Use of Case Studies and Structural Coding in a Relational Database for Storage and Analysis of Irrigation Institutions and Systems in Nepal

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Since the 1970s, a large number of individual field studies of diverse irrigation systems have been completed in Nepal. Some of these studies were undertaken by masters or doctoral students and are based on extensive periods of time in the field. Others were written on the basis of shorter periods in the field: rapid rural appraisals, brief reports, and field-site visits by expatriate advisors. This large number of completed field studies of irrigation systems in one country represents an immense investment in learning about and documenting how government and farmer-organized systems operate in practice. This gold mine of information is of importance for farmers and officials in Nepal as well as for external observers interested in how attributes of irrigation systems and the institutions governing them affect performance. Many of these studies were undertaken by individuals in close communication with one another. But without some way of recording the information contained within them in a consistent manner, it is difficult to obtain a synthesis of what is known and unknown about irrigation systems in Nepal.

The process of mining and refining this treasure trove of information about irrigation institutions and systems in one country is the topic of this paper. Many studies of irrigation by social scientists have drawn on a relatively small number of case studies for the purposes of discussing national policy issues, patterns of particular cultures, or assessing the performance of irrigation systems. Clifford Geertz (1972), for example, compared two cultures, Moroccan and Balinese, using just two irrigation systems as his referent. A recent book by David Freeman (1989) focuses on a total of five cases. Relatively few studies involve a large number of case studies. Prachandra Pradhan (1989) examines twenty-one irrigation systems in Nepal. De los Reyes (1988) undertook an important study of around 50 farmer-organized irrigation systems in the Philippines and John Ambler (1990) has collected information on a large number of systems in Indonesia. Our colleague, S. Y. Tang (1992) analyzed 50 irrigation systems using a database structure similar to the one we describe herein. Neglecting for the moment the considerable knowledge and wisdom scholars of irrigation have developed from their experiences with many irrigation systems, many conclusions about the nature of irrigation are supported by evidence gathered in a systematic way from a small number of case studies. A corresponding lack of extensive empirical evidence touches on governance and management issues related to irrigation. There are few studies, Wade and Seckler (1990) contend, that "deal with the question of organizational structure: the extent to which differences in organization structure affect canal performance, or the extent to which changes in organization can be expected to improve performance" (1990: 15).

In 1988, members of the Decentralization: Finance and Management (DFM) project,[2] were invited to study decentralized governance in Nepal. Because so many studies of irrigation systems had already been undertaken, the DFM team proposed to understand how various systems operated and what affected their differential performance. They created a database where a consistent set of indicators could be extracted and coded from existing field studies. Materials were collected during 1990 and 1991 with this goal in mind. The creation of the Nepal Irrigation Institutions and Systems (NIIS) database was initiated in 1991 with support by the DFM project, and since 1992 by the Ford Foundation.[3]

All in all, we have gathered more than 100 documents describing Nepal irrigation systems. We have also added new cases during fieldwork in Nepal. In total, we have gathered information about 151 systems. As described below, we were able to visit 82 of these systems during December of 1991 and January of 1992 in order to ground-truth the data we had already entered for most of these systems, or, in some cases, gather new information. Given limited resources, we were not able to visit all the systems for which we had field materials, and some of the written materials provided only very sketchy information. We selected 127 irrigation systems for which we had substantial information based on prior field visits (in some cases, several different visits and written descriptions by different researchers) and our own field visits. Our method for deciding which cases were included is described below.

Most of the included systems (N = 104) are farmer-managed irrigation systems (FMIS); that is, they are systems that are governed and maintained by farmers themselves. Some (N = 23) are agency-managed (AMIS), where the systems were not only financed and built by a governmental agency but continue to be operated and maintained by it as well. Some (N = 8) of the agency-managed systems in the database involve a considerable amount of joint management and could be considered jointly managed irrigation systems (JMIS). Since many of the JMIS still involve substantial involvement by the Department of Irrigation (DOI), and the number of such systems in our sample is quite small, we have kept all of the government organized systems in one category and refer to them as AMIS.

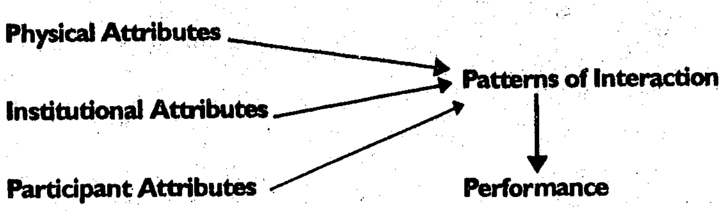
In this paper, we will first discuss the theoretical background of the design of this database drawing on the Institutional Analysis and Design framework. We will then discuss the creation of a structured database from qualitative cases and describe the coding manual we have developed. We will discuss the combination of research methods we have used to understand irrigation institutions and our fieldwork in Nepal. And, finally, we will provide a brief descriptive overview of the cases included in the NIIS database.

INSTITUTIONAL ANALYSIS AND DEVELOPMENT FRAMEWORK

To increase the probability that our work adds to theoretical and empirical foundations for policy analysis, we draw on an evolving framework--the Institutional Analysis and Development (IAD) framework--that has been used to organize theoretical explanations for a wide variety of collective action problems (See Kiser and E. Ostrom, 1982; Oakerson, 1986; ACIR, 1987, 1992; E. Ostrom, 1986). Participants in this project have already analyzed the structure of key problems associated with the provision of and appropriation from common-pool resources in general (E. Ostrom, 1990 and E. Ostrom, Gardner and Walker, 1993) and irrigation systems in particular (E. Ostrom, 1992). In this paper, we can only briefly identify how attributes of the physical and material world combine with attributes of community and the rules-in-use to affect patterns of interaction among participants that in turn affect irrigation system performance (see Figure 1). Readers wanting to see a more detailed development are referred to other works (Kiser and E. Ostrom, 1982; E. Ostrom, 1986, 1990, 1992; and E. Ostrom, Gardner, and Walker, 1993).

FIGURE I

An Institutional Approach to Irrigation System Performance



Attributes of the Physical World

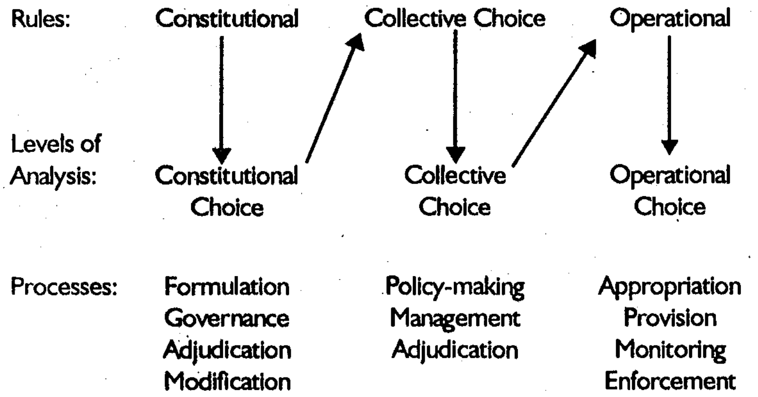
In the IAD approach, we focus first on the physical attributes of a resource system. We examine the key attributes of a good or resource (such as how easy or difficult it is to exclude potential beneficiaries and how subtractable one person's use of a resource unit from other persons' uses) and how these affect incentives facing participants. We also explore the effect of the size of the resource system, the length of the canals, the type of engineering works, the predictability of the water supply, and the availability of water to irrigators located at the tail end of an irrigation system. We expect all of these to potentially influence patterns of farmer interactions that eventually affect the performance of a system given the type of rules in use and key attributes of the participants themselves. (See Lam, Lee, and E. Ostrom, this volume for detailed discussion.)

Institutional Attributes

The incentives generated by physical variables are modified by the rules used by officials and farmers to govern and manage irrigation systems. Rules are linguistic statements that may or may not be written that refer to prescriptions commonly known and used by a set of participants to order repetitive, interdependent relationships. Prescriptions refer to actions (or states of the world) which are required, prohibited, or permitted. Rules result from both implicit or explicit efforts by individuals to achieve order and predictability within defined situations (E. Ostrom 1986: 5). Rules are forward looking in their effect. Once a rule is agreed upon and enforced, some actions or outcomes in the future are "ruled-in" and others are "ruled-out." While all rules are linguistic phenomena, they may or may not be written, and they may or may not have originated in a setting recognized by outsiders as a formal arena for the establishment of rules.

Rules that are made, monitored, and enforced by farmers themselves, constitute farmer-governed irrigation institutions. Rules made by farmers, however, are not made in isolation of other contingencies relating to the irrigation system, including other rules. Rules relate to one another; as a set of rules, they are frequently configurational in nature. In other words, the

FIGURE 2
Linkages Among Rules and Levels of Analysis



Source: E. Ostrom (1990: 53).

The constitutional level is where decisions are made about decision rules.

Constitutional-choice rules affect operational activities and results through their effects in determining who is eligible and determining the specific rules to be used in crafting the set of collective-choice rules that in turn affect the set of operational rules (E. Ostrom, 1990: 52; emphasis in original).

effect of one rule on incentives and outcomes frequently depends on the other rules also in use.

Rules are also multi-leveled in nature as illustrated in Figure 2. There are rules about day-to-day decisions, in the world of action, in what we call the operational level.

Operational rules directly affect the day-to-day decision made by appropriators concerning when, where, and how to withdraw resource units, who should monitor the actions of others and how, what information must be exchanged or withheld, and what rewards or sanctions will be assigned to different combinations of actions and outcomes.

The second level is the collective-choice level where collective decisions are made by officials to determine, enforce, continue, or alter actions authorized within institutional arrangements.

Collective-choice rules indirectly affect operational choices. These are the rules that are used by appropriators, their officials, or external authorities in making policies--operational rules--about how a CPR should be managed.

These levels affect one another. Decisions made at a constitutional-choice level specify, for example, what boundary rules are initially established and what procedures must be used to change boundary rules. Boundary rules specify who is an irrigator and what are his rights and duties. Using these rules, members of the irrigation committee (working at a collective-choice level) can identify those farmers who have irrigation rights and those who do not. They use this information to decide on how much input each irrigator needs to devote to the maintenance of the system. They also make decisions to provide or deny water to farmers based on these rules. Thus, the operational level is also affected.

Attributes of Community

Understanding how physical and institutional attributes affect patterns of interaction and outcomes cannot be achieved without knowing something about the participants themselves and how they are related. Thus, in addition to the impact of physical and institutional variables on the patterns of interaction affecting irrigation system performance, the number of farmers, whether they are similar or dissimilar to one another in regard to their wealth, ethnicity, or caste, and their previously established levels of reciprocity and trust also affect how they relate to one another in regard to irrigation.

We have learned from prior theoretical and empirical analyses of incentives and behavior in CPR situations that verbal promises made on a face-to-face basis in a small group of individuals with similar assets are sufficient for many immediate and short-term activities where the temptations to deviate from the promises are not too great and the benefits of everyone keeping their commitments are obvious to all. When the commitment that is needed involves costly activities to be undertaken over a long period of time, and where the benefits (even though greater than the costs) are dispersed over time and space, simple verbal promises--covenants without swords--may not be sufficient.

When community members interact with one another repeatedly with respect to many different types of problems, the likelihood that they will keep their commitments is much higher than when individuals come together only once in a while in a limited set of arenas (Tailor, 1987). In such settings, the threat of community scorn and the unwillingness of some families to relate to other families is a significant sanction that can be applied locally without waiting for the uncertain responses of external officials. Local sanctions may have stultifying results, but they can also increase the probability that individuals, faced with difficult collective action problems, are able to solve them on their own.

The above provides a brief sketch of the IAD framework used as a theoretical foundation in the development of the NIIS coding forms. We hope that this short overview helps provide the reader with some context as we move to discuss the methods used in the NIIS project.

NIIS PROJECT

To capture the rich information in the extensive field studies of irrigation systems in Nepal using the IAD approach as an orienting framework, we developed a structured coding manual. Fortunately, this was not the first time we confronted this task. In 1985, the National Academy of Sciences Panel on the Study of Common Property convened an international conference to study the performance of various types of common property systems throughout the developing world (National Research Council, 1986). Given the richness of case materials gathered in this process, colleagues associated with the Workshop in Political Theory and Policy Analysis began the process of devising a structured coding manual that would provide a mechanism for comparing institutions related to inshore fisheries, irrigation systems, forests, and grazing areas. The first effort took several years to develop since many of the variables had not been systematically measured in any previous research. The CPR project staff had to devise and test many new measures for key concepts. Some variables of theoretical interest could not be included in the effort because they were infrequently recorded in the case materials. The CPR manual was used to code information from approximately 50 irrigation systems and 40 inshore fisheries (see Schlager, 1990; Tang, 1991; 1992, E. Ostrom, 1990).

In the spring and early summer of 1991, the existing CPR manual was extensively reviewed and customized so that case materials about Nepali irrigation systems could be coded and entered. Faculty, staff, and graduate students at the Workshop aided in this endeavor. Assistance was also obtained from Robert Yoder, Anthony Bottrall, Robert Hunt, and Mark Svendsen. Yoder provided sage advice, including recommendations on how to capture important aspects of Nepal's annual cropping cycle for analysis of irrigation system performance in Nepal. A matrix--now called the Yoder matrix--was developed to show availabilities of water and cropping intensities at both the head and tail ends of irrigation systems and the overall cropping pattern adopted. Mark Svendsen, asking questions out of his own research (Small and

Svendsen, 1990; Svendsen and Small, 1990) added a concern about the measures of performance in irrigation systems, particularly with regard to general characteristics of successful systems. Bottrall and Hunt brought a long and rich experience in the history of irrigation institutions to help us improve the clarity of what we are doing. We modified the CPR manual in other ways as well. Several variables were dropped from the original CPR manual. Most of the variables dropped related to unique aspects of inshore fisheries. Others were dropped because initial data analysis had given us little confidence in the reliability or validity of the measure. The coding manual, like its predecessors, excluded variables that were conceptually important but not likely to be described in in-depth case studies. Attempts were also made to clarify and simplify the descriptions of the variables so that the manual itself would be easier to learn and use.

The NIIS Coding Manual

The NIIS coding manual is composed of seven coding forms that are used in conjunction with one another. The seven forms are entitled: Location Form, Appropriation Resource Form, Operational Level Form, Subgroup Form, Operational Rules Form, Organizational Inventory Form, and Organizational Structure and Process Form.[4]

Location Form. The purpose of the Location Form is to capture general physical, economic, and institutional characteristics of the area in which an irrigation system is located. The location not only encompasses the irrigation system but also other crucial features of the resource environment, including governmental activities in the location, such as formal village and district political structures. If several irrigation systems are located in the same local jurisdiction, only one Location Form is completed. Each irrigation system is linked through the relational database to that form. With this linkage, we can aggregate information in the database about all irrigation systems located within a particular governmental jurisdiction. We can also add contextual information obtained from other sources. We have, for example, now identified the nearest rain station to each of the locations in our database, and have merged information about the level and distribution of rainfall in these locations. We have not yet been able to convince ourselves, however, that these stations are located close enough to the irrigation systems in the database that we can rely on the information about rainfall collected at the station as being indicative of the amount of rain and its distribution for the relevant irrigation systems.

Appropriation Resource Form. The purpose of the Appropriation Resource Form is to record the important physical attributes of the resource systems, delineate the boundary of the irrigation system, and describe how the appropriation resource is related to the relevant organizations for producing, distributing, and using the resource unit. On this form, we code information about the type of headworks (temporary or permanent), length and number of canals, whether the canals are entirely or partially lined, the steepness of the terrain, and the predictability of the water flow. For the delivery of irrigation water, we distinguish among three different stages: production, distribution, and appropriation. For each stage in this delivery process there can be, but does not have to be, a separate resource.

The production resource in an irrigation system is the set of engineering works that divert or hold back a water course and thus "produce" water for the users of the irrigation system. Thus the production resource is usually some kind of permanent or temporary headworks. A *distribution resource* is what irrigators call the main canal; it is the part of the main canal that is located after the headworks and before the command or service area (or, what is frequently called, the idle length). The *appropriation resource* is the area in which the irrigation water is appropriated by the farmers. Conventional usage in irrigation would call this the command or service area. Where the service area is directly adjacent to the headworks, there is no separate resource devoted exclusively to distribution.

In addition to recording information about the physical attributes of each of the resources involved in an irrigation system, we also record who operates and maintains each resource. In a farmer-organized irrigation system, the farmers operate and maintain (and, in many cases construct) all of the resource systems. In an agency-organized irrigation system, it is usually assumed that the Department of Irrigation operates and maintains all resources. Frequently, the agency operates the production and distribution resources and does not operate the appropriation resources. The exact borderline between an agency-managed and a jointly-managed irrigation system is hard to distinguish. In some cases of formal, jointly-managed irrigation systems, there is a clear understanding that the division of responsibility comes at the border between the distribution resource and the appropriation resource. In this case, the agency operates and maintains the headworks and operates the main canal while the farmers operate and maintain the secondary and tertiary canals. Farmers may also be responsible for maintaining the main canal. In other cases, the farmers actually operate and maintain the distribution resources and the agency only operates and maintains the production resource.

Operational Level and Subgroup Forms. The Operational Level Form is where we code information about the attributes of community, the action situations that individuals face, and their patterns of interactions and outcomes achieved. Basically we record information about the stakes of individuals, about their patterns of communication, the types of actions they are taking, and information about various performance characteristics. The Yoder matrix that provides information about system performance related to seasons and crops is on this form. For irrigation systems where there are few differences among the individuals using the system in regards to their water rights, the *Subgroup Form* is a continuation of the *Operational Level Form.* Here we code the number of households, their landholding patterns, their ethnic and caste identifications, their regular patterns of information exchange, and the information that farmers possess about their system. It is important to note that a subgroup is not necessarily the same as all those farmers who use the irrigation system. A subgroup is defined as those who have the same rights to water. So, if an irrigation system is composed of different sets of people, each with different rights of access to water, each set of water users would be a subgroup. If a system has more than one subgroup, we code one Subgroup Form for each such group.

Operational Rules Form. The Operational Rules Form is designed to provide information about the operational level rules particular to a single subgroup which appropriates from this resource. Operational level rules are prescriptions and proscriptions that outline what actions are forbidden, required, or permitted. Of particular interest in this form are boundary rules that define the requirements that must be fulfilled before individuals are eligible to withdraw units from the appropriation resource; authority and scope rules which define what farmers must, must not, or may do at a particular stage of the appropriation process; and information rules which define what kind of information must be communicated and recorded. Also of interest are payoff rules that specify the external rewards or sanctions that must, must not, or may be assigned to specific actions or outcomes, and aggregation rules which are authority rules that are assigned to multiple position for partial control over the same action.

The Organizational Inventory Form. The Organizational Inventory Form is a matrix, the columns of which represent provision, production, distribution, appropriation, and use activities related to a particular appropriation resource.[5] The rows of the matrix represent the level at which the activities have been organized, including the operational, collective-choice, and constitutional-choice, levels which were discussed above.

Organizational Structure and Process Form. Finally, the Organizational Structure and Process Form is where attributes of the irrigator organization or the government agency that directly manages the irrigation system are coded. We focus here on the type of leader, how the leader is chosen, and how he is supervised by others.

The Concept of Time

The concept of time is rarely tackled analytically in research on the governance, operation, and performance of irrigation systems. In some case studies, the author presents a long history of various events that have happened related to an irrigation system under change. The performance of the system may have changed from poor to good to excellent (and, perhaps even, back to poor) during the course of that history. If one is interested in understanding how various aspects of the physical, cultural, and institutional worlds affect incentives, behavior, and outcomes, it is essential to relate performance to the factors present at the time (or just prior to) measuring performance.

If one plans to conduct a monitoring program where data is collected every year or decade (or some other arbitrary unit of time), then one can use that external time metric to determine when you record a "new case." When working with a combination of in-depth field studies combined with our own fieldwork, we did not have such an external metric, but we did have quite a few cases of change. In our earlier CPR project, we had confronted this problem and developed an analytical concept of a time slice. A *time slice* is a period of indeterminate length, during which the structure of the situation that farmers face remains relatively consistent. That is, the rules-in-use, the physical structure, the local economy, and other key factors remain relatively constant over a defined period of time. Some time slices are only a few years; others may be centuries long. By using this concept of a time slice, we are able to record major changes in system structure when they occur rather than using an arbitrary and external concept of time.

For example, we had recorded descriptions of 20 of the irrigation systems located in Sindhupalchowk. These were written as part of a WECS/IIMI project to provide a rapid appraisal of which irrigation systems should be part of an innovative effort to improve their performance (see Laitos et al., 1986; Shivakoti, 1992). During December of 1991, Naresh Pradhan revisited many of these systems as part of the ground-truthing effort we describe below. Since the data recorded in 1991 occurred after there were many changes in physical structure and rules, we considered that data to be a second time slice. By recording two time slices, we have now been able to do an analysis of the difference in performance before and after the WECS/IIMI intervention (Lam and Shivakoti, 1992). The capability of recording several time slices in the NIIS database will be particularly important in the future applications of this database in Nepal.

The Database

The data recorded using the instructions contained in the NIIS coding manual are systematically entered in a database. The master copy of the database is located on a desktop computer at the Institute of Agriculture and Animal Science in Rampur. Two copies are located in other Nepali institutions and several working copies are located at the Workshop in Political Theory and Policy Analysis at Indiana University. Sharon Huckfeldt (1992), the systems programmer for the database, has prepared a detailed reference manual that is located at all sites where the database has been installed.

The NIIS database is designed as a relational database using R:BASE 3.1b, a relational database management system produced by Microrim, Inc. We purposely chose to use a commercially available program for ease of transportation of the database from Bloomington, where it was developed, to other research and policy centers.[6] Each coding form from the NIIS manual, with the exception of the Operational Rules Coding Form, is stored in the database as a separate table. The Operational Rules Form is stored on two separate tables. Data within each table can be tallied for frequencies or compared via cross-tabulations. Entirely new tables can be constructed that contain variables of interest from any of the other tables. Relevant data can also be exported to statistical software packages for more sophisticated analysis. Examples of the type of analysis that is feasible are contained in the paper by Lam, Lee, and E. Ostrom (1993) presented at this conference.

Relational databases allow those who enter and retrieve data to represent the type of highly complex, nested arrangements that one finds in many aspects of natural resource management in general and irrigation management in particular. One can link the rules used by a subgroup for appropriating water with the type of agency operating the head of a system and with performance measures even though these measures all exist on separate tables. If information about forestry resources and institutions is collected in the same location as irrigation systems, we will be able to link this cross-section information in the future. These linkages save storage capacity and allow analysis not feasible with earlier types of databases. On the other hand, relational databases are notoriously difficult to learn and use. Data entry can take substantial time, and retrieval requires skilled knowledge of how to combine information from various "tables" inside the database.

Coding Cases and Fieldwork

In the early stages of this research, we depended on case-study materials gathered from a variety of sources. These cases varied in quality and depth; some of them were hastily written field notes from rapid rural appraisal investigations while others were thorough and careful long-term studies of particular irrigation systems. Dissertations contained some of the best materials we have worked with, particularly those by Hilton (1991), Yoder (1986), Martin (1986), and U. Pradhan (1990).

During the summer of 1991, colleagues at the Workshop in Political Theory and Policy Analysis at Indiana University in Bloomington read and coded 130 case studies. The general method was to assign cases to individuals according to district[7] so that each coder could become familiar with the conditions and linguistic terms of a region. Myungsuk Lee, for example, was assigned the cases from Chitwan and Tanahun, two districts in central Nepal. Wai Fung Lam was assigned the 23 cases from Sindhu-Palchok, a district just to the east of Kathmandu valley. We felt Gopendra Bhattrai, a Nepali engineer who is now a graduate student at Indiana University, would be well-equipped to study systems from all over Nepal, since he is widely traveled in his own country. Ganesh Shivakoti was given the task of coding his own previous fieldwork and to help interpret questions from all of the field materials. Paul Benjamin, because of his long experience in Nepal, was also given general responsibilities, including some of the more indecipherable cases such as the faint photocopies where the originals were handwritten in pencil in English but with Nepali syntax.

Once the cases were assigned, the general method was to read each case thoroughly, taking brief notes about information the coder was certain would be required by our coding manual. The coder then would go through the case a second time and code as he proceeded. He would attempt to answer all the questions, but would answer "MIC" or "Missing in Case" to those questions for which there was no information. We employed Confidence Levels (CL) to indicate our faith in our responses. For those questions where the text specifically and concretely provided answers, we assigned the CL of "5". For those questions that were answered by the text with less certainty, we assigned CLs of 4 through 1, where "1" represented the least certainty.

The staff worked individually, but the group met once a week during the coding period in Bloomington to discuss the meaning of particular questions, problematic cases, and for distribution of coding materials. Depending on the quality of the report, the coding process was quick and confidence levels could be rated at a high level. Some cases gave tantalizing but relatively sketchy information. It became apparent as we moved through the materials, however, that we were coding many answers "Missing In Case" or with low levels of confidence. This was due in part to the quality of some of the materials but also because we were asking questions that are infrequently recorded by irrigation scholars and practitioners regarding institutional arrangements. Questions about boundary rules, authority and scope rules, sanctions, and monitoring had not been systematically asked of any irrigation system in Nepal, with the possible exceptions of the dissertations of Yoder, Martin, Hilton, and Pradhan. Until recently, irrigation was not perceived as a common-pool resource with a growing body of theory that identified variables that should be consistently measured in empirical work. Nor was there a general perception among irrigation specialists (with the exception of those trained by Coward, Levine, and Uphoff at Cornell University) that social organization was fundamentally important to the development, operation, and maintenance of an irrigation system.

We were then confronted with the problem of what to do with data that was not capable of answering some of our most basic questions. Years of work had been invested in the development of theory and method for the study of CPRs. The coding manual that had been developed from that work had been further modified and customized especially for irrigation in Nepal, and we had already invested time and energy into coding case materials we had brought over from Nepal. Should we proceed with analysis, upon completion of coding and entry of the data, of material that was at best incomplete and at worst inaccurate?

About this time, late summer 1991, we began to think of the possibilities of scheduling a period of fieldwork in Nepal to "ground-truth" the coded case materials and do original fieldwork on additional irrigation systems where feasible. A window of opportunity was approaching in December 1991 and January 1992. Shivakoti would be finishing his Ph.D. in East Lansing in late October and would return to Nepal soon after that. He would be able to arrange for fieldwork that would include hiring other Nepali field-workers, and Benjamin (who is fluent in Nepali) could join him in early December for a two-month period of intensive fieldwork.

Ground-truthing the Database

The plan for fieldwork in Nepal depended on an enormous amount of work prior to departure. All the data for all the systems coded up to that time had to be printed in a useful format in triplicate to produce one set for Shivakoti, one set for Benjamin, and one spare set in case of loss. All of this work was accomplished by Database Coordinator, Julie England, with a maximum of efficiency, accuracy, and good cheer.

We divided the data printouts into "Priority" and "Non-priority" notebooks on the basis of case quality and site accessibility. We decided to grade each case we coded as "A", "B", or "C" quality. "A" grade cases were cases that contained sufficient information with high confidence levels such that we could dispense with visiting them for further "ground-truthing." "A" grade systems were therefore put into the "non-priority" category. We also put into the "non-priority" category systems so remote that time spent traveling to visit them would devour precious field time; although many highways have been built in the last three decades in Nepal, the majority of villages in the country are only accessible on foot. That takes time so we tried to find accessible systems to visit.

"B" cases were those that had good quality data but were not complete enough for our purposes. "C" grade systems were those about which we had little information and/or low confidence levels. We originally placed these in the "non-priority" list, because we thought it would take too much time to code a system with so much missing or low-confidence information. The "Priority" cases were, therefore, cases that were considered to be "B" grade and accessible.

Our distinction among the cases, especially between "B" and "C" cases, however, turned out not to be terribly important once we gained experience collecting data in the field. It took us the same amount of time in the field to code a "C" case as it did a "B" or even an "A" case. The crucial variable for efficient use of time in the field was the distance between systems, regardless of their quality grades. If, as in the districts of Dang, Chitwan, and Sindhupalchowk, the systems on our list were densely packed, then we would visit systems we were close to, regardless of the way we had initially graded them. In fact, we did visit and re-code a few "A" cases that we had previously marked as "non-priority." Although we abandoned the quality distinctions among the already-coded cases while conducting fieldwork, the exercise of grading them was important in that it classified cases as either infeasible (too far) or not worth it (already sufficient data). We were then able to plot our route and schedule our time accurately; we knew very well what it was that we wanted to do in the limited time available to us.

By the time Benjamin joined Shivakoti in Nepal in early December, one field-worker, Naresh Pradhan, was already gathering data in Sindhupalchowk. Pradhan had worked in Sindhupalchowk a few years before, knew the systems we were interested in, and has had considerable experience in irrigation research. Shivakoti trained him in the use of the coding manual and sent him out alone to cover the twenty systems in Sindhupalchowk. Shivakoti was also able to gain the help and cooperation of several important irrigation-related agencies for vehicles and other logistical support. The Irrigation Line of Credit Project of the World Bank and the Irrigation Sector Support Project of the Asian Development Bank provided much valued help. The International Irrigation Management Institute (IIMI) also provided hospitality, encouragement, and logistical support for fieldwork.

Four team members--Ganesh Shivakoti, K. N. Pandit, Bharat Mani Upadhya, and Paul Benjamin--split into two teams, with Benjamin and Pandit forming one team and Shivakoti and Upadhya forming the other. The four of them provided over 130 person-days of fieldwork in six weeks.

The Nepal irrigation manual, although simpler than the original CPR manual, remains complex. One could not work with it in the field like a survey instrument, where one simply reads questions to respondents and then records the answers. To use the method required a considerable familiarity with the theory behind the questions and the way of recording the information used as a standard throughout the data set. We had printouts of all of the data already entered in the system. Thus, we did not need to write down any information where we already had correct information printed on the coding sheet.

Even though Shivakoti and Benjamin had extensive experience with the manual, the use of it in the field was new. When we began, we would ask our questions verbatim, in Nepali, in the order they appeared on the form. We would then listen to the response (and any discussion of it among the farmers) and record new or more accurate information.

As we gained, quite literally, fluency in the use of the manual, our modes changed to engaging farmers in conversations about the system and noting responses that would answer questions which we knew were contained within the manual. This conversational style also permitted more participation by the respondents, of whom there were often many. The participation of respondents was valuable; more people present meant that uncertainties about the validity of data could be checked. People would often contest answers. When they did, the ensuing discussion would produce some sort of consensual answer. We also asked farmers to draw a map of the system, or to help us draw a map. And where the system was relatively small, we would walk through the entire system. In the larger systems we visited key sections. The combination of these methods enabled us to develop greater rapport than if we had only read the questions and recorded the responses. Farmers were always helpful. We were greeted with courtesy and interest wherever we went. There was always humor present during the interviews.

After we had some practice with the technique of interviewing with the NIIS coding manual, we were able to code an entire system within three hours. That allowed each team to have time in the village to examine the canal structures and service area. With two teams, we could manage about four systems per day, although in one long day, our two teams reviewed the coding for seven systems. Benjamin split off from the other three members of the group in the final days of fieldwork to visit an area he worked in during his Peace Corps days and coded three systems in a day and a half. The NIIS manual enabled us to gather important data quickly for a comprehensive examination of the organization of an irrigation system.

A total of eighty systems were visited during December and January by our research team. Almost all of these systems were ones that had already been entered in the database, but we did add several new systems located near to where we had information about other systems. This enabled us to see how easy or difficult it would be to obtain thorough information about a system when we had no prior printout of information about it with us in the field. As we mentioned above, we were quite surprised how rapidly we could obtain the information in our coding forms for systems that had not been previously coded.

When Benjamin and Shivakoti returned to Bloomington in February of 1992, an intensive period of data entry was initiated. The first tentative data set was available for initial runs during April and May of 1992, but considerable data checking continued through the summer of 1992. Data analysis is proceeding in several stages. The first analysis contained in Chapter 5 of E. Ostrom, Benjamin, and Shivakoti (1992) was an effort to present many of the key variables about attributes of the physical resource, the community, the rules-in-use for each of the three major agricultural zones of Nepal (the hills, the river-valleys, and the Terai), and by the type of governance arrangement for the system (AMIS and FMIS). We consider this chapter to be the "first pass" at the data. In addition, we have written a history of irrigation in Nepal and of the organizations that have been involved in developing irrigation. An initial draft of a report with these materials was made available in November of 1992 for comment and criticism.

Since so little work has been done on measuring the performance of irrigation systems in a systematic manner, one of the other essential tasks of our early work was the development of a measurement model that could be used as the foundation for all of our other work. Wai Fung Lam (1992) spent several months reviewing the literature on irrigation performance and conducting a detailed and extensive analysis of the performance measures we had gathered and recorded. Lam identifies three dimensions of performance: the physical condition of the system, the delivery of water, and agricultural productivity. These measures are consistently used in our efforts to understand how various factors are associated with different dimensions of performance as is illustrated in Lam, Lee, and E. Ostrom. We hope to complete our data analysis during the coming spring and have a completed monograph ready for comment and criticism as soon as possible.

Limitations and Possibilities of NIIS Data Set

While this is the largest data set about irrigation systems in Nepal that has ever been collected and analyzed, it is not a random sample of irrigation systems in Nepal. It is as close to an inventory as we could come of those systems which were previously described. There are substantial numbers of systems, included in the database, from districts (such as Sindhupalchowk) where studies had been undertaken prior to interventions. We consider the database to be extremely useful in the following respects:

1. in establishing the feasibility of developing such a database containing information about physical, cultural, and institutional factors likely to affect performance;

2. in beginning the analysis of key theoretical questions;

3. in beginning the process of developing better measurement instruments;

4. as the foundation for an extended research program that eventually develops a better sample of systems and monitors these systems over time.

Thus, the database should be used extensively by academics and policy officials, but they should keep the following limitations in mind:

1. the collection of systems is not a random sample of all irrigation systems in Nepal. It currently has more information about FMISs than about AMISs--a situation which may be remedied soon. Systems located far from modern transportation networks are not adequately represented in the current database;

2. the coding manual includes only those variables that we thought could be coded in a consistent manner from already completed case studies. Thus, new variables should be added as more fieldwork is undertaken.

FUTURE PLANS

The NIIS database will be one of the resources used by the IMSSG at IAAS in Rampur as part of its teaching, research, and extension activities. During the past year, this Study Group has started a complete inventory of irrigation systems located in the Chitwan area where the Asian Development Bank intends to undertake a large project. Further data will be gathered from these systems and entered into the NIIS database so that changes in the structure and performance of these systems can be monitored over time. In addition, during the spring and summer of 1993, plans are underway to collect information from a larger number of DOI systems to remedy the lack of information about AMIS systems currently in the database.

A proposal to create a Rural Resource Studies Program at the Institute of Agriculture and Animal Science, Rampur, has been formulated. As part of its future activities, the Program plans to conduct farmer training programs based on the successful WECS/IIMI farmer-to-farmer training program utilized in Sindhupalchowk. Farmers from systems identified in the NIIS database as performing at a high level will be asked to show farmers from systems that are not performing very well how they solve their physical and institutional problems. If funds are made available, efforts to create a federation of farmer governed irrigation systems will be initiated and a Nepali language newsletter established that can provide information to farmer governed irrigation systems in Nepal about ways to improve their performance.

The Department of Irrigation in Nepal has also asked to receive a copy of the NIIS database and be trained in the use of this resource. Consequently, efforts will be made to work with officials at DOI in an effort to improve performance of DOI systems or those that are being turned over to the farmers after major DOI construction.

Marilyn Hoskins in the Food, Trees, and People program at FAO in Rome has asked colleagues at the Workshop in Political Theory and Policy Analysis to help develop a database about forestry resources and institutions throughout the world. Hopefully, one of the first countries where extensive data will be collected is Nepal. It is our hope that we can eventually relate information about forestry and irrigation systems located near to one another given the substantial influence of one sector on the other. To our knowledge, no previous research has systematically analyzed how forest resources influence irrigation system performance and vice versa. We also hope to begin a major effort to record forestry and irrigation systems using Geographic Information Systems (GIS) technologies.

Thus, in many respects the NIIS database of today is simply the beginning of a long-term process. Hopefully, in the years to come, a systematic method for monitoring the structure and performance of irrigation (and forest) systems in Nepal will be established, and farmers, officials, and researchers will gain better insight to the complex problems of irrigation development in the fragile ecosystems of Nepal.

Notes

[1] Elinor Ostrom is Professor of Political Science and Co-director at Workshop in Political Theory and Policy, Indiana University, 513 N. Park, Bloomington, IN-47405, USA. Paul Benjamin is Research Associate at the Workshop in Political Theory and Policy Analysis, Indiana University, 513 N. Park, Bloomington, IN-47405, USA, and Ganesh Shivakoti is Faculty at the Department of Agricultural Economics, Institute of Agriculture and Animal Science, Central Campus, Rampur, Chitwan, Nepal.

[2] This is an AID-funded project involving the Workshop in Political Theory and Policy Analysis at Indiana University, the Metropolitan Studies Center at Syracuse University, and Associates in Rural Developement in Burlingtion, Vermont.

[3] Needless to say, the authors are deeply appreciative of the financial support of AID and of the Ford Foundation. We are also deeply appreciative of the help extended to us while conducting our own field work in Nepal during December of 1991 and January of 1992. The Irrigation Line of Credit project of the World Bank, the Irrigation Sector Support Project of the Asian Development Bank, and the International Irrigation Management Institute all provided essential logistic and other help to our team during that crucial time.

[4] For ease of use, these separate forms and their respective coding sheets are color coded to ease retrieval and to match with the appropriate answer sheet.

[5] We employ a distinction between "provision" and "production" that draws on the early work of V. Ostrom, Tiebout, and Warren (1961). Provision refers to "decisions that determine what public goods and services will be made available to the community. Production refers to how these goods and services will be made available" (ACIR, 1987: 1). In addition, we focus on several activities that must be undertaken in such a manner after water is "produced". These are delivery, appropriation, and use. There may be several organizations involved in any of these activities.

[6] Since the data base is large, it operates best on more recent models of IBM type computers that operate at high speed and have high-capacity hard disks. The data base can operate on a 286 machine, but some runs would be very slow to accomplish. Recent 486 high-speed machines are the optimal hardware foundation for this type of a data base.

[7] There are 75 districts in Nepal.

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