Appendix F

Summary of Selected Systems Analysis Procedures for
Incorporating Environmental Considerations in Development Assistance

Introduction:

Although a number of systems analysis procedures have been suggested for formal inclusion of environmental analyses in project design and development, few have been systematically used by development assistance organizations. The most commonly applied procedure is simply supplying environmental guidelines and checklists to project design teams and managers. While helpful, these guidelines and checklists leave little room for institutional learning, and provide neither assistance nor encouragement for interdisciplinary analysis or local participation in planning. Further, these techniques rely wholly on the knowledge, interest and creativity of the project manager or designer to adapt them to each project, and do not provide for continued monitoring of the development activity:

> Certainly, development professionals need net be told that there is no secret, no checklist, no single approach that triggers the development process and sustains its momentum. They know that even the best-laid development plans are fragile, temporary structures vulnerable to constantly changing conditions [7].

Checklists and guidelines may proliferate beyond the capabilities of even the most dedicated manager.

Therefore, procedures are being developed by numerous groups to encourage formal and systematic consideration of environmental and other impacts in project design. Each of these methods is based upon interdisciplinary communication and analysis (and rely increasingly on local participation) to generate insights into the working of natural and social systems and to predict the probable impacts of alternative development activities. Experience has shown that the generation of these insights relies upon “organizing concepts and frameworks and a relatively formal working procedure which encourages and engineers cross-disciplinary exchange” [2]. The basic method underlying each procedure includes:

1. Identification of key interactions between a proposed development activity and the surrounding natural and socio-economic systems.

2. Prediction and estimation of the effects on natural system productivity and environmental quality.

3. Valuation and/or comparisons of the gains and losses sustained by natural, socio-economic, and human recipients of the impacts.

Five major technologies are:

Environmental Impact Assessment
Extended Benefit-Cost Analysis
Integrated Regional Development Planning
Integrated Planning Technology/System Dynamics
Agroecosystcm Analysis

The first two involve categorizing and valuing environmental impacts expected to occur from a proposed development project; the latter three depend upon systems analysis--a process of identifying all the important components of a system and determining how they interact to produce a set of behaviors [6]. While other techniques or subtechniques also are in use [cf: 5], these methods have been used by, developed by or their development was funded by development assistance organizations.

Environmental Impact Assessment

Environmental Impact Assessment (EIA) is, in theory, an overarching process in which systematic identification and assessment of alternative projects is undertaken. In practice, however, EIA refers to a process in which environmental analyses largely are kept separate from other analyses -- economic, social impact, and engineering -- and predicted environmental impacts commonly are valued on monetary scales to allow decision makers to identify trade-offs.

> EIA is a tool for predicting, assessing and estimating an economic value for the effects of a proposed action and its alternatives across a number of dimensions representing the main indicators of natural and socio-economic systems.... It also applies methods for determining the significance of individual and amalgamated effects and for estimating their value to permit selection of a preferred alternative [4].

AID often includes other measures in environmental impact statements, such as reliability or comparative evaluations of incidence (e.g., rates of incidence of a health impact).

Although methods vary, and sub-assessment may also be undertaken, EIA tends to follow a basic sequence of steps:

- Define the development objective and the key constraints to its achievement.
- Identify the alternative options for achieving it.
- Identify key linkages of development with natural resources, socio-economic systems, and other development activities.
- Determine the need for EIA on the basis of evident implications for or uncertainties about the impacts on natural system productivity and environmental quality.
- Scope the assessment, if needed, so that analysis and presentation of results focuses on the most prominent and potentially harmful problems.
- Assemble baseline data.
- Analyze the proposed development activity to identify resource demand and outputs and the effects on natural systems productivity and environmental quality.
- Predict the magnitude and severity of the effects.
- Assess the significance, distribution, and permanence of predicted effects.
- Determine the monetary equivalents of real resource costs and benefits associated with development and incorporate these values into the overall economic evaluation of the development.

- Propose realistic cost-effective measures for mitigating and managing the environmental effects.

- Establish mechanisms for monitoring and controlling environmental problems during the life of the project.

Extended Benefit-Cost Analysis

Benefit-cost analysis (BCA) is a complex, largely theoretical attempt to incorporate environmental considerations directly within economic analysis, and commonly is applied in EIA. While BCA has been used and developed by a number of groups, the Asian Development Bank (ADB) has sponsored (and AID has supported) its development by the East-West Center in Hawaii. Because the ADB has accepted the objective of maximizing the economic efficiency of Bank projects, the goal of developing extended BCA is to include "explicit economic measure of environmental impacts through the identification and prediction of development project impacts on environmental and natural resource conditions, quantification of direct and indirect impacts, and monetization of these impacts" [3].

While economic analysis techniques are well-developed, the methods for measuring and valuing the economic value of environmental impacts remain largely theoretical. A number of measurement and valuation techniques have been developed, including those that use the market value of directly related goods and services (changes in productivity, loss of earnings, and opportunity costs), those that use the value of direct expenditures (cost-effectiveness analysis; preventive expenditures), those that use surrogate-market values (property or other land value, wage differential, and travel cost approaches) and those that use the magnitude of potential expenditures (replacement costs, relocation costs, and shadow-project approaches). While the final product is a number--a benefit to cost ratio--the primary value of BCA is found within its analysis and (sometimes qualitative) comparison of impacts.

Interated Regional Development Planning

This technology, developed by the Organization of American States (OAS) is based on the concept that negative environmental impacts are a manifestation of the "conflicts created by the activities of one development sector inhibiting or negating the activities of another development sector" [9] such that spatial, temporal, and sectoral integration of the development process is needed rather than simply a trade-off between project costs and benefits. Most adverse environmental impacts can be considered as conflicts between interest groups which commonly can be associated with existing public agencies. While "maintaining its conviction that an area's natural resource base is a major determinant of its development potential," [7] the focus is expanded to include the collection and analysis of regional economic and social data.

The goal of integrated regional development is to organize a number of discrete development projects in a piece of landscape into a unified development strategy. Thus, the purpose of Integrated Regional Development Planning (IDRP) studies is to formulate ideas for projects and programs that are compatible with one another as well as with the needs, cultures, and economics of the affected populations.

The underlying precept incorporated in this technology is that, if environmental relationships ("the environmental dimension") are considered early in the planning process, sectoral conflicts can be identified and minimized, thus obviating the need for costly environmental impact statements [7]. If environmental quality is defined as the degree to which a given environment provides the goods and services required to satisfy the needs and wants of individuals and interest groups who depend on that environment, a development activity can be defined as an effort made to improve environmental quality. This can be achieved through the use, enhancement or conservation of goods and services and through the mitigation of hazardous events [8]. Conversely, adverse environmental impacts are the en forcead non-use of a region's goods and services, the impoverishment or destruction of those goods and services, or the intensification of hazardous phenomena.

Conflict commonly arises because "the development activities of one sector have changed the mix of goods and services available from a system shared with other interest groups or they have become competitive with another sector using the same goods and services." It is a fundamental assumption of IRDP that "only the parties that are involved in the conflict can provide a satisfactory solution to that conflict" [8]. Major components of IRDP, then, are multisectoral systems analysis and conflict resolution.

Any regional system can be considered to have three main subsystems: (1) **a** physical subsystem composed of natural resources and infrastructure; (2) an activity subsystem composed of social and economic components; and (3) a regulating subsystem of institutions and technology. The major steps of the environmental analyses can be identified as:

1) classification and description of the region's major ecosystems;
2) examination of the goods and services available from these ecosystems (including consideration of economic, social or cultural values; scientific and future development option values; and key component of ecosystem functioning values);
3) review and selected evaluation of existing development proposals;
4) identification of the most likely types of development;
5) identification of the conflicts that would result from implementation of each proposal; and
6) notification of the interests involved in identified conflicts.

Major tasks of the IRDP studies are institution building and technology transfer. The regional development studies are performed jointly by technical experts and national counterparts, providing a mechanism for on-the-job training and helping to mobilize local participation. This improves the likelihood that the study's recommendations will be implemented. The studies commonly take from two to four years to complete and cost anywhere from US $350,000 to U$l,000,000 [7]. The final products are usually a detailed five- to ten-year regional development strategy and a package of interrelated development projects within a proposed action plan.

Integrated Planning Technology

Integrated Planning Technology (IPT), founded on a computer-based systems analysis paradigm, is being developed by AID and International Institute for Environment and Development (IIED) and tested as a method to help guide the AID Office of Forestry, Environment, and Natural Resources' research planning. Previous demonstrations of the technology have identified potential uses of this technology in USAID'S development program planning and implementation cycle:

> There are several levels... where systems analysis could be applied: where demonstrations of linkages among sectors, cause and effect, and scenario simulation might be of most benefit. Three levels where systems amalysis might be most useful are (1) at the CDSS policy and strategy planning step, (2) at the PID project-level design stage; and (3) mid-term evaluation [6].

IPT's basic assumption is that, in addition to the need for multidisciplinary analyses, human understanding of large systems is limited by an inability to consider more than a few variables or relationships between variables at a time [6]. Because of this inability to think through the complex linkages of a large systems, such as are common in biophysical, economic or regional systems, connections are overlooked that, in implementation, result in unintended or “count erintuitive” impacts.

In order to make the relationships between variables explicit, the IPT approach features a several day workshop that draws together the knowledge of a multidisciplinary team of experts whose role is to identify the ecological, economic and social variables that together make up the system in question and to examine the interconnections between them. In this way, a graphic picture (called a causal loop diagram) is incrementally constructed illustrating the inner workings of the system. During this process, assumptions are made explicit and data and knowledge gaps are identified. This process often is more useful than the model itself, in that it aids the specialists to gain insight into the workings of the system and the interrelations of each specialist’s knowledge with others [6].

Further discussions or analyses identify more specific information about the relationships between each set of variables (e.g., magnitude of response or length of time delays). Each of these relationships can be quantified to form the mathematical basis of a computer simulation of the system. Once quantified, the model must be tested to determine if its behavior matches the known behavior of the system, and further refined or reconstructed if it does not. Once it has been recogized as a valid representation of the system, the model can be run with changes in variables identified as amenable to policy manipulation. The effects of these changes on other variables can be compared to expand the mental models of the participants, and to help predict the impacts of various development options. Thus, IPT provides “a simulated policy-testing environment which is more informative than common subjective methods and less expensive or dangerous than trial and error in the field” [1].

It should be emphasized that the model does not and is not intended to provide “the answer,” but only to provide a structure through which ideas can be tested and alternate scenarios explored [6]. Further, although IPT analyses may be fastened upon by planners who have long been looking for an integrated and quantitative decision tool, it’s use still requires sound human judge merit, and other benefits may be even more useful:

1) it encourages and even required cross-field collaboration between experts;
2) it enhances understanding of the system and the needs of colleagues; and
3) the systems includes retrievable data, allowing ready updating or expansion (“a living source of updated information which at any moment will give an environmental profile for status and trends in specific resource areas” [1]).

<u>Agroecosytem Analysis</u>

Agroecosystem analysis also in in an experimental stage. AID has supported its application through case studies in the Philippines and Thailand.

In this form of analysis, an agroecosystem (a natural ecosystem simplified and manipulated for the purpose of food or fiber production) is determined to be a basic system underlying rural development in developing countries. Agroecosystem analysis, then, is the interdisciplinary analysis of agroecosystems aimed at producing agreed upon programs of research or development. A multidisciplinary team is needed because each individual has, “necessarily, a narrow perspective restricted to only one geographic part of the agroecosystem or to only one aspect of its behavior” [2]. The major steps of agroecosystem analysis are definition of the agroecosystem, analysis of its patterns and discussion of its properties.

While the agroccosystem of interest may be readily identified, each is actually one of a large number of agroecosystems that are arranged in a nested hierarchy. For example, a farm is an agroecosystem, but it is a subsystem of an area of landscape, which is situated in a watershed that 1 ies with in a particular ecological region, that is governed by the policies of a nation, etc. Systems higher in the hierarchy tend to control those beneath them, thus each level must be considered in the analysis.

Agroecosystems are characterized by four interconnected properties. Productivity, defined as the net output of valued product per unit of resource input (in which resources are land, labor, capital, energy or technological inputs), is the property of most obvious value to humans. [If there is no resource introduced to the system, valued products may still be produced, but the ecosystem in not properly then an agroecosystem.] Stabilitv, or "the constancy of productivity in the face of small disturbances caused by the normal fluctuations of the surrounding environ merit," can be measured in terms of changes in productivity over time. The third property, sustainability, refers here to the resilience of the system's productivity i n the event of a major disturbance. Finally, equitability measures the "evenness of distribution of the productivity among the human beneficiaries." Thus, development of an agroecosystem can be seen as a series of major changes in agroecosystem properties [2].

The key functional relationships that determine a system's properties are spatial relationships; temporal relationships dynamic flows of materials; energy, information, etc.; and decisions. The first three are important to understanding the ecological functions of ecosystems, and the fourth reflects the processes of human management. These "patterns" can be depicted in maps, graphs and simple flow diagrams.

During the entire procedure of defining the system, analyzing its patterns and discussing its properties, questions, working hypotheses and management guidelines are expressed by the participants. Evaluation of the questions and working hypotheses can uncover areas where further data collection and/or research are needed. Guidelines and working hypotheses differ only in expression of certainty: while guidelines are based on well-established knowledge derived from experience in the area or elsewhere, working hypotheses reflect greater uncertainty and need to be tested. Further, contained with the guidelines and hypotheses are a number of proposed innovations in management of the system. Evaluation of these proposed innovations for their impact on the system's properties, cost, time horizon of benefits and technical and operational feasibility allows them to be ranked to assign priorities for action.

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