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A RELATIONAL ARCHIVE FOR NATURAL RESOURCES GOVERNANCE AND MANAGEMENT

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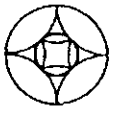

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Abstract

Colleagues at the Workshop in Political Theory and Policy Analysis at Indiana University, with input by researchers from many different universities, research centers, forest users, donors, national governments, and international agencies, have developed the International Forestry Resources and Institutions (IFRI) research program in order to provide an empirical base for systematic analysis of data at the local level on:

- How institutions affect the incentives facing forest users (e.g., forest dwellers, timber corporations, transhumant populations);
- How these incentives encourage forest users to engage in sustainable development or destructive use of forests;
- How forest users establish their own effective governance arrangements or continue to pursue independent strategies; and
- How forest users are affected by government-driven development activities and policies?

IFRI researchers will compile information about the physical world--the forest--and the institutional world--the community attributes and the rules for harvesting forest products and for making decisions about harvesting practices and rules.

The development of this archive for natural resources governance and management is based on the Institutional Analysis and Development (IAD) framework. Colleagues at the Workshop have developed the IAD framework over the past decade. The IAD framework is a method for identifying and analyzing how attributes of a physical world interact with those of the general cultural setting and the specific rules-in-use to affect the incentives facing individuals in particular situations and the likely outcomes to result. Past Workshop research projects have applied this methodology in developing a database on common-pool resources (particularly irrigation systems and in-shore fisheries) located in different regions of the world.

A RELATIONAL ARCHIVE FOR NATURAL RESOURCES GOVERNANCE AND MANAGEMENT

Background

A central puzzle underlying the work described in this paper is why it is that some forests around the world are disappearing at the reported overall rate of 17 million hectares per year, while other forests are being maintained in a sustainable manner. As forests diminish globally from many causes including lumber and firewood extraction, agricultural clearing, construction projects, and animal foraging, so do the indirect products of shade, soil fertility, water supply, clean air, and genetic diversity of flora and fauna. Trees, such as Pygaeum in Cameroon, for example, provide natural derivatives for treating prostate cancer. As these trees are quickly harvested for medicine and firewood, extinction is becoming a reality, as is the loss of a natural sources of treatment for cancer. Watersheds depleted by increased deforestation in Ethiopia, India, Pakistan, and numerous other countries threaten life-giving supplies of water and agricultural subsistence.

The United Nations Conference on the Environment and Development in Rio de Janeiro and the negotiation of international conventions and treaties on global warming and bio-diversity suggest a willingness to begin taking global environmental problems seriously (Brown, 1992). Yet defining a global strategy on forest sustainability is by no means sufficient for dealing with those problem. Not only is such an approach plagued with the difficulties of reaching global consensus, but it also neglects the reality that forest use, governance, and management *is inherently local.*

Forests are often common-pool resources,[2] the sustainable uses of which entail intricate relationships between village groups and local institutions; between individuals and the laws that govern the forest; and between governments and villages. Under these circumstances, dumping vast sums of money on a global scale into technological fixes, without understanding complex interrelationships on the local level, is unlikely to work. Past efforts of applying large-scale solutions

to forest conservation provide many examples of misplaced time, energy, and funds (Dixon and Sherman, 1990). Conservation efforts that have tried to move entire indigenous forest populations outside of a forest zone in order to maintain a pristine, biodiverse forest have frequently led to: (1) overdevelopment of the outer fringe of forest regions without sustained regeneration of the internal forest, (2) high levels of conflict, and (3) destruction of local economies and ways of life (Gómez-Pompa and Kaus, 1992). Wholesale privatization often weakens community management of forested areas and increases levels of resource extraction (Arnold, 1992). Plantation economies tend to rely on monocultural agriculture or agroforestry rather than biodiverse ecologies. State policing mechanisms have proven to be costly, vulnerable to corruption, and difficult to monitor, as well. Forest size and remote locations make it difficult to enforce regulations consistently and equitably.

Understanding how individuals and groups govern local forests, grazing areas, or village nurseries thus becomes crucial to understanding how to solve problems confronting the globe. Tucked away in towns and villages around the world are lessons of successful, traditional methods of governing forests as commons. In the Brazilian Amazon, for example, the Kaypa belief system and ecological management revolves around maintaining an energy balance between the natural and spiritual world by regulating animal and plant use through ritual and custom (Gómez-Pompa and Kaus, 1992). In Uttar Pradesh, India, studied by Agrawal (1992), villagers design their own rules for measuring and withdrawing fodder from forests through a complex means of assessing fodder availability, fixing extraction levels, and ensuring compliance through collective monitoring and sanctioning activities. In South Turkana, Kenya, the Ngisonyka, according to Ellis (1984), have developed a pastoral lifestyle consistent with the local ecosystem. They raise livestock which graze on shrubs of little use to others, and live on a diet of milk products which require no cooking in wet season, reducing the demand for firewood.

How is it that these groups jointly protect a forested commons in an interdependent fashion? What are their traditional methods of conservation, and how are they passed on from generation to generation? Can these traditional methods be sustained? How have they managed to govern themselves to obtain continuing joint benefits when facing temptations to free ride, shirk, or otherwise act out Garrett Hardin's (1968; but, see Feeny, et al., 1990) tragedy of the commons? Did they use these methods before they faced a crisis? Could they have? In what legal context do these methods work?

To answer some of these questions, the Workshop in Political Theory and Policy Analysis (the Workshop) at Indiana University, with funding from the Food and Agriculture Organization of the United Nations, United States Agency for International Development, the National Science Foundation, and Indiana University, is developing an International Forestry Resources and Institutions (IFRI) research program to provide an opportunity for sustained observation and systematic analysis of forest resources. The research program will address the complexity of forest ecologies--including the diversity of forest products, of users, and of consumptive and nonconsumptive uses of forest products--and the complexity of structures governing their use. It will be provide a unique linkage between social and natural science contributions to understanding forests.

The linkage is accomplished by using the Institutional Analysis and Development (IAD) framework as a departure point for the design of the overall research program. The IAD framework has been developed and used by colleagues associated with the Workshop over the past decade (Kiser and E. Ostrom, 1982; Oakerson, 1992; E. Ostrom, 1986; E. Ostrom, Gardner, and Walker, 1993; V. Ostrom, 1991; V. Ostrom, Feeny, and Picht, 1988; Thomson, 1992). The IAD framework is an evolving method for identifying and analyzing how attributes of a physical world interact with those of the general cultural setting and the specific rules-in-use to affect the incentives facing individuals in particular situations and the likely outcomes to result. Past Workshop research projects have applied

this methodology in developing a database on common-pool resources (particularly irrigation systems and in-shore fisheries) located in different regions of the world (Tang, 1991, 1992; Schlager, 1990; Schlager and E. Ostrom, 1992; E. Ostrom, Benjamin, and Shivakoti, 1992). The IAD framework links the characteristics of the physical world (forests) with those of the general cultural setting (the villages and harvesters that use forests), the specific rules that affect the incentives individuals face in particular situations (how forest products can be harvested, utilized, and maintained), the outcomes of these interactions (regeneration or deforestation), and the evaluative criteria applied to these patterns and outcomes (efficiency, equity, sustainability).

The IFRI database will provide an empirical foundation for systematic data analysis about:

- How institutions affect the incentives facing forest users (forest dwellers, timber corporations, transhumant populations, etc.);
- How these incentives encourage forest users to engage in sustainable development or destructive use of forests;
- How forest users establish their own effective governance arrangements or continue to pursue independent strategies; and
- How forest users are affected by government-driven development activities and policies?

Based on past theoretical and empirical work on natural resource governance and management, the database will assist in explaining and predicting the types of institutional arrangements that are most likely to lead to the establishment of sustainable forest systems in diverse ecological settings. Regional and national forests will also be included in the database so that factors associated with the success of large-scale institutions can be identified.

Hypotheses

Data collected for the IFRI database will then be used by researchers who initially collect the data and other collaborating IFRI Research Centers to test a broad series of preliminary hypotheses

derived from past theoretical and empirical work. The initial working hypotheses used in designing the database are that *sustainable forest systems are more likely to result where*:

- Local forest users participate in and have continuing authority to design the institutions that govern the use of a forest system.
- The individuals most affected by the rules that govern the day-to-day use of a forest system are included in the group that can modify these rules.
- The institutions that govern a forest system minimize opportunities for free riding, rent seeking and corruption, through effective procedures for monitoring the behavior of forest users and officials.[3]
- Forest users who violate rules governing the day-to-day uses of a forest system are likely to receive graduated sanctions from other users, from officials accountable to these users, or both.
- Rapid access is available to low-cost arenas to resolve conflict between users or between users and their officials.
- Monitoring, sanctioning, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.
- The institutions that govern a forest system have been stable for a long period and are understood by forest users.
- Population pressure in the surrounding area is low.
- The rate of population growth is low.
- Markets for forest products are relatively distant.[4]

Given the detailed nature of the information to be included in the database, it will be possible to analyze many questions not originally posed as part of the initial development process. Applied researchers and scholars located at collaborating IFRI Research Centers will be able to utilize the database to approach the tasks of analyzing community forestry activities, designing and evaluating community forestry projects and operations, and supporting indigenous community forestry efforts with a firmer knowledge base. It will also enable practitioners to analyze community forestry activity design principles, improving the efficiency of technical and institutional assistance efforts in the community forestry sector.

The Institutional Analysis and Development Framework

The development of the IFRI research program has drawn on and contributed to the Institutional Analysis and Development (IAD) framework. As shown in Figure 1, analysis of human actions and consequences, frequently starts with a focal arena. Examples include situations where individuals decide when and how much to harvest of forest products from different locations, whether to establish a forest users association, or whether to fence off a particular part of a forest to prevent animals from foraging within. What arena is analyzed depends on the questions of interest to the analyst. The analyst wanting to examine recurrent structures of situations must, however, find ways of separating one situation from another for the purpose of analysis. Further, individuals who participate in many situations must also know the difference among them. The actions that can be taken in harvesting timber are different than those that can be taken in harvesting thatch or those that are involved in selling either timber or thatch. An individual who is repeatedly mixed up about what situation he or she is in, is normally not considered to be competent to take independent actions.

What is distinctive about the IAD framework, when contrasted to many frameworks that are closely tied to a single scientific discipline, is that all situations are views as being composed of the same set of elements. Thus, while harvesting or marketing timber or thatch differ in many important ways, these diverse situations can all be described by identifying and analyzing how particular elements constituting the situations under analysis lead to the patterns observed. These elements include identifying:

- Who are the participants?
- What are the positions they hold?
- What actions can they take?
- What information do they possess?
- What outcomes can occur?

- How are actions and outcomes linked?
- What benefits and costs are assigned to actions and outcomes?

These elements are themselves relatively complex. Many different action situations can be constructed from them. At the same time that the IAD framework stresses a universality of working parts, it enables analysts to examine unique combinations of these parts. The array of potential outcomes that can be analyzed and evaluative criteria, such as equity, efficiency, sustainability, and adaptability, is also very large. Further, these elements are themselves constituted by a deeper layer of attributes about a physical and material setting, the community within which a situation occurs, and the specific rules-in-use that affect the structure of the situation (see Figure 2).

Action situations are perceived to be nested within at least three relevant tiers of action. *Operational level actions* occur whenever individuals are directly affecting variables in the world by doing such things as harvesting products, worshipping at a forest shrine, planting seeds, building fences, patrolling the borders of a forest, or feeding leaves to their animals. *Collective choice actions* occur whenever individuals are making decisions about operational activities. Thus, the actions taken at an annual meeting of a forest user group association to keep a forest closed for the harvesting of a particular product except for a specified time, is a collective choice action. *Constitutional choice actions* occur whenever individuals are making decisions about how collective choice actions will be made. Consequently, the decision of a forest user group association to create an executive committee that will meet once a month to make decisions about joint activities to be undertaken is a constitutional choice action. Constitutional choices are made frequently without recognition that they are indeed creating a future structure to make future rules about an operational level.

For illustration purposes, we have taken a typical *operational* level situation--that related to harvesting forest products--and indicated in Figure 3 the types of variables related to that action situation in the IFRI database. The three most important products harvested by a group of forest

users is recorded for each group. For the most important product harvested by a group, for example, we will also record the number of harvesters involved and the positions that they hold, the information that they have about forest and market conditions, the allowable harvesting strategies they face and the relative cost of different strategies, the value of the forest product to them, the severity of the punishments they face for breaking harvesting rules (if any), and the likelihood that rule infractions would be observed and punished (see Figure 3). Among the outcomes that are recorded are the quantity and total value of the product harvest, the effect of harvesting effort on the forest ecology, and the extent to which rules are followed. These are evaluated in the coding forms using criteria such as equity of distribution, efficiency, sustainability of the forest, the biodiversity of the forest, and the adaptability of a rules system over time. The underlying physical variables recorded include the density of the forest product (in a sample of forest plots), the length of time during which the forest product is available, and the technologies in use. We also record the size and homogeneity of the residents of nearby settlements, how similar or different their belief systems, the population distribution in space and time, and the isolation or integration of the settlements into a larger economy and polity. Many variables are recorded about the rules-in-use including the presence of restrictions on harvest practices by time, location, quantity, technology, or quality. Since there are many typical action situations that users face it is somewhat understandable that the coding forms developed for the IFRI project are relatively extensive.

International Forestry Resources and Institutions Database

Description

Information entered in the IFRI database will be collected by individual researchers and research centers with whom prior collaborative arrangements have been established using a series of data collection forms that have been widely reviewed and pretested in Bolivia, Mali, Nepal, and Uganda.[5]

The International Forestry Resources and Institutions coding manual, composed of ten separate coding forms facilitates systematic recording of data collected from field visits lasting between two and four weeks per site (depending on size and complexity). Both quantitative and qualitative data will be recorded. Provisions for narrative paragraphs to be entered as text fields will supplement and provide context for variables coded using nominal, ordinal, or cardinal measures.

The coding forms are titled: *Site Overview Form, Forest Form, Forest Plot Form, Settlement Form, User Group Form, Forest User Group Relationship Form, Forest Products Form, Forest Association Form, Governance Form,* and *Organizational Inventory and Interorganizational Arrangements Form.* Data about the universal elements of the IAD framework are spread across multiple forms. Data for variables that relate to the physical and material world are contained in the *Forest Form* and the *Forest Plot Form;* data for variables related to the attributes of a community are contained in the *Settlement Form* and the *User Group Form;* data for variables related to rules-in-use are contained in the *Forest Form,* the *Forest Products Form,* the *Forest Association Form,* the *Governance Form,* and the *Organizational Inventory and Inter-organizational Arrangements Form;* data for variables related to a forestry action situation are contained in the *User Group Form* and the *Forest Association Form;* data related to patterns of interaction are contained in the *User Group Form, Forest Association Form, Forest User Group Relationship Form, Forest Products Form,* the *Organizational Inventory and Interorganizational Arrangements Form,* and the *Governance Form;* and data related to outcomes and evaluative criteria are contained in all of the forms.

The coding forms are generally mapped to the database as single tables or master table/detail table(s) sets. The separate forms represent either distinct entities or many-to-many relationships between the entities.[6] The conceptual schema of the IFRI database is shown in Figure 4, and readers may want to examine it as each form is discussed.

Questions about the history of "entity" (e.g., the forest, the settlement, the user group, etc.) designed to gather baseline information such as a general description, reason for being, age, and major historical changes are found at the beginning of most coding forms. In general, these questions are asked and recorded on the first field visit and then stored in separate history tables. On second and subsequent visits, changes that have occurred since the last visit will be recorded. Thus, the historical development of a forest and the institutional setting in which a forest is embedded will be an important component of the IFRI database.

The *Site Overview Form* (Site Overview on Figure 4) will be completed for each research site and provides a general overview of the configuration of each site. A site overview map will be drawn which includes major physical features of the area including whether there is one or more distinct forests and/or settlements in the site and how they are laid out in relationship to one another. Further general information about the site that is relevant to all of the other forms will be completed including local wage rates, local units of measurement used in relationship to forest products, the exchange rate for local currency. Information about the diverse individuals with whom in-depth discussions were held and procedures followed in a particular site will be documented on this form.

The *Forest Form* (Forest on Figure 4) defines a forest as a surface area with woody vegetation of at least .5 hectares, exploited by at least 3 households, with a similar legal structure. The size, ownership, internal differentiation within the forest, forest products harvested, and uses made of organic and inorganic forest products are recorded in this form. Changes in density of trees, grasses or ground cover, and changes in forest area will be recorded here. Questions in this form identify rules related to entry rule, rules for maintaining and monitoring the forest and penalties for breaking these rules. A forester's appraisal of the overall condition of the forest concludes the forest form.

The *Forest Plot Form* (Forest Plot on Figure 4) is used to collect information from a random sample of plots ranging in size from 3 to 10 meter radius. Within each plot, a count of the trees and

bushes will be recorded along with local and botanical names, and the circumference and estimated height of trees and scrubs located along two diagonals will measured. The proportion of a plot containing various species of ground cover will be coded. Evaluation of soil quality, problems of erosion, presence of livestock, and insect and pest damage will also be undertaken.

The *Settlement Form* (Settlement on Figure 4) identifies a settlement inhabited by one or more forest user groups. The settlement is located near one or more forests. The form elicits demographic information about the settlement, its relation to external markets and administrative centers, and the differentiation of settlement inhabitants. Questions about the climatic features, soil types, vegetation, topography, and elevation of the settlement and the surrounding area are asked in the settlement form.

A forest user group is defined as a group of people who harvest products from a forest and share the same customary and/or legal rights to products from the same forest(s). Forest user groups include forest dwellers, forest product harvesters, timber corporations, and transhumant populations. The *User Group Form* (User Group on Figure 4) identifies the size, social-economic status and related attributes of a user group. A variety of forest-related characteristics are collected about the user group including dependence on the forest; ownership, maintenance and management of livestock; and strategies used by the user group to maintain or improve the forest(s).

The *Forest User Group Relationship Form* (GrpToFor on Figure 4), gathers information about products harvested by the user group from a particular forest. It codes <u>all</u> forest products harvested from the forest and identifies the top three products in importance to the user group. Uses made to the forest products are listed and tagged if for household purposes, for commercial purposes, or for both household and commercial purposes.

The *Forest Products Form* (Products on Figure 4) records specific details for up to three of the top-ranked product harvested from a particular forest by the user group. It identifies the uses made of the product, temporal harvesting patterns of the forest product, alternative sources and substitutes

for the product, and tools and techniques used to harvest the product. The form also codes information about harvesting rules--when, how much, harvesting restrictions--and penalties imposed for breaking a harvesting rule.

Many forest groups have developed formal or informal organizations that frame rules and determine the activities of a group with respect to use of the forest(s). Federated forest associations may also exist, composed of two or more of these forest group organizations that work together to accomplish some joint activities and/or objectives with rules, policies, and guidelines. The *Forest Association Form* (Association on Figure 4) captures some of the institutional information required to analyze institutional arrangements for forestry governance and management at both the local and federated level. It records those activities the association has arranged, coordinated or adopted rules about; the governance and structure of the association; the general membership of the association; and the type of records maintained by the association or submitted to a higher authority. A matrix is used to extract the variety of forest-related decisions that are created and enforced by the association staff. Resource mobilization and account keeping, collective and constitution choice processes, and internal relations within the association are other categories of questions in the form.

The *Governance Form* (Governance on Figure 4) obtains information about any organization that makes rules about or influences the utilization of the forest (harvest, maintenance, forest guarding, etc.) but does not itself use or harvest from the forest. The organization could be a local or regional office of a national government ministry, a multi-national organization, private voluntary organization or non-government organization. This form identifies governance and structure, officials and functionaries, resource mobilization and account keeping and collective and constitutional choice process of the organization.

Information about the inter-relationships between all organizations, harvesting or non-harvesting that govern a particular forest (or cluster of forests) is gathered by the *Organizational Inventory and*

Interorganizational Arrangements Form. The first part of this form (OrgInven on Figure 4) inventories all organizations involved in harvest and governance activities and identifies the type of activity each organization undertakes with regard to a site--provision, production, harvesting and use, consuming and processing, or sale--and the level of activity, whether at the operational level, the collective choice level, or the constitutional choice level. The second part of this form (InterOrg on Figure 4) focuses on relationships among organizations and user groups and how potential conflicts are resolved in this site.

In addition to the substantive variables already included in each form, several variables will be left undefined on each form so that researchers at IFRI Collaborating Research Centers can add variables of particular local interest not included in the standard data collection forms. While a household survey is not contemplated as part of the regular data collection efforts in a site, the database will be designed so as to link household surveys that are conducted along with the other data collection to the full IFRI relational database.

The Structure of the IFRI Database

Relationships

The relationships contained in the IFRI database are dictated by the nature of the entities themselves: user groups are part of settlements; forest associations are formed by user groups; user groups utilize forests. Some relationships are so crucial to understanding the sustainable, productive use of a forest that a separate coding form is used to capture elements of the relationship. The *Forest Products Form* and the *Forest-User Group Relation to Forest Form* both capture information about how a particular user group relates to a particular forms.

The data collected as part of the IFRI research program is intended to include comparable cases from diverse forest situations in many different countries. In order to construct a database that will

accommodate a variety of forestry settings, most relationships have been modelled as many-to-many (M:N) relationships. For example, a settlement may contain more than one user group and a user group may live in more than one settlement. Likewise, residents in a settlement may use many forests and a forest may be used by residents of many settlements. The structure of the database must reflect all possibilities, rather than the generally expected situation. Relationships with M:N cardinality complicate the database by requiring the addition of linking tables but provide the necessary functionality demanded by the international scope of the IFRI database.

Temporal Elements

A major intent of the IFRI research program is to take a conceptual snapshot of a forest, the users of a forest, and the rules used to govern and manage a forest at different points in time. Changes in such matters as the sustainable, productive use of the forest and the type and amount of forest product harvested will be examined in conjunction with changes in harvest rules or forest association activities. The initial data collection will include data not expected to change over time. This static data is archived in one of the history tables--e.g., Settlement History, User Group History, Forest Association History, Forest History, Governance History--and will not be gathered in subsequent data collections.

Database Design

The database structure is relational in design. The entity tables, based on the individual IFRI coding forms, are represented by rectangles on the conceptual model (see Figure 4); relationship tables are represented by ovals. The cardinality of the tables--the relationships of table rows to other table rows--are identified as:

- M:N meaning many to many, (several user groups may use several forests);
- N:1 meaning many to one, (many organizations may be involved with one forest);
- 1:N meaning one to many, (one forest has many plots); and
- 1:1 meaning a one to one relationship (only one interorganizational relationship for each forest).

Neither table columns, corresponding to individual questions on the coding forms, nor detail tables, created by questions with multiple answers, are identified at this general level. The unique identifiers (table keys) used for maintaining the relationships between rows of data stored in separate tables will contain site identification numbers, country codes, research center identification numbers, and the date of the data collection effort.

Units of Analysis

Several units of analysis are incorporated within the IFRI database structure. The forest, using data collected in the *Forest Form* and data aggregated from the sample of plots recorded on the *Forest Plot Form*, the user group, and the forest association are three potential units of analysis. Research questions regarding the sustainable, productive use of a forest will depend on forest and forest plot data over time and forest product data over time. Changes over time in the way a user group relates to the forest in the type and amount of products harvested, in the uses made of forest products, in harvesting tools and techniques and in the methods used by group members to maintain or improve the forest should correspond to changes seen in the forest data.

Implementation of International Research Program

The field collection coding forms were completed at the end of April of 1993. We are now embarking on the second phase of this research program. During this phase we will develop formal collaborative relationships with research centers in different countries who have substantive interests

in policy research related to community forestry and sufficient technical capabilities to work with the IFRI database. An IFRI Collaborating Research Center could be an individual researcher; a research group associated with a university, a private association, or a government research laboratory; or a consortium of individuals and agencies that have agreed to work together to collect, analyze, and archive IFRI data in a particular country or specific region of the world. A second key aspect of this phase of the program is the development at the Workshop of a series of applications specifically designed to facilitate accurate data entry and checking as well as to increase the probability that researchers, who are already familiar with the use of computers in research but who are not computer scientists, can actively participate in this collaborative effort.

The IFRI database will eventually contain data collected about forests located in parts of the world where active researchers and/or research centers are located that wish to become IFRI Collaborating Research Centers and where funding is available for data collection and entry. The first data will be collected by a team headed by Dr. Arun Agrawal, Department of Political Science, University of Florida, for a sample of forests in Northeastern India and Bhutan. Agrawal has actively participated in all stages of the initial design of the IFRI database and data collection forms. He will translate the forms into Hindi during May of 1993. Data will be collected in the field during the summer of 1993, translated into English, and sent to the Workshop for data entry at the end of the summer of 1993. Once the initial development of an data entry application is completed and thoroughly tested, we envision data entry being undertaken close to the site of data collection rather than in Bloomington. But, the first data sets will be entered in Bloomington in order to test modules of the application and to provide a data set to Agrawal by early fall for his analysis.

During March of 1993, a series of meetings were held in Nepal with interested centers and projects and a decision was made to create a Nepal Forestry Resources and Institutions Database Consortium to be coordinated by Rajendra Shrestha, of the Agricultural and Forestry Development

Associates (AFORDA). Subcommittees have been established to design an appropriate sampling strategy for Nepal, to develop a household survey, to translate the forms and field manuals into Nepali, and to seek funding from diverse sources for data collection, entry, and analysis purposes. It is hoped that the first data will be collected in December of 1993.

Initial discussions have been initiated with potential IFRI Collaborating Research Centers in Uganda, Bolivia, Nepal, and Madagascar. Many aspects of establishing a network of IFRI Collaborating Research Centers must be worked out during the forthcoming year to insure that:

- researchers heading project research teams are thoroughly familiar with the conceptual foundations on which the IFRI database is built so that they can conduct in-depth training of foresters and social scientists to insure reliability across sites.

- adequate time is budgeted in proposals for extensive training of field workers, sufficient time in each site to insure collection of reliable and valid data, and adequate staffing for data entry and checking.

- translations of the IFRI data collection forms are made available to others who may eventually want to use the data from a particular country.

- researchers who contribute data to the international database have an assured period of time in which they have exclusive use of the data that they have collected, but after which the data will be shared with other Centers in the network.

To collect data systematically over a long period of time and maintain a high quality data archive will necessitate considerable coordination between IFRI Collaborating Research Centers and the Workshop. Researchers from an IFRI Collaborating Centers will collect new data on a sample of forests and related user groups, settlements, and institutions. They may also code previously collected data in the format used to store IFRI data. Once the data entering application is completed, data entry will be undertaken by staff of the Collaborating Center, will be archived there, and will be provided as part of the international database to the Workshop. In addition to maintaining the cumulative data archive, the Workshop's responsibilities--assuming adequate levels of funding are obtained--will include:

- providing the theoretical framework used as the underlying foundation in the IFRI database;
- supplying coding forms and additional coding documentation;
- providing database tables in a PC-based relational database management system;
- directing training workshops and developing training materials for field workers collecting data;
- producing a database application program that facilitates data entry and editing and produces initial reports;
- assisting with any necessary coordination of independent research projects collecting data for the IFRI database;
- consulting with researchers about hardware and software alternatives;
- furnishing digital or hard-copy data from previous data collection at the same site (e.g., forest names and identification numbers, settlement names and identification numbers, etc.);
- undertaking general theoretical and public policy directed analysis of data after it has been analyzed by researchers at the Collaborating Centers; and
- sharing with researchers at Collaborating Centers, IFRI data collected from one or more sites over multiple time periods for research purposes.

In addition, the Workshop will carefully check all incoming data before uploading it into the central archive database and insure that corrections of archived data occur in a systematic, well-documented way.

Hardware and Software Requirements

Decisions about the hardware and software platforms are based on the data sharing aspect of this multi-researcher project. Due to the decentralized nature of the IFRI project, a DOS personal computer has been selected as the hardware platform. Computers with fast processors, substantial memory and an abundance of storage are becoming less expensive in desktop and laptop models.

In order to collaborate effectively with the IFRI research program, a researcher or a collaborating research center will need:

- FoxPro 2.5 for DOS and DOS 5.0 (FoxPro 2.5 for Windows, DOS 5.0, and Windows 3.1 is an alternative), and
- 80486/33 Mhz computer with 8 MB RAM and a large hard drive.

Such a combination will provide ease of data entry, in the field or at the research center, facilitate data sharing, and ensure adequate speed and memory demanded for analysis of IFRI data. The IFRI data need not remain on a DOS-based computer. Importing the data to client-server databases on UNIX workstations or networked personal computers will expedite analysis and data modelling as the database grows in size.

IFRI GIS Applications

Why GIS?

In recent years, there has been a tremendous surge in the use of Geographic Information Systems (GIS) in natural resource management. A GIS is a collection of hardware and software that integrates computer graphics with a relational database for the purpose of managing data about geographic locations (Ripple, 1989).

The relational database described above linked to the graphical and analysis capabilities of a GIS, could enhance the IFRI researcher's analytical and communication capabilities. In a report on GIS use in Nepal, Schreier and Brown (1992) state that a GIS implemented on a portable system had a magnetic effect on the local administrators and individual farmers, and enhanced their understanding of the situation. For the researcher and the forest user alike, GIS will provide visual depictions of the current spatial relationships within and around the forest, and will graphically capture the changes of a forest (or forests) temporally. GIS' ability to analyze more than one forest over time will provide new methods to compare and analyze similarities and differences in forest use, forest group behavior, and the influence of natural resource governance structures.

The geographic depiction of governance structures (nonphysical attributes) surrounding the forest is one of the most interesting and unusual aspects of the IFRI GIS conception. GIS has been widely utilized in the natural resource arena for analysis of physical forest characteristics. Insect control (Van Sickle, 1991) and forest fire management (Wells and McKinsey, 1991) are just two of many examples. But few, if any natural resource GIS applications have explored the mapping of nonphysical yet spatially related natural resource attributes such as forest rules. Forest rules and the behavior of user groups in regard to such rules are crucial to the understanding of why changes in the physical aspects of the forest have occurred. This integration of physical and nonphysical forest characteristics makes the IFRI GIS application particularly unique.

The Conceptual Use of GIS within IFRI

It is important to note that the GIS portion of the IFRI project is in early stages of conceptualization. But even in these early stages, the implementation of GIS in the IFRI project clearly involves two distinct parts: a specific forest GIS ("IFRI regional GIS") and a forest comparison GIS ("IFRI comparison GIS").

The IFRI regional GIS will focus on one particular site, and would provide queries about this site. In addition to being able to geographically locate physical site attributes such as borders, locations of user groups, settlements and harvest areas, etc., many requirements can be linked to the general hypotheses described earlier in this paper. For example, a GIS could easily plot the base location of the various users of the forest, and highlight user groups who are influenced by a particular set of rules or incentives. Because of the temporal aspects of the database, a GIS could depict physical changes of the forest (via the utilization of forest plot data, or potentially aerial or satellite imagery), and consequently provide visual evidence on the depletion of a particular forest product over time. In addition, these "slices of time" provide the ability to look at changes in

governance and its impact on the behavior of forest users geographically, as well as analyzing naturally occurring changes in the physical resource and its impact on a governance structure. In short, a vast number of conceivable geographic analysis queries could be implemented. A GIS which links physical and nonphysical attributes of a particular natural resource and collects these attributes over time, has great explanatory utility for a regional researcher as well as local forest administrators and users.

The ease or difficulty of developing an individual GIS site map will be dependent on what is available in that particular area. A field researcher will rarely have a digitized base-map at his or her disposal, and therefore the particular research organization may have to digitize available paper maps. The worst case would necessitate the utilization of Global Positioning Satellite (GPS) or remote sensing technologies to develop these base-maps. Gathering the particular location information on user groups, settlements, virtual rule boundaries, etc., will most likely require a separate GIS survey instrument and the utilization of GPS technology. The mapping aspect of the IFRI project is one of its greatest GIS hurdles, and consequently, a pilot project described below has been initiated to clarify and define these issues as well as to identify mapping solutions.

The second GIS product, the "comparison IFRI GIS," is not yet well defined. In general, it will be utilized by researchers interested in the comparison of multiple forests. The researchers at Indiana University will be the primary users of this GIS product, but once developed, users will eventually include IFRI Collaborating Research Centers studying multiple forests. Two forests with similar physical or nonphysical characteristics could be compared in order to identify common influence factors on resource sustainability or depletion. For example, a researcher may be interested in analyzing the effects of changes in rules of two different forest associations and the impact of these rule changes on the forests located in a particular site. Conceptual design of this portion of the project will be conducted after completion of the pilot project described below.

The IFRI GIS Pilot Project

The IFRI development team has initiated a pilot project to investigate the feasibility of the GIS proposal stated above. The pilot study will focus on a forest located near Bloomington, Indiana. Three entities, the Hoosier National Forest, Brown County State Park, and Yellowwood State Park all share boundaries. The pilot site, consequently, will be the land encompassing all three parks and neighboring towns where users are heavily clustered. Each of these parks have established various governance structures regarding the use of the forest resources, and therefore will provide an interesting, easily accessible, GIS test-bed. The pilot study will also utilize GPS technology to gain expertise and understand the appropriateness of the technology toward this effort. The outcome of the pilot will have significant impact on the decision to continue with the conceptual GIS ideas discussed above.

The GIS portion of the IFRI project is considered a stand-alone module; a research organization interested in developing a regional IFRI database will not be required to develop a GIS as well. The regional GIS is not seen as a mandatory part of the project, rather, it is seen as an "add-on" which has great potential for additional analysis and communication.

Conclusion

This paper provides a very brief descriptive overview of an effort to develop a long-term monitoring program that monitors both the conditions of a series of forests and of the institutional arrangements developed to govern and manage these forests. Readers interested in obtaining copies of the data collection forms, instruction manuals, or who are interested in considering eventual participation as an IFRI Collaborating Center should write Elinor Ostrom or Mary Beth Wertime.

Notes

1. Elinor Ostrom, Arthur F. Bentley Professor of Political Science and Co-Director of the Workshop in Political Theory and Policy Analysis, Indiana University; Sharon K. Huckfeldt, Systems Analyst and Database Administrator, Workshop, Indiana University; Charles M. Schweik, Research Assistant, Workshop, Indiana University; Mary Beth Wertime, Research Associate and Coordinator of IFRI Research Program, Workshop, Indiana University. The authors gratefully acknowledge the support of the Forests, Trees and People Program of FAO and the encouragement of Marilyn Hoskins, Program Officer; of U.S. Agency for International Development through its Contract DHR-5446-Z-00-7033-00 to the Decentralization: Finance and Management Project at Indiana University, Syracuse University and Associates in Rural Development in Burlington, Vermont; of the National Science Foundation, Grant Number SES-8921884; and of Indiana University through its support of the Workshop in Political Theory and Policy Analysis.

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2. Common-pool resources share two important attributes: "(1) the difficulty of excluding individuals from benefiting from a good, and (2) the subtractability of the benefits consumed by one individual from those available to others" (E. Ostrom, Gardner, and Walker, 1993, forthcoming).

3. *Free-riding* behavior that occurs when individuals do not contribute to the provision and/or production of a joint benefit in the hopes that others will bear the cost of participating and that the free-riders will receive the benefits without paying the costs. *Rent-seeking* occurs when individuals obtain entitlements that enable them to receive returns that exceed the returns they would receive in an open, competitive environment. *Corruption* occurs when individuals in official positions receive personal side-payments in return for the exercise of their discretion.

4. These ten hypotheses are obviously stated in a very general manner. We are presently developing a working paper that specifies how more specific versions of these hypotheses could eventually be analyzed using the IFRI database.

5. The pretest in Bolivia was conducted by Dr. Rosario Leon, Bosques, Arboles y Comunidades Rurales; in Mali, by Dr. Hamidou Magassa, Service d'Experts pour les Ressources Naturelles et l'Environment au Sahel (SERNES); in Nepal by Rajendra Shrestha of Agriculture and Forestry Development Associates (AFORDA); and in Uganda by William Gombya-Sembajjwe of Makerere University, Kampala. We are deeply appreciative of the outstanding work of these colleagues and their pretest teams.

6. When used in connection to databases, the term **entity** refers to an object in the real world with an independent existence that is represented in the database.

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Figure 1

A FRAMEWORK FOR INSTITUTIONAL ANALYSIS

FOCAL ARENA

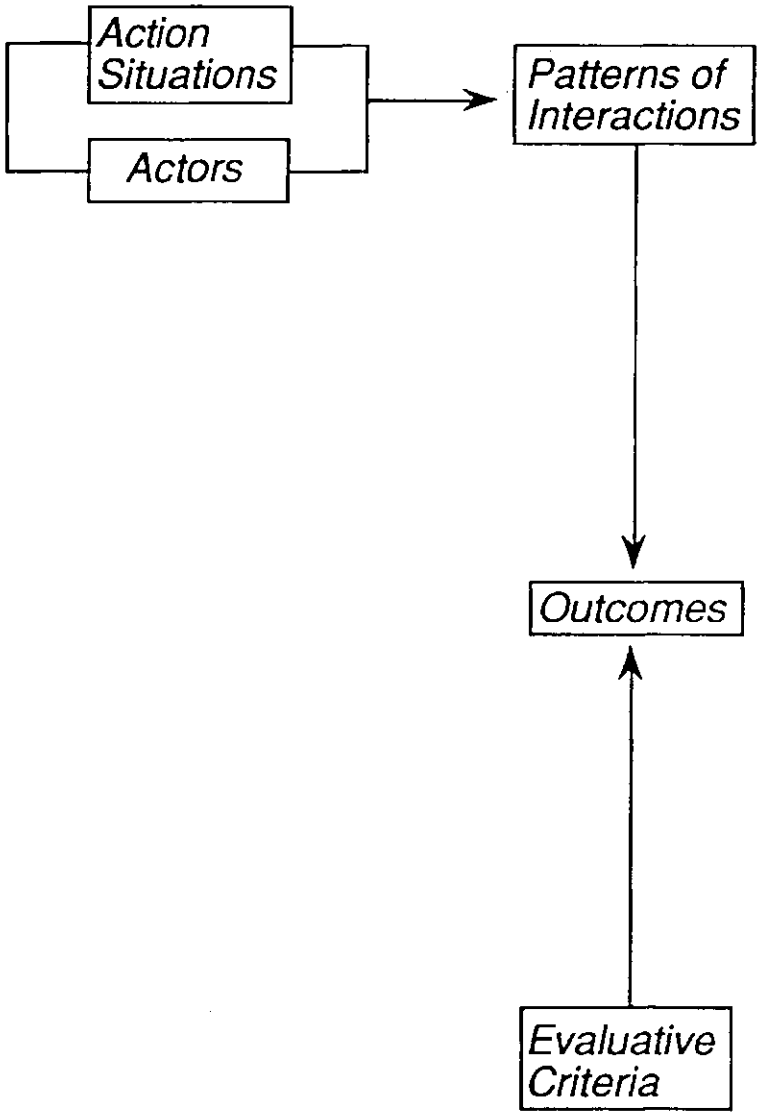

Figure 2

A FRAMEWORK FOR INSTITUTIONAL ANALYSIS

EMBEDDED ARENAS

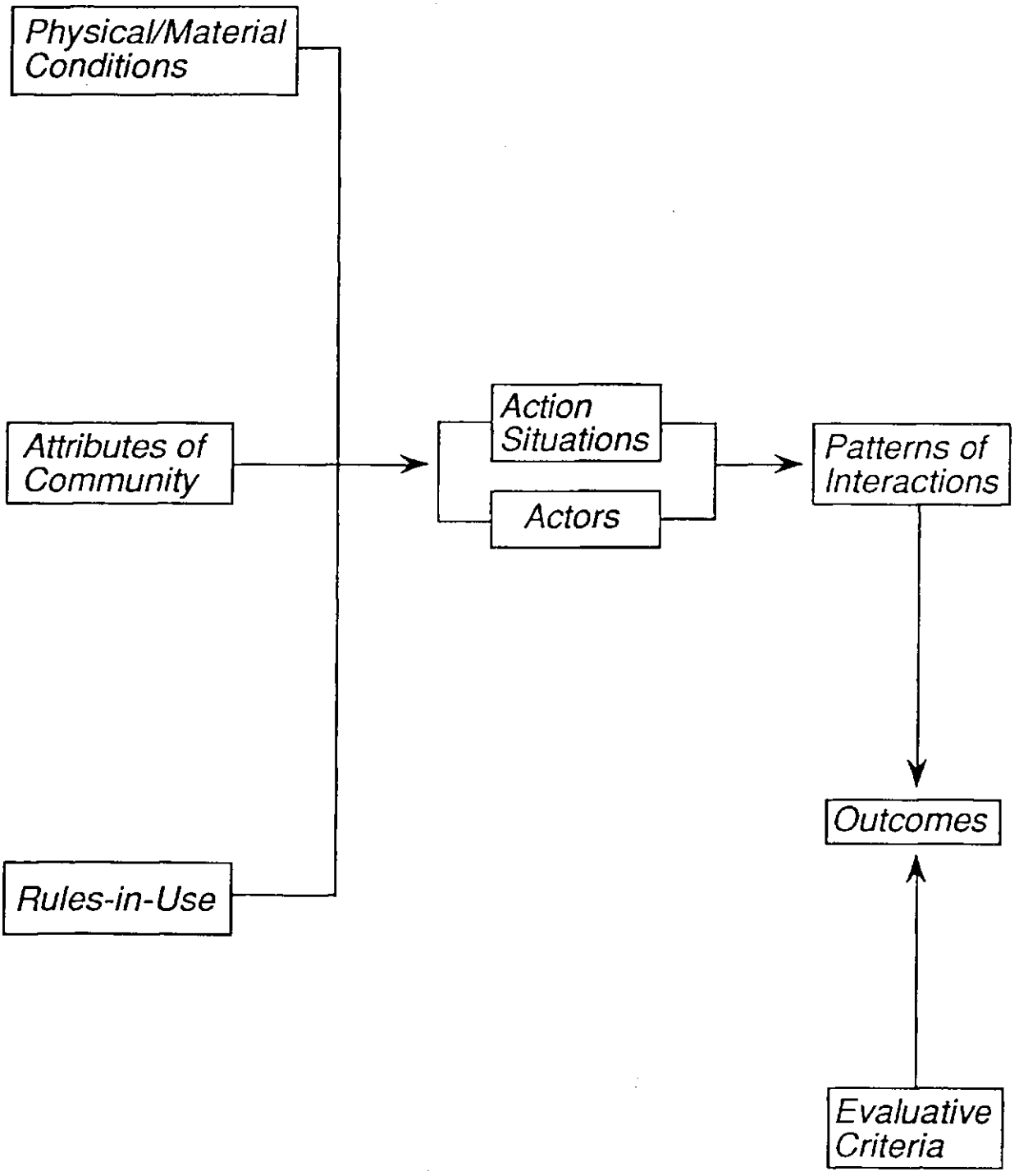

Figure 3

A FRAMEWORK FOR INSTITUTIONAL ANALYSIS

Illustrative Variables in IFRI Database

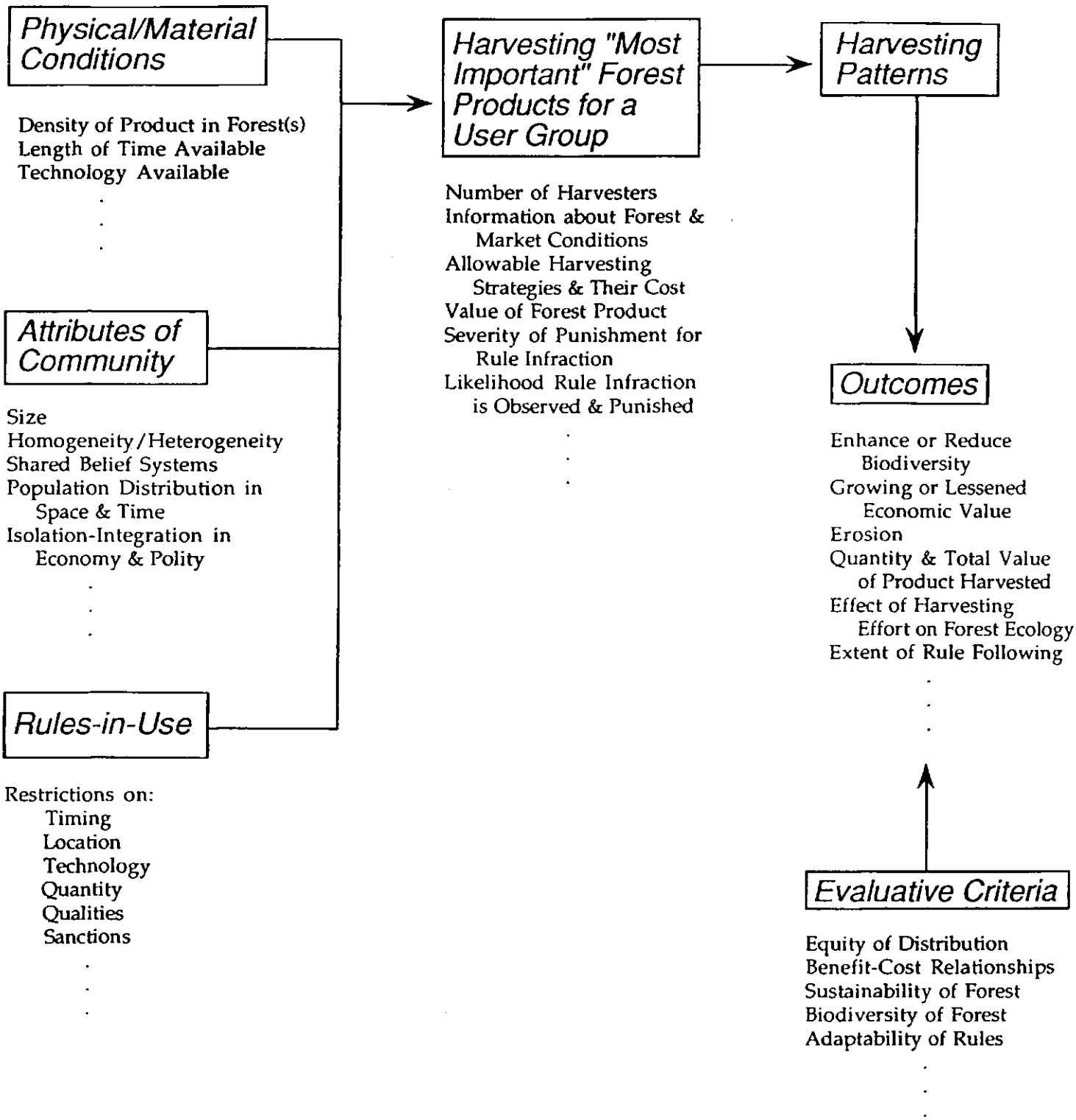

Figure 4

IFRI Conceptual Model