impacts. First, because the concept of income is commonly understood, policymakers and decision-makers comprehend it better than indirect indicators. Second, since in income surveys it is necessary (or at least desirable) to identify different sources of income for various members of a household, the data gathered are extremely useful to assess the impact of a development project. For example, survey data can reveal that the primary reason for a rise in income in a project area is not the increase in agricultural production and productivity, as project management may believe, but rather the expansion of employment opportunities in the nearby town. The opposite may hold true in other cases. Third, survey data permit investigators to measure the frequency, timing, and reliability of income streams. These facts affect household welfare and are therefore important to consider when monitoring and evaluating project or program impacts.

Despite these advantages, participants suggested that household income data are usually not reliable and valid and thus are of limited value. Measuring direct income in rural areas is extremely difficult and unless it is carried out with utmost care (as is rarely the case), the findings can be inaccurate or even misleading.

Participants discussed several factors that undermine the accuracy of direct measurements of income. First, questions about income are sensitive, and it is often considered impolite, on initial contact at least, to ask such questions. In most cultures, people do not like to reveal their incomes to strangers. Many respondents may evade questions or give inaccurate answers. Second, the accuracy of data may be undermined if the respondent is unable to recall all cash and goods and services received. Usually, respondents are asked to recall their earnings for fairly long periods, such as a year.

Problems also arise because most respondents, especially subsistence farmers and petty business operators, do not keep records of their sales, costs, wages, or profits and thus depend on their memory for their responses. As a result, although they usually remember significant earnings and events, they typically forget many small transactions.

Third, income surveys are quite costly because they require interviews with all earners in a family. Often both male and female enumerators must be fielded to interview members of both sexes. In addition, since the income of farmers fluctuates with different agricultural seasons, data must be collected at several time periods. Fourth, as indicated earlier, monetizing the values of goods and services introduces many biases. Often the enumerators are forced to make assumptions that are not justifiable.

3.2.2 Expenditure as an Income Indicator

Household expenditures can be used as a proxy indicator for measuring income. Expenditure data are gathered through budget and expenditure surveys, which involve multiple visits to a household during a given short-term reference period; such surveys are concerned with measuring current consumption, as opposed to measuring the long-term effects of savings on household welfare.

Participants mentioned several advantages of using expenditure data as a proxy indicator. They agreed that expenditure data are more reliable than income data because people are less inhibited when they talk about their expenditures than they are when they talk about their incomes. Moreover, expenditures are easier to remember. Respondents tend to remember what amounts they spent and for what purpose, provided the reference period is not too long. Another strong argument in favor of using expenditure data is that such data represent actual, and not potential (as is the case with income), consumption, thus providing a more accurate measure of economic welfare.

Several limitations related to using expenditure data as an indicator of income were also mentioned. First, since households can build or deplete savings to maintain a reasonably constant level of expenditure, changes in income may not be immediately reflected in consumption patterns. Thus, in the short term it is possible that while the incomes of beneficiaries have increased as a result of project activities, their expenditure patterns have for the time being remained the same. Still when viewed from a long-term perspective, there is little doubt that income is closely and positively related to expenditure. Second, experience shows that to the extent items consumed are not purchased, expenditure data will underestimate income. Third, the choice of reference periods is very important in performing expenditure surveys. These surveys require multiple visits to households. If such visits are not carefully planned, the validity of collected data may be questionable.

3.2.3 Assets as an Income Indicator

Ownership of assets was another proxy indicator discussed in the workshop. Participants suggested that the ownership of production or consumption assets can often provide a good measure of household income in various socioeconomic systems. Land, farm equipment, livestock, and ownership of small business are examples of production assets, while examples of consumption assets include family house, household furniture and appliances, means of transportation, and radios. Variations in stocks of assets reflect the changes in income levels. Thus if the assets of a target population have increased after the implementation of an irrigation project, enumerators can conclude that incomes have risen.

Participants identified several advantages of using assets as a proxy indicator for income. First, the concept of assets is tangible, and enumerators' questions about them are easily understood by respondents, thereby minimizing errors. Second, assets are directly observable. By simply visiting a house, farm, or business, enumerators can easily record assets owned by the household, and the respondents' answers can be instantly verified. Moreover, since people in rural areas know about each others' assets, they tend to give truthful answers.

Third, assets are more stable over time than is income. Thus, the effect of seasonal fluctuations in incomes is minimized. Fourth, an increase in production assets is generally indicative of long-term improvements in the economic conditions of the target population and thus provides a better measure of impact in some cases. For example, if data show that the number of farmers who own tractors has increased in an area covered by a credit project, one can infer (if other supportive evidence is available) that the project will continue to have positive effects for some time, at least as long as the tractors remain in working condition. Finally, the cost of collecting data on assets is relatively low when compared with household income surveys.

Participants also discussed some of the limitations of using assets as a proxy indicator for income. First, they suggested that assets do not provide information on short-term fluctuations in income, because people do not immediately convert higher incomes into greater stocks of assets. The reverse is also true: a fall in incomes does not usually lead to an immediate reduction in consumption or production assets. Second, ownership may be difficult to define because the concept has different connotations in different cultures. For example, in the case of land, use rights are often assigned differently than are rights to sell or to transfer land to others. Sometimes assets, particularly those used in production, are purchased in the name of another member of the household to evade taxes, a practice that causes difficulties in assigning ownership. Such ambiguities can undermine the reliability of data collected.

Third, assets that can be used as a valid indicator are culturally specific, making cross-cultural comparisons difficult. For example, ownership of 5 acres of irrigated land may indicate a rich household in India but a poor one in Brazil. Fourth, unlike the direct measurement of income, changes in assets are more difficult to attribute directly to a given project. Since changes in assets are more indirectly related to project interventions than are changes in income, there is a greater likelihood that intervening variables will influence asset levels. Finally, changes in assets may be totally unrelated to project interventions; instead, such changes may reflect changes in other sources of income, including remittances from family members who have migrated abroad or to other areas within the country.

3.2.4 Standard-of-Living Indicators

Finally, a set of standard-of-living indicators can measure change in income levels. For this purpose, it is possible to construct a composite index to cover items such as food, clothing, housing, access to medical and educational facilities, and transportation. In a number of A.I.D. projects such indicators have generated relevant, useful information about changes in the economic status of target populations.

Participants stressed that the list of items selected to measure standard-of-living changes should be comprehensive so that different aspects of living conditions are accounted for. If only one or two areas are covered, investigators may arrive at erroneous conclusions. For example, if a house is the sole measure of standard of living, findings might be misleading because people may spend more of their incremental incomes on food, clothing, and household furnishings than on the purchase or renovation of a house.

Standard-of-living indicators as a proxy for determining changes in income have several advantages similar to those of assets. Many aspects of living conditions are easily observable, and questions about living conditions are readily understood. An advantage that standard of living has over assets as an indicator is that changes in income are better reflected in living conditions than in accumulation of assets.

A major disadvantage of using standard-of-living indicators is that they are highly specific to local social and economic settings. Thus, indicators that are valid for Malawi may not be valid for its neighbor Zambia. In fact, within a country itself, different sets of indicators may be needed for different regions, depending on the region's level of economic development, social and cultural circumstances, and even climatic differences. In any case, cross-national comparisons are not possible on the basis of such indicators.

Also, since many services offered by the community or government agencies should be included in standard-of-living indexes, this indicator may not be a valid measure of the economic status of a household. Finally, policymakers and decision-makers, who are used to dealing with the direct measurement of income, do not easily understand standard-of-living indicators.

In conclusion, participants suggested that in selecting income indicators, the considerations identified earlier in this report should be kept in mind. There was broad-based consensus that, as far as possible, direct measurement of income should be combined with one of the indirect indicators in order to provide a more accurate assessment of change. Overall, participants preferred standard-of-living or expenditure indicators over the ownership of assets as proxy indicators of income.

3.3 Intrahousehold Income Distribution

The issue of income distribution within the household was raised several times in the workshop. Participants pointed out that a household is not a single, homogeneous unit that earns and spends income. Within a household, there are differences in age and gender. Therefore it is wrong to assume that income increases for the household in general are invariably translated into greater welfare for all members. For example, evidence available from several studies conducted by A.I.D.'s Center for Development Information and Evaluation (CDIE) suggests that a greater portion of incremental earnings may be spent on male members.

Participants suggested that surveys or studies focusing on household income should address the intrahousehold dimension in three ways. First, whenever possible, income sources of each member of a household should be examined. As indicated earlier, this requires separate interviews with members of both sexes. Second, the question of who controls the household income should also be examined. Although the person earning income is generally in control of it, in many cultures most earnings are pooled and controlled by the male head of household. In such instances, women may not receive a fair share of the household income. Third, changes in members' access to consumption goods and services (e.g., food, clothing, health care, and education) should be examined. To explore these issues, additional data may be required on household structures and composition, individual incomes and assets, and the allocation of consumption goods within a household.

3.4 Identification of Target Populations

The identification of target populations was another problem area that surfaced during the discussion of income indicators. Several participants pointed out that changes in income can be measured only if target populations are precisely identified. Once this is done, researchers can take a sample of the target population and find out whether the peoples' incomes have changed over time.

However, in many of the Agency's projects and programs, the target populations are defined imprecisely. Even when a Project Paper mentions a target population, it does not follow that the project is designed to reach all or even most of the targeted population. An example was given of a project designed to promote fertilizer distribution by private traders. Who is the target population? Is the target group the private entrepreneurs or the farmers who purchase these fertilizers? If the farming populations constitute the target group, are all farmers to be included in the sampling frame? Since all farmers do not use fertilizers, it would certainly be inappropriate to include the entire farming population of a country or a specific region in the sampling frame. Furthermore, it might be misleading to include all farmers using fertilizers in the target group, because many of them would have used fertilizers regardless of a project intervention. It should also be noted that without a precise identification of the target group, it is impossible to define the control group against whom the behavior of the target group is to be compared.

Although participants recognized the problem, they provided no immediate solutions. Still, they made several general observations. First, micro-level data should be restricted to projects that have identifiable target populations with clear boundaries separating them from nontarget populations. Second, when target populations are not identified, some indirect estimates are still possible. For example, in the case of a fertilizer distribution project, evaluators can estimate the average amount of fertilizer used by a farm household and then project the number of farm households that may have benefited. On the basis of farm budgets evaluators can compute the additional profits that a household might have made as a result of using the fertilizers. It should be recognized, however, that farmers may use fertilizers on crops other than those targeted by the project, which makes assessments by planners/evaluators flawed. Nevertheless, although such data might not be very reliable, they will provide at least an indication of the impact.

3.5 Sources of Data

Participants identified and discussed several sources of information. First, they discussed the usefulness of data previously collected by population censuses, agricultural censuses, income and expenditure surveys, and special studies undertaken by governments and donor agencies. Participants mentioned that in many countries during the past two decades, the institutional capabilities of host government agencies for collecting and analyzing statistical data have greatly improved. Statistical offices and other governmental agencies now regularly gather vast amounts of statistical data, some of which can be used to assess changes in income.

Participants did, however, caution against a heavy reliance on secondary data. While they agreed that such data are necessary for macro-level analysis, they expressed reservations about heavy reliance on such data at the project level. Often secondary data are not easily accessible to investigators; and even when they are available, it is usually difficult to disaggregate the data for specific populations reached by the Agency's projects. Moreover, data sets do not always include all the variables needed for an analysis of project impacts. The quality of secondary data remains uncertain, and the costs for preparing them can be considerable. Despite these limitations, participants agreed that efforts should be made to seek out secondary data and evaluate them for their potential usefulness. If nothing else, such data can provide baseline information or can be used to cross-check the primary data collected on a project under review.

Second, participants discussed the need for income and expenditure surveys, which they agreed provide most of the data on the target population. Such surveys should be carefully designed and respondents selected by random probability sampling in order to ensure that the generalizations made about the target populations are statistically valid. Participants suggested that sample sizes should remain small to reduce the cost and time required for the surveys. In fact, small samples are often preferable to larger ones to reduce nonsampling errors and increase validity.

Third, participants discussed the use of qualitative studies to generate useful data. They suggested that qualitative studies be conducted to analyze the nature of impacts and the processes by which the impacts were generated. Such studies can use a wide variety of data collection methods, such as key informant interviews, community meetings, focus group discussions, and direct observation.

Finally, participants mentioned that in many cases administrative records can provide useful data and information for determining changes in the economic status of target groups. For example, land revenue records can determine changes in the ownership of land in an area. Records from vehicle registration offices can provide information on changes in ownership of tractors over time. Similarly, loan records kept by lending institutions can provide information on the assets and economic status of borrowing farmers. The sales records of wholesale or central agencies -- particularly those focusing on key consumption items or production inputs -- can also be used for this purpose. However, such records can suffer from systematic biases in recording information. For example, farmers may overstate the value of their assets in order to obtain loans, or they may understate the size of their land holdings to avoid taxation. Retailers may understate sales to avoid attracting competition.

The workshop participants generally concluded that one or more of the sources of data and information discussed above can be useful when assessing impacts of agricultural and rural development interventions on income.

4. MEASURING CHANGES IN FOOD CONSUMPTION

Food consumption is closely related to income. In fact, as suggested earlier, a rise in income contributes to improvements in food consumption, both at the national and household levels. Participants pointed out, however, that the relationship between income and food consumption is affected by a wide range of factors often overlooked in discussions, for example, market price fluctuations, seasonality of food production, crop mix and cultivation of minor crops, crop labor requirements, gender stratification, and macroeconomic policies.

Changes in these factors affect the linkage between income and food consumption. For example, income increases resulting from greater cash crop production do not necessarily translate into improved food consumption because gains in cash crop production may come about at the expense of traditional crops used for home consumption. Experience of dairy farming projects indicates that commercialization often deprives farm families of dairy products, which are a major source of families' protein.

Participants suggested, therefore, that in addition to income, food consumption should be examined to assess the impact of agricultural and rural assistance on the quality of life of the target population.

4.1 Food Consumption Indicators

Participants identified and discussed several direct and indirect (proxy) indicators that can be useful for assessing the impact on food consumption at micro levels and macro levels. Direct indicators focus on food consumption per se, while indirect measures focus on food availability and marketing channels.

4.1.1 Per Capita Calorie Intake

Per capita calorie intake can be measured by household surveys, and is undoubtedly the most precise, direct indicator of food consumption.

In nutrition studies undertaken by dietitians and health workers, food consumed by an individual is precisely measured at each meal to estimate food intake. Respondents or enumerators weigh amounts of different foods consumed and record them for each meal, taking care to exclude foods left by individuals at the end of a meal. Despite the preciseness and accuracy of data, such surveys cannot be used to cover large populations because of the costs and time involved. They are primarily useful for clinical studies rather than for shaping public policy or assessing impacts of specific development interventions.

The more widely used source of data for the per capita calorie intake indicator is household food surveys that focus on major food items consumed at a meal and the frequency of meals per day. Instead of directly weighing food, respondents are asked to recall the number of meals and amount of specific food items they consumed during the last 24 hours. Investigators must make several visits throughout the year to each household in the survey sample to adjust the data for changes in food consumption due to seasonal changes in food availability and income.

Participants discussed several advantages of this food consumption indicator. First, the information obtained is direct. Second, if surveys are conducted carefully, the resulting data are quite reliable and accurate. Third, collected data can be disaggregated by gender (head of the household), social class, and region. Thus, comparisons can be made across various categories depending on the needs of the impact assessments. Fourth, investigators can target surveys to focus on specific groups that are most vulnerable to food scarcity and undernutrition. Such groups may include landless farmers, women, and other groups who constitute the poor majority for A.I.D. assistance programs.

Several limitations, primarily related to the problem of data collection, were also identified. First, surveys required for gathering data are usually costly, and it is doubtful that sufficient resources would be available to undertake them at the project level. Second, such surveys are also time consuming because enumerators must gather data from each household in the sample several times during each season.

4.1.2 Per Capita Food Expenditure

Per capita food expenditure indicators focus not on the quantities of foods consumed, but on the money spent on food by an individual or household. In some cases, however, estimates are expressed as calories consumed by converting expenditure data to calories, using price-per-unit and calorie-per-unit conversion factors.

The data for this indicator are gathered primarily through budget/expenditure surveys. Estimates of food expenditure for a household are computed on the basis of cash spent on food items plus the monetary value of foods produced at home or received in kind from outside sources.

Participants discussed several advantages of using this indicator. First, secondary data are often available to compute per capita food expenditure. Most countries conduct budget and expenditure surveys at regular intervals for a variety of reasons, such as determining how to assign weights to specific items in a cost-of-living index. Second, available data can be easily disaggregated. Most of the budget and expenditure surveys contain information about the socioeconomic background of households sampled, and this information can be used to estimate per capita food expenditure for different socioeconomic groups and regions.

Participants also mentioned several limitations. First, as discussed earlier (see Section 3.2.2), expenditure surveys tend to underestimate expenditure on food. The value of food produced at home or gathered locally is often underestimated or not recorded at all. Second, the surveys required to meet data requirements are relatively expensive. Third, information about price/unit factor conversion may not be available. Finally, data from secondary sources may have an urban bias, with remote rural areas generally underrepresented. Findings in such cases may thus be inaccurate. Because of these methodological and data collection problems, the food expenditure indicator should be used only when the available secondary data can be suitably analyzed to generate the relevant information.

4.1.3 Per Capita Food Availability

Per capita food availability is computed by dividing total food available at the national level by total population. Availability is estimated by adding total food production to food imports and food in storage and subtracting food exports. These estimates are regularly published by the Food and Agricultural Organization, U.S. Department of Agriculture, and A.I.D. and are presented as per capita daily consumption of calories.

While participants agreed on the usefulness of this indicator for preparing the Country Development Strategy Statement and providing an overall rationale for the project or program, they also generally agreed that its value for assessing impacts at the project level is extremely limited. This is true for several reasons. First, the data cannot be disaggregated to provide an accurate picture at local levels. Thus, while the data provide a general picture on food availability for a country as a whole, they do not inform investigators about local conditions or even about changes at the regional levels. Second, these data ignore distributional aspects of food consumption. Increases in a country's food production do not mean that the access to food for various socioeconomic groups has also improved, since access depends not only on production but also on the purchasing power of households, the efficiency of markets and transportation networks, and other factors.

Third, the macro-level data used to calculate this indicator invariably reflect all the errors inherent in production and foreign trade estimates. Particularly, such surveys underestimate subsistence food production, local food crops, and foods gathered or hunted. Finally, the data may overestimate food consumption because they omit or underestimate use of commodities for purposes other than human consumption. Thus, this indicator provides only a broad, general picture of food availability at the national level and is primarily used to monitor potential food scarcity situations or to make international comparisons on the progress of different countries.

4.1.4 Market Availability and Prices

Availability of major staples in local markets together with their prices can also be used as an indirect indicator of food consumption. The underlying assumption is that a rise in the prices of major staples is generally indicative of food scarcity, and vice versa. Thus, if the prices of food grains have risen significantly, investigators can assume (other things being equal) that the per capita consumption of food has declined.

At regular intervals, governments gather data on the availability and prices of major staples. When such data are not available from government sources, it is easy to gather the data using simple market surveys of food stocks and prices. Such surveys should be repeated in each agricultural season and, in particular, during lean periods, when food stocks reach their lowest levels.

Participants discussed several advantages of this indicator. First, data required are usually available from secondary sources, or they can be quickly collected at low cost. In fact, for most project settings, a few enumerators can collect and analyze data within a few weeks or even days. Second, data are quantifiable and comparisons can be made over time to measure change in food availability.

Participants did mention several limitations of this indicator. First, although data can be disaggregated regionally, it is not possible to disaggregate them on the basis of gender, social class, or other criteria. Such a limitation is important because it is often necessary to assess impacts of developmental interventions on groups that are especially vulnerable to food scarcity. Second, farmgate and retail prices may be greatly influenced by government market interventions and price-setting policies. Many governments deliberately attempt to force down the prices of staple food grains using artificial controls, and therefore free market mechanisms cannot operate fully. Third, since such surveys include only major staples, many minor crops that are essential for diet are overlooked. Finally, food prices and food availability alone are not very informative. Only when such data are combined with information on the purchasing power of the target population can evaluators begin to understand the impacts of an intervention on food consumption.

Given the considerations discussed above, participants suggested that this proxy indicator, when used alone, can give a misleading picture of the local situation. The indicator should be used with other indicators or with information gathered from qualitative studies.

4.1.5 Household Food Availability

The food availability indicator measures food availability at the household level and is computed by adding food production, food in storage, and purchases minus food sales. The data are gathered through household surveys in which questions about the volume of production, storage, sales, and purchases of food are asked. Survey data are usually complemented by information from secondary sources.

Participants expressed some reservations about using household food availability as a proxy indicator. First, collected data cannot be disaggregated by gender and thus do not provide information on intrahousehold food consumption differences. Second, conducting such surveys requires extreme care, because poorly phrased questions, particularly concerning food storage, can result in inaccurate information. Third, when secondary data are not available, investigators must conduct their own surveys, which can be costly. There was a general consensus among participants that this indicator should be used only if the secondary data are available or if primary data can be gathered by adding a module to a planned survey of target populations.

4.1.6 Anthropometric Indicators

Anthropometric measures are undoubtedly the most commonly used proxy indicators of food consumption. Anthropometric data are generally gathered for children under 5 years old for two reasons: first, children up to this age are most vulnerable to malnutrition, and second, the effects of changing levels of food consumption are more quickly discerned in young, rapidly growing children than in adults.

Commonly used anthropometric measures are weight at birth, weight for age, height for age, and weight for height. Reported weight at birth is used to show incidence of low birth weight in a population and is computed as the proportion of the children born under 2.5 kilograms. Since precise weight measurements can only be collected if children are delivered in a maternity clinic or under the supervision of a trained nurse, which is not common in rural areas, this indicator is usually not practical. Weight-for-age and height-for-age indicators are widely used in nutritional surveillance programs; however, questions may be raised about the reliability of age data. Often parents in rural areas cannot provide accurate information about their child's age; therefore findings of studies based on such measures may not be very reliable. Participants suggested that weight-for-height measurements, which are not limited by the problems undermining the weight-for-age and height-for-age indicators, are a more accurate measure of nutritional status in rural areas.

The data required for anthropometric indicators are often available from secondary sources. In many countries, ministries of health employ staff to gather information on the nutritional status of women and children, the two groups most vulnerable to malnutrition. Some countries have even instituted comprehensive nutritional surveillance programs. However, data available from secondary sources may not be useful for assessing specific project impacts, because they have been collected for the purpose of making generalizations at the national level and are therefore not appropriate for specific geographical areas in which A.I.D. projects operate.

When suitable secondary data are not available, participants suggested collecting the data using on-site surveys that focus on the targeted populations. Two low-cost data collection strategies are available. First, if household surveys have already been planned in the area for some other purpose, a nutritional status module can be added to them. Second, community weighing programs can be undertaken to take anthropometric measurements at specified intervals. The latter is easier and requires less time for measuring a large number of children than surveys requiring individual home visits.

Participants mentioned several advantages of using anthropometric indicators to assess changes in food consumption. First, data can be disaggregated for relevant socioeconomic groups. Second, the relative cost of data collection is not high when compared with surveys previously mentioned in this section, and costs are further reduced if secondary data are used. Third, anthropometric indicators can be used to assess changes at the local, regional, and national levels.

Participants stressed that a major limitation of anthropometric indicators is that although they measure the nutritional status of the target population, the data can only be indirectly associated with food consumption or availability. The nutritional status of a population is affected by several factors other than food availability or consumption, such as food habits, sanitation, disease, and energy requirements of daily activities. Thus, the nutritional status of a group may change without corresponding changes in food availability and consumption, or vice versa. Participants suggested that in-depth qualitative studies are necessary to better link anthropometric data to food consumption.

In addition to the various indicators just described, participants discussed several other indicators that can be used to assess changes in food consumption, including household assets, household coping strategies, subsistence potential ratio, and morbidity and infant mortality rates. Although none of these indicators alone can provide reliable indications of change in food consumption, they can generate useful information when used with evidence from other indicators.

4.2 Gender Issues

Participants stressed that gender issues are very important in any analysis of impacts on food consumption. Increased food availability at the household level does not necessarily mean that all members receive their fair share depending on their physical needs. In some cultures, women and young girls are the last to benefit from increased food availability. Participants suggested, as in the case of income (see Section 3.3), that the intrahousehold dimension of food consumption should be examined using in-depth qualitative studies.

4.3 Data Collection Issues

There was general consensus among participants that a variety of data sources must be used to gather accurate and timely information for indicators.

Participants suggested that investigators should experiment with various data collection approaches that can reduce cost and time constraints. In this context, reference was made to "shortened" versions of food surveys, which are being developed and refined by the Nutrition Economics Group of the U.S. Department of Agriculture and A.I.D.'s Bureau of Science and Technology, Office of Nutrition.

These shortened surveys differ from traditional food surveys in several ways. First, the number of food items covered by the surveys is usually limited to 10; these items are carefully selected to ensure that they make up 90 percent of the diet. Second, measurements are less precise. For example, respondents may be asked to measure foods in cups rather than spoons. In no case is food actually weighed by enumerators. Third, a relatively small sample size is preferred to improve the validity of findings by reducing nonsampling rather than sampling errors. Fourth, the frequency of visits to households is reduced. Finally, longer recall periods (more than 24 hours) are used when necessary. Although no conclusive generalizations can be made about the validity and reliability of the data generated by the shortened survey approach, preliminary findings are encouraging and participants felt that such surveys should be promoted.

5. NATURAL RESOURCE INDICATORS

Finally, participants examined indicators for assessing the impact of agricultural and rural development interventions on the natural resource base, the environment, and the ecosystems of developing countries. The natural resources most critical to meeting human food, fiber, fuel, and shelter requirements and conserving natural habitat in developing countries are water, soils, and plants. The integration and interaction of these elements with human and animal communities in ecosystems require careful study for assessing the impacts of development projects and programs. Participants discussed the differences in some of the issues concerning natural resource indicators and those concerning income and food consumption. First, the unit of account at the project or program level is not always comparable with the unit of account in the ecological system. For example, unsound agricultural practices and poor management of watershed areas hundreds of miles inland can cause significant damage to coastal swamp areas and marine fisheries. Second, impacts on the natural resource base may not be immediately visible. Often it takes a long time before impacts surface, making it difficult to satisfactorily establish linkages between the impacts and specific development interventions. Third, natural resource assessments generally require a highly integrated systems approach incorporating numerous indicators, comprehensive baseline data, and long time horizons. Therefore natural resource impact assessments tend to be complicated and costly when compared with impact evaluations of income and food consumption.

Fourth, some assessments tend to rely heavily on various predictive models and simulations; however, there is still some controversy regarding the use and appropriateness of these tools. Most of the models currently in use were developed with reference to specific conditions found in industrialized nations, particularly the United States. They require significant baseline information for a large number of physical (especially climatic), economic, and farming practices parameters and must use existing data or data that are easily gathered. These models need further refinement before they are suitable for the conditions of developing countries, especially tropical and semitropical areas. Finally, participants pointed out that the Agency has limited experience in conducting assessments in this area.

Given the considerations discussed above, participants stressed that the natural resource indicators were only exploratory in nature. Much more work will have to be done before a set of viable, practical indicators can be identified for which relevant data can be systematically and cost-effectively gathered.

Participants classified indicators according to the three major components of natural resources -- water, soils, and plants. It was stressed, however, that the high degree of interrelationship between components makes it inevitable that impacts on one component will cause ripple effects on others. For example, newly introduced farm management practices and technologies may initially affect soil and water resources by reducing erosion of topsoils and lessening sediment loads in streams. However, longer term effects may become evident years later aswetland ecological systems begin to change in areas downstream from the original project area, or as yields and quality of products begin to increase or improve significantly.

The proposed indicators for the natural resource base vary in terms of their complexity. In some cases, an indicator is narrowly defined, and specific kinds of data necessary to carry out impact assessments can be easily identified. An example of such a case is the indicator entitled "actual versus tolerable topsoil loss caused by water erosion." In other cases, an indicator is defined by several elements, and the discussion of specific data requirements at this stage remains, by necessity, general. A good example of this case is the surface water pollution indicator, which is composed of three elements: sediment loads, presence of toxic chemicals, and nutrient levels. One or all of the three elements may be important in a given situation, and the decision on which should be used is up to the investigator.

5.1 Indicators for Measuring Impacts on Soils

5.1.1 Actual Versus Tolerable Topsoil Loss Caused by Water Erosion

The indicator for measuring erosion compares actual topsoil loss to tolerable topsoil loss due to erosion by water. Topsoil loss is measured in tons per hectare or acre per year -- or simply as a ratio of actual to tolerable loss per year. Tolerable soil loss is defined as the maximum annual rate of loss at which the same level of production can be economically sustained, and it is equated with the assumed rate of soil formation. Models, such as the Universal Soil Erosion Equation (USLE), can be used to measure and predict amounts of soil loss. However, the current version of USLE must be modified for tropical and semi-tropical regions. Surveys that directly measure on-site changes of topsoil thickness and sediment runoff can also provide accurate estimates. Efforts are now underway to replace USLE with a more process-oriented and less empirical set of procedures for estimating and predicting soil erosion by water.

5.1.2 Permanent Reduction in Soil Productivity Due to Topsoil Erosion by Water

The indicator for measuring water-caused topsoil erosion identifies fragile areas by measuring soil erosion that permanently lowers the productivity of soil. Fragile areas are those where yields continue to decline despite heavier fertilizer or manure application, or where yields are lower than areas with similar soils. Vulnerable soils, which are highly prone to erosion, can be identified by applying the Soil Erodibility Index derived from the USLE or as used in the erosion simulation models known as the Productivity Impact model and the Erosion Productivity Input Calculator Simulation model. The latter is being adopted for use in developing countries through A.I.D.
support.

5.1.3 Topsoil Erosion Caused by Wind

The indicator for measuring wind-caused soil erosion assesses the extent of topsoil lost and the size and area affected, the degree of damage to plants from sandblasting and redeposition of soil particles, and the magnitude of reduced air quality from atmospheric dust. Excessive wind-caused erosion can result from improper tillage practices, overgrazing, and inadequate conservation measures. It may also reflect approaching climatic changes or unusually severe drought periods. Such models as the Wind Erosion Equation are used to measure and predict wind-caused topsoil erosion rates. Surveys that directly measure changes in the thickness of topsoil between protected and exposed areas, thickness of wind-blown deposits, and content of wind dust can also produce useful estimates for this indicator.

5.1.4 Water-Caused Off-Site Soil Deposition

The indicator for determining the extent of off-site sediment disposition due to water-caused soil erosion is computed by estimating the amount of sediment accumulating in reservoirs and piled up on other soil surfaces. Often the damage caused by off-site deposition in bodies of water is more costly than that resulting from on-site decreases in soil productivity. Damage to surface waters includes reduced storage capacity of impoundments behind dams, the need for increased dredging of waterways and harbors, declines in the quality of water used for drinking and recreation, and poorer habitats for fish and other wildlife. Furthermore, pesticides and phosphates attached to soil particles are released into surface waters when sediments are deposited in them, leading to further damage of aquatic environments and other wildlife habitat.

Models exist to estimate and predict rates of off-site sediment deposition. The amount of sediment leaving local watersheds can be directly measured by installing measuring devices that can be checked periodically, and the amount of suspended sediment can be measured by taking repeated water samples. Direct measurement of off-site sediment thickness can also provide estimates of the severity of the damage.

5.1.5 Crop Yields: Actual Versus Potential

The indicator for estimating the need for additional plant nutrient and lime applications is computed by measuring the difference between actual crop yields and maximum potential yields and determining responses in yields to increments of fertilizers applied to the soil and to the times at which fertilizers were applied. Soil tests and accompanying fertility evaluations are required to assess the current status of soil properties. To determine nutrient levels, plant nutrients can be extracted with chemical solutions appropriate for the specific climate, soil, and crop in question. Additional lime needs are determined by measuring the active acidity of soil samples. The results of such tests can then be compared with fertilizer nutrient and lime response results from experimental field plot and greenhouse pot tests.

5.1.6 Actual Land Use Versus Soil Suitability

Another natural resource indicator evaluates the extent to which current land-use patterns are compatible with basic soil properties, climatic conditions, water availability, and location of human settlements. This indicator can assess the degree to which agricultural lands and important plant and animal habitats are being lost to human settlements or to the spread of wastelands. Periodic assessments will reveal trends in land use patterns, and can help gauge the effectiveness of existing patterns or the need for new land-use planning and conservation programs. Furthermore, the indicator can identify lands uniquely suited to the cultivation of specific crops or for preservation of certain plant and animal habitats.

Data required for this indicator can be collected by on-site observation and measurement of statistically selected sample sites, or by using remote sensing and sampling frames. If remote sensing is used, some on-site observation is still necessary to verify information present in the imagery -- a technique called ground-truthing.

5.2 Indicators for Assessing Impacts on Water Supply and Quality

5.2.1 Surface and Groundwater Supply

The indicator for assessing the extent to which water supplied from streams, lakes, impoundments, and aquifers meets human, agricultural, and wildlife habitat needs is determined by comparing estimates of water demand and supply parameters and determining the quality of the water. This indicator is also used to measure the impact of water conservation and development projects and to estimate probable levels of food production based on projected water supplies. Past, current, and projected estimates for several parameters can be used, including estimates on soil moisture storage for plant growth, water available for recharge of groundwater, aquifer withdrawal rates, human usage and food-crop usage rates, and water balance or budget data. The information gathered will indicate soil moisture deficits during drought periods and the needed irrigation timing and rates, as well as the amount of flow in streams and the levels of lakes and impoundments required to maintain wildlife habitats.

Water budgets that summarize water demand and supply information can be constructed by using survey data collected on site, or by using secondary data obtained from hydrologic, weather, and wildlife bureaus, as well as irrigation district offices and city water departments.

5.2.2 Surface Water Pollution

The indicator for assessing changes in surface water quality is based on analyses of suspended sediment contents, the presence of pesticides and other toxic chemicals, and nutrient loads. High suspended sediment loads result from soils washed from cultivated lands, construction sites, and unprotected stream banks, and from catastrophic events. Sediment contents can be evaluated at the source to determine trends and identify peak periods. The presence of toxic chemicals in water sources results from fertilizers and high concentrations of other compounds used in farming or originating from urban waste sites. High nutrient loads are caused by soil erosion of cultivated fields, untreated sewage, and animal wastes. All these types of contaminants can cause health hazards and threaten plant and animal habitats.

Water pollution levels can be measured using data collected by on-site surveys or secondary source data collected from government records. Models are also useful for analyzing trends and predicting peak periods.

5.2.3 Groundwater Pollution

Groundwater quality can be assessed by evaluating levels of toxic chemicals, excess nitrates, and dissolved salts found in the groundwater or inflow from soil, drainage pipes, ditches, and baseflow sewage. Three aspects of groundwater pollution deserve special attention. First, it usually takes a very long time before the presence of pollutants is recognized, because groundwater usually moves very slowly through different ground strata. Second, once present, pollutants are virtually impossible to remove, and the natural process of replacement and purification can literally take decades. Third, groundwater pollution is especially troublesome, because many communities rely entirely on groundwater for their agricultural and drinking water supplies. Methods of data collection and analysis are similar to those identified for surface water, except where soils are saline. Remote sensing can provide helpful information on severely salt-affected soils.

5.2.4 Frequency and Magnitude of Flooding

The indicator for helping to determine the frequency and magnitude of flooding in an area is determined by examining historical records of flood frequency and magnitudes of damage, and comparing remote sensing aerial photographs and satellite imagery taken periodically. This indicator is especially useful for evaluating the effectiveness of upstream control structures, planting and other conservation programs in watershed areas, and area zoning regulations.

5.2.5 Irrigation System Efficiency

The indicator for assessing the efficiency of irrigation systems measures both the conveyance efficiency and the on-farm use efficiency of irrigation water. The former is expressed as a ratio, determined by comparing the volume of water drawn from a stream, aquifer, or impoundment with the volume of water actually reaching the farm; the latter is expressed as a ratio, determined by comparing the volume of water stored in the soil and used by the crop with the volume of water entering minus the volume of water leaving the farm holding. This indicator is useful in evaluating water conservation programs and determining whether changes are necessary in farm practices or physical infrastructures. The data required to calculate this indicator include volume of water delivered on site, volume of tailwater or return flow to canals and streams, water evaporation, and plant transpiration.

5.3 Indicators for Assessing Impacts on Plants

5.3.1 Status of Rangelands

The indicator for determining the condition of rangelands measures the carrying capacity (forage supply) of range vegetation. Forage supplies can be estimated using data on the kinds and number of existing plants compared with the climax vegetation of undistured lands in the area. In addition, information is needed about the extent of recent plowing of soils, occurrences of soil degradation and other evidence of desertification (such as appearances of certain weed plant species), and outbreaks of insect plagues and plant diseases. The required data may be collected from on-site surveys and secondary sources. Remote sensing, using low-flying aircraft or satellite imagery, can also provide useful data. Information can be easily and inexpensively collected on site by trained rangeland scientist.

5.3.2 Status of Forestlands

The indicator for evaluating the status of forestlands assesses the condition of forestlands and their suitability for commercial forestry, agroforestry, and fuelwood supply and measures the rates of deforestation, a condition that can lead to environmental degradation. The indicator requires information on the kinds and quantities of woody species and their suitability for different uses, the extent to which forests are being converted to cropland and other uses, reforestation rates, and types of habitat available. The required data can be collected by experienced foresters who cruise forest stands to estimate the number, volume, and condition of forest species. In addition, interviews with government officials, public agencies overseeing harvesting and reforestation activities, and local users of fuelwood are usually necessary. Remote sensing is also useful in determining sizes of forest areas, land-use trends, insect and fire damage, and the location and size of reforested areas. Of special concern is the high rate of massive deforestation in some areas, which ultimately increases the earth's temperature by releasing more carbon dioxide into the upper atmosphere (the "greenhouse effect").

5.3.3 Status of Wetlands

The indicator for evaluating the status of wetlands assesses the condition of wetlands and their suitability in providing breeding and forage habitat for a wide range of animal and plant species. Wetlands are being lost to projects that drain and fill in areas for agricultural and urban uses. Considering the high natural productivity of these ecological systems, it is important to monitor changes in the status of the wetlands and enforce conservation programs. Primary data from on-site surveys are needed to carry out specific and exact determinations of the condition of such lands. Secondary data may be available from national and local public agencies. Remote sensing is useful for determining the size of an area, land-use trends, and the extent of insect damage.

5.4 Sources of Data

Participants agreed that a lack of baseline data and information represents one of the most critical problems facing evaluators attempting to examine impacts on the natural resource base and the quality of the environment. Environmental changes are produced by an ongoing interplay of a broad range of physical, biological, social, and political factors. Therefore, an assessment of impacts requires substantial baseline information and an understanding of a complex set of natural and social conditions and processes that link project interventions with the changes and trends in the natural resource base. However, there is very little information about such variables, especially in countries where the problems of environmental degradation are most severe.

Participants stressed the need to prepare comprehensive resource inventories at the local, national, regional, and global levels. Depending on the level of analysis, different sets of information are required for different types of inventories if they are to be useful to policy planners and program managers.

Local inventories must be reasonably comprehensive, or their utility in project and program settings will be limited. Inventories provide baseline data on the current status of the natural resources and of the environment and, when carried out at regular intervals, they provide information about trends and impacts. Participants referred to national resource inventories carried out in the United States for the years l977, 1982, and l987 in which over 20 natural resource features and characteristics were included. However, all agreed that given the magnitude of the task involved, such accomplishments in developing countries will be gradual.

Several participants referred to advances made in remote-sensing techniques that have revolutionized the data-collection process. Two types of techniques most commonly used are satellite imagery recorded by LANDSAT and other earth-observing satellites, and visible and visible and infrared aerial photographs recorded by light, low-flying planes or high-altitude aircraft. Images created by remote sensing vary according to scale and type of information presented. Remote-sensing techniques drastically reduce the time required for and costs of data collection. Participants also mentioned that the technology is rapidly advancing and sophisticated computer models are being developed to precisely analyze the information gathered. However, participants stressed that the data gathered through remote-sensing techniques will have to be complemented by on-site studies.

5.5 Proxy Indicators

Participants repeatedly stressed the need for developing proxy indicators that could measure impacts on natural resources. They emphasized that given the lack of baseline information, high costs of data collection, and long time periods required, the Agency must, in part, depend on proxy indicators to provide useful information for policymakers. Such indicators can be developed with reference to local conditions and project requirements.

By way of illustration, participants suggested that in an area that is becoming deforested because land is being converted to pasture, changes in the number of individuals or firms applying for forest land titles can be used as a proxy indicator of increasing or decreasing rates of deforestation. In this case, fluctuations in the fuelwood prices can also indicate variations in wood availability, and inferences then can be made about the variations in the rate of deforestation.

Participants mentioned three requirements for the use of proxy indicators. First, the relationship between a proxy indicator and the status of a particular natural resource component should be reasonably clear and unambiguous. Second, one should select geographical areas of limited size to ensure that natural resource trends and factors affecting them are relatively uniform and homogeneous. Third, the validity of a particular indicator should be tested at appropriate intervals to examine whether the hypothesized relationship between cause and effect is still relevant and strong.

Several participants suggested that input and output (performance) indicators can also be used to infer probable impacts on the natural resource base. For example, A.I.D.'s Africa Bureau has identified several activity-level indicators that may prove to be relevant and practical. Examples include the number of natural resource activities funded by the Agency, the number of host country nationals trained as natural resource technical specialists, the number of natural habitat buffer zones established, and the number of suggested policy changes adopted and implemented by host governments. Although such indirect indicators do not measure impacts, they can provide investigators with information about ongoing activities that may produce the desired changes. Participants cautioned, however, that such performance indicators alone are not sufficient and that they should be supplemented by impact indicators identified in this report.

5.6 Incorporating Socioeconomic Dimensions

Participants also stressed that impacts on natural resources cnnot be analyzed simply in terms of physical and biological variables. Social and cultural aspects that influence human behavior should also be examined. After all, ultimately, it is people who work the soil, use the water resources, and cultivate plants.

It is important to link changes in land use and resulting impacts on soils, water, and plants with changes in farming practices, land rights and obligations, customs governing the use of forests and wildlife, government policies and their enforcement, macroeconomic conditions, and public awareness of natural resource management issues. For example, product market values and access to new markets should be evaluated along with physical resource indicators to fully understand the economics of changing land-use patterns and to weigh trade-offs between acceptable levels of resource and environmental degradation and complete preservation.

Finally, participants agreed that qualitative studies and investigations should be used to understand various social and cultural dimensions in different situations. Thus, physical indicator data should be supplemented with insightful qualitative studies to provide a better understanding of impacts on the natural resource base associated with development projects.