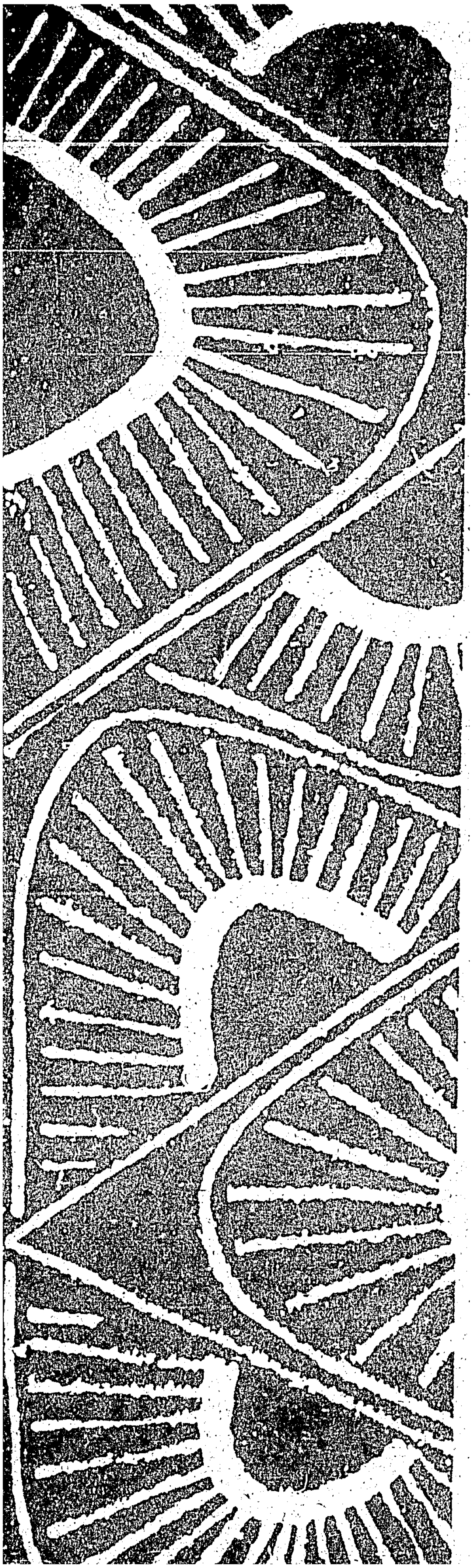

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DECENTRALIZATION: FINANCE AND MANAGEMENT PROJECT

Associates in Rural Development, Inc.
in collaboration with
Workshop in Political Theory and Policy Analysis, Indiana University
Maxwell School of Citizenship and Public Affairs, Syracuse University

INSTITUTIONS, INCENTIVES, AND IRRIGATION IN NEPAL

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FOREWORD

In 1988 Associates in Rural Development, Inc. (ARD), in collaboration with Indiana University's Workshop in Political Theory and Policy Analysis and the Maxwell School of Citizenship and Public Affairs at Syracuse University, began a research and development effort focused on decentralized public service provision. The Decentralization: Finance and Management Project (DFM), sponsored by the U.S. Agency for International Development (USAID), was designed to study problems associated with the failure of many development projects to achieve sustainable impacts--particularly those in rural areas managed by central government agencies. The project's research agenda has analyzed a variety of institutional arrangements and resource mobilization strategies to determine their effects on the sustainable provision of rural roads, irrigation infrastructure, health and education services, and the management of renewable natural resources. Field investigations and desk studies have also analyzed broader decentralization policies and issues relating to local government operations and finance.

In the initial years of the project, a series of state-of-the-art papers were prepared on the principal sectors of inquiry. These reports included a thorough review of the relevant literature and established a framework for field-level analysis. These early studies were the basis for two published books, several journal articles, and numerous conference papers dealing with the problems of rural infrastructure and irrigation management. In addition to these core research products, numerous policy studies, field research initiatives, and project designs and evaluations were conducted at the request of USAID missions in Asia and Africa and the central bureaus of USAID/Washington. These efforts provided project research staff the opportunity to test and refine analytic methods and to demonstrate the utility of institutional analysis to a variety of development problems.

At the conclusion of this major effort covering seven years and 15 different countries, a series of final papers has been prepared that synthesize the cumulative research findings and lessons learned from the project. These include a report summarizing four years of research and analysis on governance and management of irrigation systems in Nepal; a synthesis of several years of research on economic and institutional policy reform in Cameroon; an analysis of DFM research on decentralized public service provision in Africa; a research synthesis on local governance and management of renewable natural resources; a paper on the concept of social capital and its implications for development; and a synthesis of research on rural road maintenance. In addition, the DFM legacy includes two papers providing practical project design guidelines in the areas of rural infrastructure and natural resources and a final report summarizing the project's principal research and development accomplishments.

The DFM project staff from ARD, the Workshop in Political Theory and Policy Analysis, and the Maxwell School extend their sincere appreciation for the sponsorship of this project by USAID. The Agency's research programs aimed at improving our understanding of the development process and thereby the effectiveness of financial and technical assistance represent a significant contribution to the donor community and its partners in the developing world. We would also like to acknowledge and thank the dozens of colleagues from the academic and development assistance communities as well as the citizens and representatives of host countries who have participated in our enterprise. Our group has learned a great deal from this project, much of which is reflected in this final series of documents. We hope that this learning experience has also benefitted our collaborators in the U.S. and abroad.

PREFACE

This study addresses the question of how institutions, together with various physical and socio-economic variables, affect the performance of irrigation systems in Nepal. The study grows out of the work of the Panel on Common Property Resources at the National Academy of Sciences undertaken a decade ago. At that time, many policy analysts presumed that local users were unable to develop their own norms, rules, and property-rights systems to reduce the costs of externalities associated with the use of resource systems. Assuming that no evolution of local norms, rules, or rights would occur, policy analysts recommended that external agents should impose solutions on those affected. The imposed solutions were frequently presented as "the *only* way" to reduce these externalities and increase efficiency. One proposed solution was control of natural resources by a central government agency. The second favored solution was the imposition of private property. Something had to be wrong with the theories, the interpretation of the theories, or the policy prescriptions, if solutions as different as state control and market control were both proposed as the *only* way to efficiently manage natural resources.

In the mid 1980s, research on common-pool resources was bifurcated. On the one hand, sophisticated models of resource use had been developed primarily by resource economists based on assumptions that resource users were unable to enter into enforceable contracts to govern and manage their own resources. On the other hand, a rich case study literature existed based on intensive field work by scholars in anthropology, sociology, history, human ecology, agricultural economics, and political science illustrating self-organizing capabilities. Sweeping conclusions were derived from both the theoretical and the case study literatures. Few studies had been based on data collected from a large sample of resources. A major effort of the National Academy of Sciences Panel was to bring together authors of major case studies on different sectors in multiple regions of the world in order to discuss the theoretical significance of the findings from these efforts.

Once these diverse studies were brought together they illustrated that some farmers and villagers were able organize themselves to undertake many collective-action problems in regard to common pool resources. Others failed to solve these problems. Many factors appeared to work together to enhance or detract from the capabilities of individual users to organize their own governance systems. These include aspects of the physical system, including climate, terrain, soil types, water storage potential, and many others. Further, institutional rules also affect how many users are allowed to enter and harvest from a particular resource and the obligations of those who gain benefits from a system. The structure of the physical system and of the rules-in-use combine to affect the incentives and behavior of participants in a variety of cultural and economic contexts. All of these variables are potentially important in explaining why some self-governing systems achieve high levels of technical and economic efficiency and others are ineffective.

The multiplicity of potential influences makes it difficult to cumulate knowledge beyond what is possible by a close comparison of 15 to 20 systems without systematically coded data. The empirical evidence for the success of self-governed irrigation systems in many parts of the world has been considered by some analysts, for example, to be no more than "scattered examples of successful collaborative actions leading to self-managed irrigation systems" (Young, 1992: 34). Few prior efforts have been able to examine a large number of irrigation systems or other types of common-pool resources located in one country (thus controlling for the influence of a larger political-economic regime) that were governed and managed by farmers as contrasted to others governed and managed by a national irrigation agency. Thus, the case study literature -- while generating intriguing stories about both successes and failures of all types of institutional arrangements -- has been discounted by many as too scattered and lacking the capacity to test the influence of the same set of factors across a large number of systems.

Thus, if knowledge about the configural aspects of the physical, cultural, economic, and institutional worlds that affect resource system performance was to move beyond that attained by doing intensive research on a limited number of systems, it was essential to begin to build a database that could be used for rigorous analysis. Fortunately, colleagues at the Workshop in Political Theory and Policy Analysis had been developing a broad framework called the Institutional Analysis and Development (IAD) framework discussed in this study. The IAD framework is a method for analyzing how the attributes of a physical and biological 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. Several colleagues associated with the Workshop participated on the National Academy of Sciences Panel (and have continued to work together), and who thought that the IAD framework would be an appropriate framework for tying together the diverse disciplinary approach to the study of common-pool resources and common-property institutions. Ron Oakerson prepared an overview of the approach that was used by the NAS panel as the central framework for organizing a series of case studies on different types of common-pool resources (CPRs) located in different regions of the world (Oakerson, 1986).

The IAD framework could also be used as a foundation to develop the structure of a relational database. A key question then was how to obtain data on a large number of common-pool resources and their relevant institutional arrangements. The thought of simultaneously creating a pilot, relational database with extensive coding of institutional arrangements where no one had developed systematic measures that could be used in many different sites, while at the same time undertaking expensive fieldwork in many locations, did not seem realistic. Therefore, initial efforts to construct a theoretically-grounded database were combined with an effort to "mine" the extraordinarily rich case-study literature that already existed. For several years, the in-depth accounts of many other scholars about physical systems, culture, and rules-in-use as they affect strategies and outcomes were used.

As part of a project funded by the National Science Foundation (Grant Number SES 8619498), colleagues at the Workshop developed the first CPR database drawing on the IAD framework. Work was started on this effort in the Fall of 1987 and two years were spent formulating and reformulating the structure of the database as conceptual problems of translating the thick descriptions of the case studies into structured data were encountered. A section of the coding manual was developed by going back and forth from the theoretical work to the case descriptions. Once a section was developed based on an initial set of cases, its use on cases from entirely different countries and sectors was tested. Whenever there was an opportunity to make site visits, these opportunities were used to analyze the usefulness of the coding manual still further.

By the summer of 1989, a general CPR database which was capable of coding information about irrigation systems, fishery systems, groundwater basins, and to a more limited extent, forests had been developed. Information about fifty irrigation systems in different countries was entered and analyzed. Shui Yan Tang's dissertation, based on an analysis of the irrigation systems in the CPR database, was defended in August of 1989, won the American Political Science Award for the best dissertation in the field of public administration for 1989, and was published by ICS Press in San Francisco in 1992 (see also Tang, 1994). One year later, about fifty fishery systems had been entered as well as a handful of forestry cases. Edella Schlager's dissertation, based on an analysis of the fishery systems in the CPR database, is the foundation for several research articles on fishery governance and management (Schlager, 1990, 1994; Schlager and Ostrom, 1992, 1993). Arun Agrawal, a Ph.D. student in the Department of Political Science at Duke University, used the experience of working with the database in the design of his own award winning dissertation research conducted in India on the governance and management of grazing and forestry resources (Agrawal, 1992, 1994).

Studying Decentralized Institutions in Nepal

In September 1988, colleagues at Syracuse University, Associates in Rural Development (in Burlington, Vermont), and the Workshop were invited to Nepal by Dr. Dwarika Dhunghel in the Ministry of Local Development (then, MPLD) and the USAID/Nepal mission to study decentralized institutions in Nepal. This was part of the USAID-funded project on "Decentralization: Finance and Management" with Associates in Rural Development, Syracuse University, and Indiana University. Instead of studying the Panchayat system, the study of indigenous forestry and irrigation institutions in Nepal was proposed. The USAID/Nepal mission funded an initial effort. This resulted in a major study of three irrigation systems in the Dang valley by Dr. Rita Hilton, now of the World Bank (Hilton, 1990, 1992), and a study of "Effects of Different Types and Levels of Intervention in Farmer Managed Irrigation Systems in Nepal" by Shivakoti, Giri, and Ostrom (1992).

During several visits to Nepal, Robert Yoder and Prachanda Pradhan pointed out the extensive descriptive studies that already existed about Nepal irrigation systems, particularly farmer-managed systems, and Yoder and P. Pradhan provided copies of these documents. A large archive of descriptions for more than 150 irrigation systems in Nepal was thereby constituted. There are "rapid rural appraisals," master's theses, Ph.D. dissertations, brief reports, field visits by expatriate advisors, and published accounts on irrigation in books by the International Irrigation Management Institute and others. In discussions with Yoder and P. Pradhan, the idea was born to create a special database focused entirely on Nepal that could then be used for policy purposes as well as for further research and teaching purposes.

Creating a Specialized, Nepal Irrigation Institutions and Systems Database

During the spring of 1991, the DFM project decided to support the NIIS project from core funds. Support was also provided from the research budget of the Workshop in Political Theory and Policy Analysis and a National Science Foundation grant. A small research team was established in Bloomington to revise and streamline the coding forms and manuals used to code diverse types of CPR resources. In that process advice was provided by Anthony Bottrall, Mark Svendsen, Robert Yoder, and Robert Hunt who all spent some time in Bloomington during the spring of 1991.

During the summer of 1991, a remarkable research team was brought together to code cases in the Nepal Institutions and Irrigation Systems database. This group was composed of:

(1) Dr. Paul Benjamin, an anthropologist from the University of North Carolina,

(2) Dr. Ganesh Shivakoti, whose dissertation on "Organization Effectiveness of User and Non-User Controlled Irrigation Systems in Nepal" was defended at Michigan State University (under the direction of George Axinn and with Ford Foundation/Delhi support) during the fall of 1991.

(3) Gopendra Bhattrai, a CIS-trained Nepali engineer, who has now obtained a Masters of Sciences Degree from the Department of Political Science at Indiana University.

(4) Wai Fung Lam and Myungsuk Lee, then two doctoral candidates in the Political Science Department at Indiana University, who are well-trained in the IAD approach and methodology. The second section of this report draws extensively from Lam's dissertation which was completed in September of 1994. Lee also completed his Ph.D. work during 1994.

(5) Julie England, Database Coordinator.

(6) In addition to those who did the coding, the NIIS database could not have been completed without the energy and creativity of Sharon Huckfeldt who created the database for the team.

The team relied on case-study materials gathered from a variety of sources in the early phases of this research. These cases varied in quality and depth; some were thorough, long-term studies of particular irrigation systems. Others were hastily written field notes from rapid rural appraisal investigations. Dissertations contained some of the best materials, particularly those by Hilton (1990), Yoder (1986), Martin (1986), and U. Pradhan (1990). Shivakoti's research on interventions in twelve systems was also extremely relevant and valuable.

In previous efforts to use a structured coding form to record information from in-depth case studies, the research relied on only those case studies that contained substantial detail. As we went deeper into the coding of the Nepal cases, we found that many of these cases contained some but not all of the variables we wanted to code. In order to supplement missing data from many of the case studies, field investigations were undertaken in December 1991 and January 1992 with funding from the Ford Foundation. Benjamin and Shivakoti worked with K. N. Pandit, Naresh Pradhan, and Bharat Mani Upadhya to visit 80 irrigation systems to fill in missing data and also check on the other questions. Help and cooperation was also received from 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.

Thus, the initial NIIS database, which is described in some detail in Appendix A, grows out of quite a long process and has been supported by sources in our efforts to obtain sufficient, high quality data. In addition to the data about 127 irrigation systems analyzed in this study, the initial NIIS database was expanded in 1993 by adding 23 further cases that has enabled the team to address some of the potential alternative hypotheses for the explanations offered herein. This supplemental analysis is contained in Lam (1994) and supports the explanations offered herein.

By undertaking the structured coding of previously written, in-depth case studies, supplemented by field visits to ground-truth the data so coded, it has been possible to obtain consistent detailed information about a large number of irrigation systems in one country. While the number of cases included in the database is still relatively small for statistical analysis, having information about more than 100 systems is essential if one is to address the simultaneous influence of institutional arrangements and engineering infrastructure. The most important finding presented in this study is that the type of external investments made in constructing "modern" physical capital is associated with *lower* rather than *higher* performance. Further, farmer-governed and -managed irrigation systems -- especially those without any modern engineering infrastructure -- outperform agency-governed and -managed irrigation systems in all terrains and sizes found in Nepal. Such findings could be considered just "flukes" without the careful theoretical analysis that explains why the incentives facing irrigation officials and farmers is consistent with this evidence.

The time between the initial visit to Nepal and the publication of this report has been six years. It is three years since the research team began to compile the Nepal Institutions and Irrigation Systems database itself. It is two years since the team first became aware of the strongly negative relationship between the presence of permanent headworks and agency management with irrigation performance. This time has been used to be sure a thorough understanding of the relationships was reached, to insure that the quality of the data was as good as possible, and to see that competing hypotheses were carefully addressed. The research findings have been presented to technically trained groups and discussed with many irrigation engineers. While there is much more to study and a larger, random sample of irrigation systems in Nepal or other countries would provide even better data for this purpose, the team feels confident in its findings. There are policy-relevant conclusions from the study which would not be made without considerable confidence in the foundations of the analysis.

There are many colleagues to thank for their input. The helpful and cogent comments made by Louis Siegel, David Green, and Larry Schroeder on earlier project reports has been a strength of the DFM project and is much appreciated. In Bloomington, the fianl paper benefitted from careful readings of various earlier reports by Roy Gardner, Robert Keohane, Mike McGinnis, Vincent Ostrom, Roger Parks, James Perry, Duncan Snidal, James Walker, and John Williams. Without the help of Julie England throughout this project, it is inconceivable how it would even have been completed. During field visits, the team was repeatedly welcomed by farmers and government officials and we are deeply appreciative of their help. A great deal was learned from them. Dean Tej Bahadur K.C. and colleagues in the Irrigation Management Systems Study group at the Institute for Agriculture and Animal Science at Rampur, Chitwan, Nepal have repeatedly extended gracious help. Walter Coward and John Ambler of the Ford Foundation have not only supported the research financially, but their cogent comments and advice has been much appreciated.

SECTION I

INSTITUTIONS, INCENTIVES, AND IRRIGATION IN NEPAL

Chapter 1: FARMING IN THE HIMALAYAS; LIVING IN A PERILOUS ENVIRONMENT

Paul Benjamin

A Himalayan Village and the Decision to Build an Irrigation System

In a small village in what was then called Salle Gaon Panchayat in Kavre District in spring 1986, just to the northeast of Kathmandu valley in Nepal, people living in a cluster of 16 households faced a problem.[1] Heads of households calculated that each household produced only enough food each year to last two to four months. They depended on two crops; maize was planted in March and depended on capricious hot season rains to germinate the seed. The other crop was *kodo* (finger millet) which was intercropped with the maize in July and harvested in November. Production for each crop was around one metric ton per hectare with kodo producing a little less than one ton and *makai* (maize) producing a little more if hot season rains were sufficient. Sometimes, though, rainfall in the hot season was scanty and the makai did not germinate or withered if it did. To supplement the food budget each year, men had to migrate to cities in Nepal or in India to find work and send money home. Women and children, during especially difficult years, would search in the forests for *tarul* (*Dioscoria daemonia*; jungle yam) which they would boil all night long to make palatable by morning.

People had realized for some time that the situation on their steep hillside home was precarious and considered a number of alternatives. They could migrate down to Chitwan District, an inner *Terai*[2] district in Nepal near the border with India. Chitwan had been cleared of malaria some 30 years before and since then, people from all over Nepal had migrated there to take up farming. Chitwan District had become, by the late 1980s, the most productive agricultural district in Nepal. The land was flat and water was plentiful; in many parts of the district, three crops a year were possible. Growing cities and markets, and now even industries, were nearby and easily accessible via good roads that traversed the district. All of the good land had been taken already, however, and land prices were high. The people in the village in Kavre realized they did not have the resources to move to Chitwan, let alone purchase land and build homes. On the other hand, if they stayed where they were, they would have no future. But they liked their mountain village and the healthful *chiso hawa* (cool air) that was available there.

There had been an idea in the village that had not, to date, come to fruition. Village people knew that there was a source of water, a small *khola* (stream), within two kilometers of their village that could provide irrigation water for their fields. If water from the khola were brought by canal to the village fields, it would provide enough water to germinate the maize seed and irrigate periodically during the hot season to end dependency on the fickle hot season rain. During the *barsad* (rains; the monsoons between June and September), the stream would provide enough water to irrigate twenty hectares of land for *dhan* (paddy). Production of rice would be at least 3 metric tons per hectare, they knew, and perhaps double that if they used high-yielding varieties with chemical fertilizer. The soil would be chiso (in this case, it means "damp") after the applications of irrigation water in the *khet* (irrigated field) and with that they figured they could put in *tori* (mustard, an oilseed) after the rice crop was harvested in November. Everyone agreed that an irrigation canal would be far the better alternative to moving to Chitwan.

Although they knew they could build the canal, they would need some capital to get it going, to purchase tools and other hardware, and cement for certain portions of the headworks and canal. A request had been pending with the district council of Kavre District for over twenty years for an irrigation project in this village. They waited for that length of time, but as one leader said, "We never got it because we didn't have a man at the top to help us," alluding to the systems of patronage for which the Panchayat System was notorious.

Some of the villagers had heard of a new program through the Agricultural Development Bank of Nepal and the Small Farmer Development Project.[3] Village leaders decided to approach the bank to see if they would finance the irrigation project. The village leaders were surprised at the speed with which their application was completed; at the end of three months, they got funding for the project. The project required that the farmers provide all the labor. They would receive a loan from the Agricultural Development Bank, which they would have to repay, and also a small grant (approximately 15% of the total cost of the project) from the non-governmental organization CARE. The loan was no problem, and the farmers were confident that they could pay it off once they started to irrigate their fields and began to produce more. The labor involved was no problem either; it would be difficult but they could do it. Parts of the canal line cut across vertical rock cliffs. The only way the canal could be cut was for rope to be tied round the waists of the men who were then lowered down to the line of the canal to work. They would work each day cutting the rock with hammers and chisels at the rate of *ek bitta* (one handspand) per day. The work was arduous and painful but the men did it without complaining. The rewards of a successful project--that they depended on and would be ensured by their labor--were too great.

The irrigation system was completed and is now irrigating 20 hectares of land. People in this village calculate that they grow eight months food supply per year but that with additional inputs, they should reach a full 12 months supply per year in the near future. The loan is fully repaid and the canal, maintained and operated by the people who built it, works.

This happy story is a contemporary example of a process that has happened thousands of times in Nepal over several centuries. There may be in excess of 100,000 distinct farmer-managed irrigation systems in Nepal, each with their own fascinating history of how farmers cooperated to develop a common resource that would benefit them all. Farmers have responded both to more and less difficult circumstances than this village faced, most often without the assistance of outside agencies such as the Agricultural Development Bank or CARE/NEPAL. Farmers have identified sources of water and irrigable farmland, found the capital and companions to do the work, and constructed the systems. They and their descendants have governed and operated them. Farmers have often assumed considerable risk in irrigation investments, not just in the usual way we view risk in investment--where you could loose your shirt--but where you could also loose your life. Cutting canals along a steep slope from the source to the planned service area is not easy and lives have been lost.

Irrigation and the Study of Irrigation in Nepal

Until recently, irrigation development in Nepal has meant the efforts of farmers to organize themselves, to invest heavily in the construction and maintenance of their own irrigation systems. For centuries, Nepali farmers have developed their own knowledge and shaped and reshaped their mountainous and often perilous terrain. Leveling paddy fields on steep slopes, making bunds, constructing headworks, building irrigation canals and ditches, setting and adjusting field canals--all this does not just happen. Individuals conceptualize possibilities; they talk about their ideas; they decide what to do first and who should do what; they argue, have conflict, and settle disputes; they build and they rebuild; they cope with floods, landslides, and droughts; and in the process they create physical and social artifacts.

Social artifacts are as necessary for the construction of physical artifacts (the paddy fields, the headworks, the canals, etc.) as the sticks, stones, earth, and, more recently, cement and gabion wire they use. Social artifacts are the rules and principles they use to organize their going concerns. This social capital is productive capacity that is created by the application of these rules and principles among individuals who know how to make them work. All who visit Nepal see terraces, both the khet (irrigated field) for rice and the *bari* (unirrigated field) for maize and millet, cut cleanly into steep hillsides from the valley floor to the hilltops. Anyone who has bothered to take their eyes off the gleaming Himalayas will be impressed with the incredible amount of work that has gone into the construction of so much on the hillsides of Nepal. The social artifacts that stand behind that construction, however, are not so easy to see. One may see farmers at work, but not the social capital that helps them coordinate what they do. One must search more deeply to reveal the underlying social structures so essential to the accomplishment of their tasks. These are, in turn, even more deeply embedded in the accumulated knowledge organized and transmitted through language and culture giving expression to the fundamental complexities with which the farmers work.

In this study, we probe deeply to understand irrigation systems. To do so, we use a theoretical lens to help us and our reader better understand how these systems work. A "theoretical lens" is an appropriate metaphor for what we are doing. The word theory is not simply abstract thinking forever divorced from practice but is, etymologically, derived from a Greek word meaning "a looking, a seeing, an observing or a contemplation, hence a speculation" (Partridge, 1983: 710). To theorize is apparently an everyday activity and very much related to practice. We are having a thoughtful look at the social and physical capital represented by Nepali irrigation systems. We discuss our theoretical lens later, and will describe the relative power and clarity this device will have for us in our attempt to understand irrigation in Nepal. This chapter provides a brief overview of the environment and agricultural practices of relevance to a study of irrigation institutions and systems in Nepal.

Description of Nepal

Nepal is 141,000 square kilometers in area. That makes it about the size of the state of Wisconsin in the U.S.A., slightly larger than England and slightly smaller than the state of Orissa in India. It is a landlocked country with India on the south, east, and west, and the People's Republic of China on the north. The country is justly famous for the Himalayas and contains within its borders the highest mountains in the world. Famous or not, most of the people of Nepal live in the middle hills and the flat plains, the Terai, adjacent to India on the south.[4] Nepal shares the highest place on earth with the Peoples' Republic of China, but it also has lands that are only 90 meters above sea level in the Terai on the Indian border. At the same latitude as the state of Florida and northern Saudi Arabia, lands at lower elevations in Nepal on the border with India and also the low river valleys in the hills, get very hot before the annual rains arrive in June. The heat offers a strong contrast to images of the high Himalayas and mystical powers to be gained in the clarity and coolness of those heights.

The people of Nepal are as varied as the geography. It is as if the movement of different groups of people into what is now Nepal is an analog of the geological forces that formed the highlands that Nepal partially occupies when the subcontinent collided into the Asian continental landmass some fifty million years ago. Speakers of Tibeto-burman languages--Gurungs, Limbus, Rais, Tamangs, Magars, Sherpas, Thakalis, Chepangs, Newars, Thami, and others--have their ancestral origins to the north and east. They migrated into the Himals and mid-hills of Nepal within the past thousand or so years,[5] perhaps growing in number after the arrival of maize and the potato from the New World made the hills and mountains more habitable.[6] People speaking Indo-European languages such as Nepali, Bhojpuri, Maithali, and others are probably more recent arrivals. Important migrations into Nepal occurred during the Muslim conquests of northern India as Hindu Rajputs fled into the hills. David Zurick has summarized most migrations into the Himalayan region, including Nepal, in the same way: "It is generally thought that the entire Himalayan region served historically as a place of refuge for diverse culture fleeing imperial conquest" (Zurick, 1989), a function often served by mountainous areas (see Brush, 1976). *Khas* peoples, "who spoke a language closely allied to Sanskrit and were a people racially akin to Brahmans," are reported to have lived in the far western hills of Nepal since the Lichvis established their rule in Nepal, or beginning nearly two thousand years ago.[7]

Hinduism is the state religion, although religious tolerance among the people of Nepal is justly famous. It is not hard to find Nepali people who will, if they encounter a *bideshi* (foreigner), enquire about their religion and if it is other than Hindu simply comment, "That's good. Everyone should have his own god." Some of the Tibeto-burman speaking groups will practice Hinduism, while others--the Rai, for example--practice a religion that is "quite distinct from Buddhism and Hinduism," and is "based principally on a body of myths and ritual recitations aimed at the periodic appeasement of ancestor-divinities and spirits associated with nature (HMG/N and Woodlands Mountain Institute, 1990). Others, still farther north in the high Himals, the Sherpas, Manangis, and others, are Buddhist, in the land where the Buddha was born. There are also Muslims, both in the Terai and in the hills.[8]

There is a caste system in Nepal with higher castes, Brahmins and Chhetries, and lower castes such as Kami (metalworkers), Sarki (butchers), and Damai (tailors). In the middle of the 19th century, an attempt was made to fit many of the other peoples of Nepal into the caste hierarchy and this led to grouping many disparate people into named groups and attributing to them certain inherent characteristics, the most indelible of which was *pani chalne* or *pani nachalne* (basically, can water be exchanged with another or not) (see Höfer, 1979). This characterization indicated, for higher castes at least, who was ritually pure enough to engage in commensal relations or any kind of bodily contact. Tibeto-burman speakers such as the Tamang, Limbu, Rai, Magar, and Gurung, nominally outside of the caste system, were given some kind of status within it and sometimes improved their caste ranking with meritorious service in war.

These two different kinds of people--the Indo-european language speakers and Tibeto-burman language speakers--met in Nepal. Although Nepali is the official national language, Nepal now has approximately forty different languages spoken within its borders. It is not difficult to discover the delight Nepali people take in the variety of peoples within the country; this is probably best expressed in a colorful aphorism attributed to one of the first kings of modern Nepal, Prithivi Narayan Shah. He said that the people of Nepal were like *sabai jat ko phulbari*, or a "flower garden with flowers of every kind."

This varied people is also growing quickly. There are, at present, approximately 18,000,000 people in the country and the population growth rate exceeds 2% per annum. Although the population ranks among the lowest in South Asia, Nepal's population per arable hectare is among the highest in Asia, reputed to be greater than that of Bangladesh.[9] The population density in the hills was estimated in 1982 to be 650 persons per square kilometer of cultivated land.[10] This large rural population has led to increased agricultural intensification, of which irrigation is a part, and external and internal migration. Nepal, however, is changing. While the majority of its population have lived in rural portions of the hills during most of Nepal's history, the population is now shifting to cities and to the Terai (see Goldstein, Ross and Schuler, 1983).

Farming in the Hills of Nepal

Household Economies

The Russian economist, A.V. Tschaiahoff, once wrote that "[t]he first fundamental characteristic of the farm economy of the peasant is that it is a family economy," and "[s]ince the principal object of peasant economy is the satisfaction of the yearly consumption budget of the family, the fact of most interest is not the remuneration of the labor unit (the working day), but the remuneration of the whole year" (Tschaiahoff, 1931). The narrative that began this chapter described the yearly consumption budget of families in a village in Nepal and how they calculated food supplies in months of the year. In Nepali villages, it is the nuclear or extended joint family that is the landholding and farming unit (see Schroeder, 1985: 38), and who consider the number of months they can feed themselves each year. Schroeder found that

> [i]n the Pokhara area, about two thirds of all Hindu farming families were nuclear families comprising a husband and wife or wives, and their children. Two, three, and occasionally four generation joint families composed of the men of a patrilineal descent group segment and their wives also hold land in common and farm together (Schroeder, 1985: 38).

Tasks in the farming household are divided both by sex[11] and age. Men do plowing, harrowing, sowing of grain, and threshing of rice. For those who irrigate, men are the ones who keep the water flowing into the khets, and as will be seen over the course of this report, that is no small task. Men cut *daura* (firewood) and wood for construction of buildings but women will carry the wood, at least the daura. Women do rice transplantation work and weed, haul manure, tend the vegetables, thresh the kodo, shuck the maize, and harvest and haul the maize and millet. Women also cut grass for fodder and share with men the task of cutting leaves from fodder trees. They share with men the tasks of harvesting and hauling the rice, with men carrying 50 kilograms of *dhan* (unhusked rice) in jute bags called *muri* (a volumetric measure in Nepal equivalent to approximately 2 1/2 bushels) while the women carry the rice straw.

Women bear the burden of the constant preparation of food and that means, among many other tasks, the husking of the dhan with a *dhiki* or footmill. A dhiki is a heavy lever made of a long beam of wood approximately two meters long. It has an axle closer to one end at which point it is pinned to two posts fixed into the ground. It is at the short end where one or two women stand to lift up the other end of the lever. At that end, there is a hammer-head that will, when the women step off the dhiki, fall into a small cavity into which another woman will be pushing dhan. The friction of the falling hammer-head will rub the husk off the kernels of dhan to produce *chamal* (husked rice) and *bhus* (rice husk). Bennett has calculated that "it takes three people to operate the footmill at maximum efficiency, and even then it takes three hours to process 25 kilograms of rice--barely enough to last a family of ten for seven meals" (Bennett, 1983: 26). In the rice production process, from planting of the rice to storing it in the farmstead, husking of rice, along with winnowing, occupies approximately 15% of the total human labor involved.[12] This tedious and occasionally treacherous process usually begins each day in the early morning well before dawn;[13] the sound of the clanking and groaning dhiki in Nepali households is an earlier harbinger of the morning sun than the cock's crow is. Another important task for women in an agricultural household is hauling the day's water. This task can, in some villages in the dry portion of the year, consume more time than any other chore, as much as four hours per day. In a beautiful village on a desiccated ridge in western Tanahun District, a man was heard to complain about the water situation: "I'll tell you how scarce water is around here! It's so bad, even men have to carry water!"

Hindu Nepal is a patrilineal society and a young woman, usually from another village, is married into the household of her father-in-law. A prime consideration in the selection of a wife for one's son is her ability to work. The young wife will work under the direction of her mother-in-law, and in Hindu households in India and Nepal, this relationship is often a point of friction (Bennett, 1983: 180-186 deals with this at length).

Children work, too, and their tasks include watching younger children, herding the cattle, cutting grass and fodder, and weeding. Boys of around ten or eleven years of age may begin to plow and girls less than ten will begin to carry water and will help with rice transplantation. Elderly men, too weak to do heavy work, will also tend cattle.

The Annual Cycle

The yearly consumption budget of households depends on an annual agricultural cycle and what farming households do during it. And the agricultural cycle, quite naturally, depends on and follows the meteorological cycle. The entire Asian rice crop is directly or indirectly controlled by the monsoons (see Nagai, 1959). Farming households anticipate the annual rains, the monsoons, for rice transplantation, just as they anticipate the drought to gather a year's supply of firewood during the driest days of the year. The thundershowers of April and May are anticipated also but while these storms are expected to fall sometime during that time, it is not an event farmers can regularly depend on and most often they will wait until a thunderstorm has moistened the earth before planting maize.

The fundamental agricultural fact in Nepal, then, aside from the mountainous terrain and population, is the annual meteorological cycle that includes four months of rain from the southwest monsoon followed by approximately eight months of drought.[14] Rainfall during the monsoons is plentiful and occasionally dangerous. For example:

> On the night of 30 June 1987, a heavy rainstorm in the vicinity of Kalinchok, a 3,750 meter peak approximately 70 km east of Kathmandu, caused numerous landslides and mudflows between the Tamba Kosi [River] and the Sun Kosi [River] in the west. The largest landslides occurred above and east of Barabesi, and resulted in the loss of many houses (perhaps as many as 100) and an unknown number of lives in the villages of Tangathali and Latu (Schelling, 1988).

While the rains are not always a constant deluge,[15] heavy rains are not uncommon and landslides and maniacal flooding follows in the steep hills and mountains.[16]

Each year, southwesterly winds blow in over the warm waters of the Indian Ocean and the Bay of Bengal. When they strike the Himals and mountains of Nepal, rain falls. The moisture laden winds are pushed up by the mountains where the air is cooled and the moisture, as it condenses, forms droplets of water that initiate the rain.[17] While the rains are less reliable on the plains of India to the south, they are reliable in mountainous Nepal. When flying into Nepal during the monsoon months, skies over northern India may be dotted with puffs of clouds, like so many balls of cotton; north to the Himalayas, however, clouds like piled up whipped cream billow up into the sky. Older people, when queried about the reliability of the annual rains, might say they can recall one year in the past fifty when rains were scant. There are years when less falls in the four month period, and this causes hardship, as with the farmers of Dang valley after the Fall harvest of 1991 when the team visited them there, who complained the rains had been light that year. The rains may, in some years be relatively light, but they are reliable.

About the middle of June, right around the first of the Nepali month of *Asar*, the monsoon rains begin to fall daily and the face of Nepal changes dramatically. The green that had put so much color into the festivals of *Dessain* and *Tihar* the previous October will have been desiccated, burned off, and made brown or black by late May. Grass in the forests will have been burned off (the yearly burning is called *dadelu* in Nepali) so that fresh green grass will emerge after the rains come. The immediate effect of this, however, is to increase the heat, blacken the earth, and fill the dusty air with smoke. The long drought and then the searing hot sun of April, May and early June scorch the earth, almost beyond redemption, one would think. But when the rains begin to fall, the earth erupts into life and becomes a startling green quickly. Not surprisingly, there is an *okhan* (saying or proverb) in Nepali that has something to say about this. It goes like this: *Srawan ma aka phuteko goro le sadain bare hariyo dekhchha* (A bull that goes blind in the month of Srawan will see only green thereafter).

The rains will fall for approximately four months and the amounts vary across the hilly land.

agriculture, farming households will strive to insure themselves from risk. In Rajasthan, the risk would be that rain will be scattered; in Nepal, the risk would more likely be that landslides or massive river erosion might take away several khet and bari or that *asina* (hail) will strike. If a household's fields are concentrated in one small area, the margin of survival--several month's food supply--could vanish in one day. Therefore, Nepali farmers have holdings that are widely scattered too, to reduce the risk of a catastrophic loss.

Another method of risk aversion is reliance on many different cultigens. Schroeder found that farmers in the Pokhara area grow four major grain crops: rice, millet, maize, and wheat. He counted over "fifty morphologically distinct varieties of wet-rice" in one village in 1979 (Schroeder, 1985: 37). Furthermore, "farmers grew a wide range of vegetable, chili, oilseed, fruit, and lentil species, estimated at over 150 different plant species in one village in a typical year" (Schroeder, 1985: 38). Schroeder concludes by saying that the high number of cultigens grown in a single small Himalayan community "gives Himalayan farmers some measure of protection against crop failure due to drought, insect infestation, and other adverse circumstances and is a major strength of indigenous agriculture" (Schroeder, 1985: 37-38). Irrigation too, is a method of risk aversion, as it brings more certainty to water supply, especially for the germination of maize and rice.

In order to grow crops in hill Nepal, then, farmers must cope with the risks and constraints and take advantage of unique environments in the hills. Farming in this environment attains further complexity when irrigation is added to an already complex mix. In addition to a canal, which may be lengthy, it will also mean construction of terraces on hillsides. Robert Yoder has discussed the construction of terraced fields for growing rice in the hills of Nepal:

> The most striking feature of irrigated agriculture in the hills is the terraced fields. To grow flooded rice, fields must be leveled and bunds built to hold the water. Tremendous labor has gone into reshaping the hillslopes into bunded terraces. This work is usually done by an individual cultivator's family although a wealthy landowner may hire labor or have it done on contract. In the past corvee labor may have been the major input for the construction of terraces.
>
> Terrace building usually does not begin until the irrigation channel is complete and it is certain that it will operate. Then year by year the terraces are built as labor is available. Expansion continues to the extent that there is enough water to irrigate or until all the land available to those who have the right to use the irrigation water has been converted to terraces.
>
> The terraces are built by constructing a rock or earth wall and then cutting away at the slope to make a level platform. If the hill is steep terraces must be narrow. The soil type determines to a great extent the slope of the outer wall of the terrace. It is made as steep as possible to minimize the amount of land used by the wall and bund, but if it is too steep it may break when it is flooded (Yoder, 1984).

Farming in the Himalayan foothills of Nepal thus is confronted with a host of risks, difficulties and opportunities. In both the hills and mountains of Nepal, human power is used to carry compost to fields, fodder and fuel from forest areas, and agricultural production to home storage areas (see Schroeder, 1985: 34). If transportation within the hills is not difficult enough, there is the burden of carving out farm land on the hills. Added to that difficulty is the arduous labor involved in bringing water to the cultivated area, often from a source many kilometers away. And although Nepal has the blessing of a reliable monsoon, there comes with that the curse of heavy rain and the landslides that will follow. Farming in the hills of Nepal is difficult and perilous and requires both great amounts of individual and collective efforts by the farmers.

Population in Nepal

The third important aspect of farming in the Himalayas, in addition to the annual cycle and the mountainous terrain, is the human population on the land practicing subsistence agriculture. The increasing population has meant increasing intensification of agricultural practices. Following Boserup, who suggested that agricultural intensification takes places in response to growth of the population dependent on agricultural production (see Boserup, 1965), Schroeder presents data that indicates that agricultural intensification has increased substantially in Nepal during the past 90 years.

> Village informants in the Pokhara valley reported that when they were children, upland fields were either single cropped or double cropped with low management crops. Currently most upland fields are triple cropped with high management crops, and are changing to inter-cropping, commonly maize planted with beans and relay planting, in which dry-rice or millet seedlings are planted in standing maize (Schroeder, 1985: 41).

Other scholars have written of agricultural intensification and population growth in Nepal. Robert Yoder also reports intensification of agriculture in Argali and Chherlung villages of Palpa. In Argali, older farmers recalled when maize was only grown on unirrigated land on the hillsides. There came a time between 1910 and 1920 when a pre-monsoon crop of maize was planted for the first time in khet land (see Yoder, 1986: 74). Macfarlane writes about the Gurungs in a village north of Pokhara and states that:

> for centuries the Gurungs were wandering bands of shepherds who practiced hunting and a certain amount of slash and burn agriculture. By the middle of the nineteenth century they were also traders over the mountains passes to the north and beginning to be famed as army recruits. During the following century, population pressure forced them to establish villages lower down the slopes, where wet rice could be grown, but herds and flocks could no longer be grazed. They now have permanent fields which they plough instead of hoeing. . . . The agricultural technology remains extremely simple and labour intensive on the mountainous rocky slopes, yet there are increasing signs of a transition from a society where there was a surplus of land and other resources and a shortage of human labour, to the reverse situation (Macfarlane, 1976: 293).

Macfarlane worked in a village relatively affluent by Nepali standards and suggests that population growth is now "pressing on natural resources even in this community" (Macfarlane, 1976: 295).

Zurick discusses a fascinating indigenous soil conservation technique that is being abandoned as an increasing population demands more agricultural land:

> During the monsoon season, when rains are frequent and often torrential, there occurs a downslope movement of soil materials in the *bari*. Farmers "break" the slope by planting vegetated barriers (*kanlo*) between cultivated fields. These capture surface materials and reduce slope length. . . . The *kanlo* act as important repositories for transported debris--materials from upper stretches of the field move slowly down the *bari* with runoff, and come to rest at the *kanlo*. A gradual buildup of soil occurs at that point. . . . [D]iscussions with farmers indicate that they specifically use *kanlo* to trap the soil, and sometimes they redistribute the accumulated material back upslope. Farmers readily acknowledge the importance of *kanlo* for slope conservation and its use is widespread in the region, even though such areas do reduce the total amount of cultivated surface (Zurick, 1990: 28).

Zurick concludes by stating:

> The current need for additional farmland in Phalabang periodically forces farmers to cut into their *kanlo* for cropland expansion. This steepens the slope and diminishes the role of *kanlo* in promoting slope stability and in reducing soil loss. It also limits the availability of plant materials, leading villagers to more intensive use of village open lands for household biomass requirements. Phalabang farmers are well aware of the implications of *kanlo* loss and generally will cut into these areas when all other options are exhausted (Zurick, 1990: 29).

As population continues to increase in Nepal, efforts will continue to be made to further intensify agriculture. Upper limits to that, however, are close at hand. Schroeder suggests that the this upper limit was reached in Kathmandu valley about fifty years ago and that further land-use intensification is not possible (see Schroeder, 1985: 41). The amount of land under irrigation in the hills may be about at its upper limit, as well.[20] The implications of this "end point," as Schroeder calls it, are important. They will ramify in areas such as soil fertility and erosion, excessive ruminant population (see Ong, 1981), loss of forest areas due to increasing demand for firewood and building materials and expansion of agriculture, loss of indigenous means to prevent soil erosion such as Zurick has observed, emigration, internal migration and the growth of cities in Nepal, and Nepal's ability to grow food for itself. For irrigation, it will mean that irrigation facilities must be as effectively governed and managed as possible.

In this regard, one of the goals of this book is to point out that farmers who irrigate in Nepal are sensitive to local conditions and environments. Farmers are knowledgeable of the factors such as those suggested by Zurick and Müller-Böker and incorporate them into their land-use and cropping strategies. In the same way, farmers who act collectively to irrigate their land craft rules among themselves for the governance of their irrigation organizations to fit within the constraints of local circumstances.

Collective Activity for Rice Planting and Irrigation, Shifting Perceptions of Time, and Scheduling of Holidays in the Annual Cycle

About four to six weeks before the rains are expected to arrive in many areas of Nepal, irrigation system executive committees will convene meetings of all irrigators. At these general assemblies, farmers will set the dates when all members of an irrigation organization are required to commit several days of labor for the cleaning and repair of the canal and river headworks. For those irrigation systems that have a reliable source of water for spring transplantation of rice, these meetings will occur in January or February. The canals will be cleaned and the headworks repaired over a period of days specified by a general meeting. Farmers will want to have that work completed on time so that all can prepare their *biyad.*

A biyad is a small, irrigated plot of land used to develop rice seedlings from rice seed. Water is in scarce supply in the month of Jeth just before the monsoons are anticipated to arrive, and, in most of the irrigation systems in Nepal, water cannot be provided to all of the khet at this time. So farmers get a head start on the monsoons in the month of Jeth by using scarce irrigation resources during the hot season to irrigate small plots of land, the biyad. Rice seedlings will be grown densely there until the rains arrive in the following month, at which time they will be transplanted to the khet.

When the rains begin in earnest, the canals will be ready to begin distribution of water for the preparation work in each khet. If rains are insufficient to provide water on demand for each farmer to transplant, the water will be rotated on specific days of the week to particular plots within the service area. On an assigned day for each khet after rains have begun to fall regularly in June, the seedlings will be carefully removed from the biyad, tied together in bunches, and carried to the khet. The woman who does this will be called the biyadey. There they will be transplanted by women, called, for this task, *ropar*, working in lines across the khet. Each women, bent at the waist, will slip a seedling into the mud neatly and cleanly, and back up to plant another one. Men, resting from their labors a short distance away, will marvel at the skill the women have, replying when asked that, no, there is no religious sanction prohibiting men from transplanting rice: "We just don't have the skill." Men, for this task identified as *bausey*, will have prepared the khet, flooded the fields with water, reconstructed the *dil* (the bund), and broken up the structure of the soil, except for the nearly impermeable hardpan about five inches below the surface of the soil that keeps the water in the khet from seeping out quickly. When the khet is fully prepared, the mixture of soil and water churned repeatedly appears to have the consistency of soggy American breakfast cereal.

People will work in the fields at this time in *parma* teams, groups of farmers who exchange labor with one another (see Messerschmidt, 1981). Although rural Nepal may have a surplus of labor most of the rest of the year, at rice transplanting time there is an acute shortage of labor. Parma is a common means to mobilize labor to cope with this shortage in many communities in Nepal.[21] Consciousness of time is heightened in Nepal during rice transplantation. Foreigners, driven to distraction by what they think is a lack of consciousness of time on the part of Nepali people in serious matters, such as the project the foreigner is interested in, would be astonished at the punctuality of Nepali farmers at their parma dates. If a farmer misses his parma date at his neighbor's field, then that neighbor will choose to miss his parma date at the first farmer's parma. It is too important a time to be late or absent. In the event irrigation water is rotated, parma dates then will be adjusted accordingly. In arranging labor for parma, each farmer will specify his needs usually at the ratio of one or two biyadey, two bausey, and four ropar.

Nepali's have another okhan, this one to characterize the urgency of time during Asar and Srawan; it goes: *Ey! Moreka buwalaie pani kat muni rakhnu parne bhela bhyo!* (Gads! The time of year has come when I'd even have to stuff the corpse of my father under the bed!) The death of one's father is understandably a serious life-event in any person's life in any culture; among patrilineal people such as Hindu Nepalis, it is especially so. A son is expected to participate in prayer that will insure the passage of his father into heaven. A son's time is *totally* occupied during the 13 days of the *kiriya* rites that follow the death of a parent. He is isolated from society and is considered impure, polluting to the touch. The okhan cited above is a jest that brings two utterly crucial events into the same time-frame and suggests that planting rice is even more important than burying one's father. It would not be, of course, but it is reflective, in this jesting way, of the urgency of time during the months of Asar and Srawan in rural Nepal.

The annual cycle is crucial to understanding how agriculture works in Nepal and important to understanding Nepali culture as well. The scheduling of holidays in Nepal follows closely the amount of labor required in the fields. There are scarcely any holidays during the time when the rains first come; the only respite farmers get is each fortnight, during *purni* (full moon day) and *aunshi* (new moon day) when it is forbidden to plow. But after the rice is well under way so that further weeding is not necessary and the majority of the work, save the harvest itself, is done, festivals for which Nepal is famous begin. This is not the place to describe them in detail but they begin in late August and end, for the most part in late October, just before the fall harvest. The holidays include *Teej*, the festival for women who dance and sing the whole day and continue with *Goi Jatra* (festival of the cow), an often hilarious time given over to gross satire of the sitting government. The major holidays are Dessain, a celebration from the Hindu epic Ramayana, and Tihar, a festival that includes *bhai tika*, an important family ritual and feast. This is a time of happiness, just before the harvest, and when people in the village get a new suit of clothes. Tailors are busy, the skies are clearing, daughters return to their natal homes with new children, back from the house of their fathers-in-law, and the village is a happy place.

But perhaps the most telling holidays, at least for agriculture and most reflective of the extreme dependence on the annual cycle, are the holidays of *Maghe Sankrati* and *Srawane Sankrati*. *Magh* is a month in Nepal, beginning in mid-January and ending in mid-February and Maghe Sankrati is a feast whose main dish is tarul, the jungle yam mentioned in the story that began the book. Tarul is eaten on this day in January because it symbolizes the beginning of a time of want, for the harvest is now already two months past and there will be little production for the next several months. Srawan is also a Nepali month, this one beginning in the middle of July. It occurs just after the rains have come, when there is an assurance, once more, of plenty. Meat is eaten on this day, normally a luxury in almost any rural Nepali household. Just after the commencement of the rains, a feast of meat symbolizes plenty. People might say on this day, *Aba mordaina* (Now I won't die), meaning that the days of want are over. This is not merely some superstition that primitive people embroider their lives with but it is a sage understanding of when people die in Nepal. It is during those hot and dry days of want that both morbidity and mortality rates are high in Nepal. If food and water are scarce, the very young and the very old will be most susceptible to disease and death at this time. These two holidays tell of want and plenty and the annual shift from one to the other according to the change of seasons.

Notes

1. Material for this narrative comes from field notes from the dissertation of Paul Benjamin (1989).

2. The *Terai* and Inner *Terai* are geographic divisions of Nepal. The Terai is the border of land in southern Nepal that abuts the of hills, the Siwaliks, on the north and the border with India, on the south. It is flat and agriculture is easier there, although it can be terribly hot during the May, June, July, and August. The Inner Terai, or *Bhitri Medesh*, is composed of broad, low valleys such as the Rapti Valley in Chitwan and Makwanpur, the eastern portion of Naral Parasi District, Dang and Deokuri Valleys in Dang District, and Surkhet Valley in Surkhet District, just to the north of the Siwaliks.

3. The Agricultural Development Bank of Nepal is a semi-public bank dedicated to investing in agriculture in Nepal. A highly successful program of the Bank is the Small Farmer Development Program where farmers with few resources are given loans for agricultural development projects, including irrigation. Unlike traditional loans, however, the collateral for these loans is provided by a group of other farmers, usually the loan recipient's neighbors and kin, who are also members of the local Small Farmer's group. The idea is that enormous social pressure can be brought to bear on anyone who renegs on a loan because it is that person's closest neighbors and kin who will be required to repay the loan in that event.

4. For anthropologists and others who have spent time in Nepal, the flight from Kathmandu to Pokhara on Royal Nepal Airlines is not the frenzied competition for the seats on the right side of the aircraft for the splendid view of the Himals to be had there, but a leisurely stroll to the unoccupied window seats on the left side where spectacular views are available of villages and agricultural fields, the artifacts of Nepali farmers in the hills of Nepal.

5. Gurung (n.d.) has postulated that "Mongoloid groups" had migrated into Himalayan hills as long ago as 2,000 B.C.

6. von Fürer-Haimendorf (1964) suggests that adoption of the potato by the Sherpas in the mid-19th century enabled them to expand their population. He states: "The population of Khumbu was a fraction of its present size until the middle of the nineteenth century and there can be no doubt that the great increase of the last hundred years coincided with the introduction and spread of the potato. In 1836 there were in the whole of Khumbu only 169 households, compared with 596 households in 1957. No great imagination is required to realize that the introduction of a new crop and the spectacular increase in population must have been connected" (1964: 10). See also Regmi (1978b).

7. See Bista (1972: 2). See also Acharya (1963) and Tucci (1962). Zurick (1989) presents some interesting figures about the Khas in an area he studied in Salyan District in western Nepal. Documents he has looked at indicated that Khas were a recognized group in western Nepal until the beginning of the 19th century. Data available to him now shows that there are no Khas in the area but nearly the same percentage of total population that once had been Khas are now identified as Brahmin and Chhetri, high caste Hindus.

8. There are Muslim villages in the hills of Tanahun, Palpa, Lamjung, and Gorka districts. Their presence in these areas is probably at least two centuries old.

9. Schroeder (1985) states, citing Tuladhar (1977): "In 1971 the hill and mountain areas of Nepal had a population density per unit of arable land that was much greater than that of Bangladesh where double and triple cropping are more agronomically feasible and the land is more productive than in most of Nepal."

10. See Agricultural Development Bank of Nepal/His Majesty's Government of Nepal, n.d. This "fact," like other "facts" in Nepal is subject to a fair amount of error. For example, Kingsley Davis "calculates the number of persons dependent for a living on each square mile of arable land" and he comes up with 1225 (cited in Poffenberger, 1976: 1). That works out to 456 persons dependent on agriculture per square kilometer, 200 less than the 1982 estimate cites here. It is not likely that this difference could have occurred within seven years. Thompson and Warburton (1985) have written at length about the problematics of uncertainty and policy formulation.

11. Material here on the sexual division of labor in farming has been taken in large part from Schroeder (1985: 39). Bennett (1983: 24) describes the division of household farm labor in similar terms.

12. Calculated from data from Macfarlane (1976: 128). It is not clear from the information Macfarlane presents, however, if the labor required to repair the irrigation system is accounted for.

13. Work with the dhiki involves timing. If there is more than one woman operating the device, the one who pushes the dhan into the cavity must be sure to keep proper time with the rhythm set by the one or two women standing on the dhiki. If she does not or if the woman's foot slips off the dhiki, the woman pushing the dhan into the cavity might have her hand crushed.

14. This contrasts with American industrial agriculture where "[t]o the extent possible, nature is diminished as a factor of production" (Strange, 1988: 381).

15. A Peace Corps volunteer once told one of the authors that at any particular moment during a typical monsoon day: "it has just finished raining, it is raining, or it is about to rain."

16. The Nepali expression for deluge of rain would be *bhola pani* (crazy or maniacal water).

17. Known as an orographic rainfall effect.

18. Zurick (1990: 27) assumes a "lapse rate" of 6.4°C per 1,000 meters of elevation.

19. Nepali farmers are not unlike "smallholders" in other parts of the world who are, in Robert Mc. Netting's words, successful because of their "amazing bag of techniques and an expert, practical grasp of their own farms' micro-ecology."

These fundamental bases of farming in Nepal--the annual cycle, the mountainous terrain, and the population--do not take into account another crucial factor the farming household must consider in its subsistence. Land tenure and taxation policy has been an important consideration for the farmer. It has hardly been a constant factor over the past two centuries and varies spatially. Regmi has written:

> The most conspicuous feature about the system of land tax assessments in Nepal is its motley character. In general, the form and level of assessments differ not only from district to district, but often even from holding to holding (1978a: 72).

He adds that:

> In the country as a whole, lack of uniformity in the form of assessment is characterized by assessments in cash or in kind, the imposition of numerous supplementary levies in addition to the main assessment, and in the prevalence of different currency systems (1978a: 72).

The influence the government has had on farming and irrigation will be discussed in Chapter 2.

20. Yoder: personal communication.

21. Bennett (1983: 23-24) suggests that most of the laborers that are exchanged through parma are women and that the "major responsibility for arrange and scheduling the work of these groups falls to women." This might vary in different areas and may depend on the number of males who have migrated to India for work or who work in cities in Nepal. In Dolakha District, to the northeast of where Bennett worked, parma tasks are arranged by the head of the household, usually a male.

Chapter 2: HISTORICAL BASIS OF IRRIGATION IN NEPAL

Paul Benjamin

We have seen in the previous chapter that physical factors such as the mountainous terrain and the annual cycle affect agriculture in Nepal. We have also seen that increasing population in Nepal has apparently contributed to the use of a variety of agricultural intensification techniques, of which irrigation is important. This chapter attempts to trace the development of irrigation in Nepal by examining the political context of Nepal and incentives the state initiated for the expansion of agriculture, for the development of irrigation in Nepal has taken place in a context of state formation. We will also take a look at how the unification of many small principalities into the modern state of Nepal in the late 18th century and a variety of state policies on taxation and land tenure shaped behavior of cultivators and landlords in agriculture.

Irrigation Prior to 1950

Evidence on the extent and development of irrigation in Nepal prior to 1950 is scanty. Most of the published information on irrigation comes somewhat indirectly via the work on land tenure and taxation from Mahesh Chandra Regmi.[1] Primarily, Regmi discusses the plethora of land tenure systems and myriad of taxation regimes in Nepal in the late 18th, 19th, and early 20th centuries. His references to irrigation are occasionally direct but usually, they are in the context of state policy with regard to revenue to be obtained from the cultivator and the kind of land tenure systems in Nepal. A variety of land tenure systems existed to serve purposes of the state, military expansion, and maximization of revenue to the state. The state applied a series of policies designed to provide incentives to the farmer to expand the area under cultivation and, once the farmer had expanded production to that point, keep him there at the highest taxation rate possible.

Regmi does discuss irrigation more directly, and before moving on to the incentives and constraints the state applied, we will deal with the evidence he provides on irrigation. In *Thatched Roofs and Stucco Palaces*, Regmi (1978b) cites observations of two Englishmen in the 19th century, perhaps for want of other historical materials on irrigation from Nepali sources (Regmi, 1978b). H. A. Oldfield recorded that only one crop a year was grown in Nuwakot, because of "the excess of moisture in the *byasis* (river valleys) and the total want of artificial irrigation in the *tars*" (Oldfield, 1971: 62), the plateaus often found on either bank above rivers in Nepal.[2] Orfeur Cavanagh also commented on the absence of irrigation:

> Although the country is everywhere interspersed with streams, which might be made available for the purpose of irrigation, and the people are perfectly well aware of their great value in this respect, yet from not possessing the means of conducting the water to the high grounds, a large portion is entirely wasted and land which might otherwise afford a profitable return to the cultivator remains unutilized (Cavanagh, 1851: 154, cited in Regmi, 1978b: 11).

Regmi concludes that "there is little evidence to show that irrigation facilities were much developed in any part of the country." He went on to suppose that irrigation facilities may have "remained undeveloped because of the peasant's inability or unwillingness to finance irrigation schemes. Construction of new irrigation channels was usually a costly enterprise. Moreover, such channels often passed through the fields of several peasants, and this gave rise to disputes and litigation. Their construction required cooperative effort which only rich and influential farmers were capable of organizing" (Regmi, 1978b: 11).

In the absence of more historical evidence, Regmi's discussion is necessarily speculative; the history of irrigation development is an important area for future irrigation research in Nepal. Regmi suggests that the financing of irrigation systems was problematic and this is certainly so even today. He suggests that only wealthier farmers would be in a position to develop irrigation systems. But whereas it might have been easier for a wealthier farmer to do so, perhaps especially a *birta* grant owners,[3] this does not mean that Nepali farmers have not had the means and the abilities to construct these irrigation systems. Regmi suggests that "channels often passed through fields of several peasants, and this gave rise to disputes and litigation." Although organizations for the development of irrigation are not easy to construct, the team found in its work that Nepali farmers are often highly skilled in building organizations that successfully deal with the problems Regmi identifies.

If irrigation was not well developed, on the other hand, intensification, such as irrigation, may not have been necessary until this century.[4] Farmers were producing for households and not for the kind of markets that Cavanagh must have observed in India in the 19th century. We have seen Schroeder's suggestion in Chapter 1 (page 9) that intensification of agriculture practices in the hills of Nepal have followed population increases. Intensification of agriculture in the 19th century in Nepal was limited; land was in abundance such that even slash and burn agriculture was practiced in some areas. Irrigation, as an example of agricultural intensification, may not have been used as much for the same reason that practices mentioned by Schroeder were not used; with a much smaller population in Nepal, irrigation may not have been needed. Pressed by the state for increasing revenue, however, peasants may have been driven to expand agriculture. In this regard, Regmi suggests that for the period between 1768 to 1848, that

> The legal and administrative arrangements made to protect the rights of the privileged Birta and Jagi[r] owning classes inevitably meant corresponding limitation on the rights of the cultivator. It therefore became impossible for the cultivator to take advantage of the abundance of cultivable lands and improve his bargaining power in respect to both security of tenure and level of payments (Regmi, 1971: 75).

In other words, regardless of the lack of population pressure on the land, cultivators may have a been pressed by the state and *birtawals* to intensify agriculture.

Regmi discusses irrigation in Kathmandu valley, which was apparently well irrigated in the 19th century, and cites British observers who noted irrigation there. The British Residency surgeon during the early 1860s, Dr. Daniel Wright, noted that "every available scrap of ground is cultivated, the hill-sides being terraced wherever water can be obtained for irrigation" (Wright, 1972: 46). Another observer, Sir Richard Temple, who visited Nepal in 1876, said that "one special cause of the fertility [of the soil] is the artificial irrigation from the countless streams and streamlets from the neighboring hills" (Temple, 1887: 227). In another work, Regmi notes irrigation in Bhaktapur in Kathmandu, and states that "[e]laborate arrangements existed for the maintenance and repair of such irrigation channels, and rights to utilize irrigation facilities were carefully regulated" (Regmi, 1971: 18; Regmi uses material here from Paudel, 1965: 46-48). Regmi warns that Kathmandu valley "represented an island of high agricultural productivity against a general background of inefficient and extensive farming practices" (Regmi, 1978b: 12).

It might be as difficult to conclude, from this vantage point and in the absence of much evidence, that irrigation was not developed as to conclude that it was. The team has data on the ages on 109 irrigation systems in Nepal, however, and 33 of them have their origins prior to 1900; 13 of those were operating before 1800. Other evidence of irrigation in the Himalayas exists as well. Raj Kulo of Argali in Palpa was built, "as legend has it," by Mani Makunda Sen, a Sen raja of Tansen, 350 years ago. "He stubbed his toe on a *murti* (religious icon) while bathing in the Kali Gandaki at Riddi and built a temple on the spot. To support the temple priests that he brought in, he dug the Raj Kulo and established a *guthi* for it"[5] (see below for definition of guthi). In the Kangra Valley of India, an area similar to hill Nepal west of the present border with India in the Himalayan foothills, irrigation networks were "noted by the British as early as the middle of the 19th century when they initiated their procedures for assessing taxes in their newly acquired territory" (Coward, 1990: 78). Berreman, on the other hand, cites an observer who, in 1907, reported that "only 3 per cent of all cultivated land in Garhwal was irrigated, and 8 per cent in Almora" (Berreman, 1972: 47), mountainous areas just to the west of Nepal in India. That area is drier during the rainy season than most of Nepal is, however. There was irrigation activity in the hills, perhaps more than Regmi suggests, and perhaps in some places as much as was going on in Kathmandu. *Exactly* how much is not clear even today.

The Unification of Nepal

By the middle of the 18th century, the Mogul Empire in India was long past the grandeur of the late 16th century court of Akbar. It had entered into a decline that would eventually result in the rebellion of Sikhs in the north, Marathas in the south, and wars among the Himalayan principalities. Mogul suzerainty could no longer keep the peace and former satrapies could exercise their ambitions independently. At roughly the same time, the British, in form of the British East India Company, were expanding their role as traders and closing out what remained of French influence on the Sub-continent. With the decline of Mogul power, Hindu people in outlying areas began to act with a new autonomy while the British moved into Bengal and founded Calcutta.

Nepal, as it is presently known, was at that time a collection of many semi-autonomous principalities. There were at least two large confederacies of principalities, call the *baisi* (a word meaning twenty-two) and *chaubisi* (twenty-four) *rajya* (kingdom) in what is now western Nepal. They were, as their names imply, composed of twenty-two and twenty-four kingdoms each. In addition to these, there were the three kingdoms of Kathmandu Valley (Kathmandu, Patan, and Bhaktapur), the Kingdom of Gorkha, and several more principalities to the east. The three cities of Kathmandu Valley were wealthy, not only in agriculture but also in trade and handicrafts. The Kingdom of Gorkha was a relatively insignificant hill state, notable for its lack of mineral wealth and, relative to the other states, agricultural resources. Yet it was this hill state, Gorkha, that set about to conquer the wealthy cities of Kathmandu Valley and then turn upon its old enemies in the baisi and chaubisi rajyas. In about fifty years of warfare, the Gorkhalis succeeded, even beyond the extent of Nepal's present borders. Why should the impetus come from the small, poor hill state of Gorkha? Historian Ludwig Stiller answers: the leadership of Prithivi Narayan Shah, the unifier of Nepal (Stiller, 1973).

We will not go into the history of unification here but concern ourselves only with the impact of unification on agriculture. Military expansion continued in Nepal until 1816, when the British defeated the Gorkhalis at Makwanpur, in south-central Nepal.

Nepal has been for all of its history a rural, agricultural country. Trade has coursed through its borders, from both the north and the south, but its magnitude and exotic origins were only great enough to attract the attention of the British, not to sustain it for very long (Pemble, 1971). There has been a long tradition of handicrafts in Kathmandu valley and the production of bricks there. Elsewhere in the Kingdom, there has been mining, paper production, and munitions production. Chain-link pedestrian suspension bridges, built of iron mined, smelted, and forged locally, still stand today as a tribute to the skill of early iron workers. And paper was manufactured in Nuwakot that was said to be of particularly fine quality (Regmi, 1971: 18). Overwhelmingly, however, people have been farmers. The state has realized its revenue, until fairly recently, through taxation on agricultural lands.

As a first consequence of military action, one can suppose that taxation to support lengthy and expensive military campaigns was burdensome on the peasants. And this was so. Tax free birta land grants in newly absorbed principalities were confiscated by the growing state of Nepal and converted to taxable lands to support the military; the previous owners of birta grants were often given cultivation rights, but only if they paid half of their production to the state. Discussing confiscation of birta grants that occurred around the beginning of the 19th century, Regmi states:

> These measures thus diminished the status and earnings of the cultivator and even sought to restrict his freedom and convert him into a virtual serf. It was hardly surprising therefore that, at least in a few cases, the dispossessed Birta owners preferred to surrender their farmsteads rather than submit to such degradation. As a result, cultivated lands reverted to waste at some places, while some areas were entirely depopulated (Regmi, 1971: 76).

In a similar vein, Stiller reports that in 1810,

> word came to Kathmandu that the farmers were deserting the land in Doti, Kumaon, Accham, and Dullu-Dailekh. And in 1815, the farmers of Chainpur complained of excessive demands being made on them by the military in that area (Stiller, 1976: 72).

And in areas where Gorkhalis were waging war fought far to the west in 1806, in what is now the Indian state of Himalchal Pradesh, the state of affairs was described by the Kangra Gazetteer:

> For three years this state of anarchy continued in the fertile valleys of Kangra; not a blade of cultivation was to be seen; grass grew up in towns, and tigresses whelped in the streets of Nadaun (Punjab government, 1813-1814, cited in Stiller, 1973: 238).

Stiller also writes of the likely increase, during this period, of slavery and bondage (Stiller, 1976: 62). During a time of warfare and expansion, rents, particularly *kut* rents,[6] were high and tenancy was insecure, both for landlords and cultivators. Irrigation involves mobilization of relatively large amounts of labor, land, and capital, and pays back the investment over a long period of time. It can be said, that if cultivation was as difficult and tenancy so insecure as has been described above, it is likely that irrigation did not expand at all; it may have declined. Without security of tenure, the investments in the construction of an irrigation system would not have been worthwhile. And without regular and annual maintenance, irrigation canals quickly become unusable. It is not hard to imagine this happening in the first two decades of the 19th century in Nepal.

The burden on the peasant in Nepal did not lighten after the war either. Stiller suggests a number of reasons but perhaps the most important was the nature of the expansion of the state in a land that made communication extremely difficult. While no new technology was introduced to expand national wealth, costs of administering a larger country increased. Stiller suggests:

> The mini-states that existed in the hills of Nepal before unification were the most efficient economic units that the hills could support. Communications were simple, central government was small, and the cost of administration on the village level minimal. On the other hand, any combination of two or more of these mini-states into one larger unit dramatically increased costs. The farther removed the village was from the center, the more imperative it was to have some sort of central supervision in the village in the form of a government officer or government revenue collector. Communications between this man and the center had to be maintained. And the central government had to be expanded to meet this need plus increased costs in defense and public security. When the area united under one government involved not two or three such mini-states but scores of them, the costs increased steadily. . . . Unification necessarily involved increased costs for administration (Stiller, 1976: 74).

Unification was not necessarily a blessing for cultivators in Nepal and during the wars that brought principalities together and for many years after, it is not likely that irrigation practice expanded much in Nepal. The comments of Cavanagh, circa 1850, quoted above, followed close after this time; if irrigation was sparse in Nepal at that time, it may have been because of the predations of war and the insecurity of the years before.

Land Taxation and Agriculture in Nepal

The purposes of government until 1950 were not dedicated to the provision and production of public goods and services but, as Mahesh Chandra Regmi has pointed out in several books, extraction of revenue and maintenance of order, if not law, in the kingdom. The policy of taxation on agricultural land, therefore, was geared toward the goal of increasing revenue to elites in Kathmandu, not toward the welfare of the peasant who tilled the land or for improving national aggregate production in agriculture as part of an overall economic policy. For example, Regmi stated that "[t]he Gorkhali rulers attached considerable im[p]ortance to land reclamation and settlement" (Regmi, 1971: 143), and cites an order from Prithvi Narayan Shah:

> In case there are houses on lands which can be converted into fields, these shall be shifted elsewhere; irrigation channels shall be constructed, and the field shall then be cultivated (Naraharinath and Acharya, 1953, cited in Regmi, 1971: 143).

"The primary objective of land reclamation and settlement," Regmi continued, "was to increase revenue and thus finance the growing military consideration" (Regmi, 1971: 143). Earlier in the same book, Regmi cites a letter to a general from Prithvi Narayan Shah that illustrates the fundamental concern for revenue when he described the Terai as "superior and revenue-yielding territory" whereas the hill region was an "inferior territory" in that regard (Anonymous, 1955: 13, cited in Regmi, 1971: 9). In another work, Regmi sums up:

> Seldom do we find steps taken purely with the objective of increasing production or improving the condition of the producer. In other words, the economic policies of the state were determined primarily to suit the interests of the political elites, not those of the producer or the trader (Regmi, 1984).

With this perspective, the rulers of Nepal in the 18th, 19th, and first half of the 20th century provided a number of incentives to farmers to increase the amount of land under cultivation and also a number constraints to keep them from reducing their obligations once they took advantage of incentives the government offered.

Incentives to Expand Cultivation

Regmi discusses a variety of incentives the rulers of 18th, 19th and early 20th century rulers of Nepal introduced to expand cultivation in Nepal (Regmi, 1978a). No attempt will be made here to provide an exact chronology of policies and how they fit within the state of Nepal at the time; rather, the idea here is to provide the general pattern of incentives that the state was willing to provide for expansion of agriculture. The general idea was to give a tax break to those who would reclaim land. The remission period was generally three years. This period of time was probably long enough to make an irrigation system and *khet* productive; it takes time to get the water to flow in the canals and it takes time for the development of a hard-pan in the khet to prevent excessive seepage and percolation of water. Sedimentation--that is, new soil that is brought in by the irrigation water into the khet--also takes place during the first years, so during the initial period, the soil is not likely to be as fertile and productive as in following years. A period of three years, therefore, may have only been enough to cover the losses a farmer would normally take during the first years of reclamation of lands for irrigated agriculture.

The Law on Reclamation of Wastelands has been effective since 1853 and remains in force to this day. One rule clearly states incentives to encourage cultivators to irrigate:

> Dams or irrigation channels may be constructed on any land, cultivated or uncultivated . . . to bring into cultivation any land . . . No obstruction shall be caused. The owner of the land shall be compensated with the value of the cultivated land taken up by the dam or irrigation channel, or given other land in exchange. But if the land that is thus taken up in uncultivated land is not liable to taxation, no compensation shall be paid. When landowners incur expenditure on irrigation works to bring waste land into cultivation, if the tax on the newly cultivated waste land is double that being paid on the cultivated land taken up by the dams or irrigation channels, the tax for the land taken up by the dams or irrigation channels shall be remitted (Regmi, 1978a: 244).

As part of the Law of the Realm (*Muluki Ain*), the *raibandi* system was introduced; it was a system where lands that belonged to the state "were to be redistributed in proportion to the available area among the local population on the basis of 'physical capacity and the size of the family'" (HMG/N, 1870: 51-2). Regmi further described this provision: "any person who reclaimed wastelands and constructed irrigation facilities thereon with his own resources could retain them even if his total holding exceeded the area that would otherwise have accrued to him through redistribution" (Regmi, 1978a: 523). Regmi went on to say that these provisions were no innovation but "merely gave statutory form to a long standing custom" (Regmi, 1978a: 523). This suggests that there was substantial incentive to bring irrigation to lands that one cleared oneself. The land would become one's own.

Constraints on the Farmer

We've already discussed excessive taxation after unification and its impact on cultivators in Nepal. Following unification, there was another consequence for the farmer and that was a lack of choice. That is, prior to unification, a cultivator had a choice of governments, limited perhaps, but an ability to choose better conditions if he saw them. The many principalities that existed in the Himalayas were sufficiently small that costs of movement from one to another would have been small. If one kingdom could not provide terms of tenancy, taxation, and compulsory unpaid labor due to the local *raja* to the cultivator's liking, he could pack up and move out to the next kingdom over (Stiller, 1973: 51). After the unification of Nepal, this choice was no longer possible, except from one birta to another.

Beyond this, however, farmers were constrained by a number of other factors. While there were incentives provided by the state to reclaim land, once the land was reclaimed it could not be returned to an uncultivated state. After the period of time for tax remission elapsed, the land would be taxed at the assessed rate, even if the land was not producing (Regmi, 1971; Stiller, 1976).

Beginning in 1889 in two districts and spreading slowly in tax settlements in other districts, attempts were made to divide agricultural land into several different grades (Regmi, 1978a: 56-57). By 1934, the gradation formulae were devised for determining the grade of khet land. They categories are *abal, doyam, sim, chahar,* where abal is graded to be the highest, most productive soil.

While this gradation of soil is an understandable attempt to relate productivity to assessment, in practice it did not always work out that way, especially in the Terai. In the hill districts and Kathmandu Valley, Regmi states that "the grade is determined separately for each plot of land" whereas in the Terai, "it is the usual practice to grade each village or even each revenue subdivision separately" (Regmi, 1978a: 61). Regmi cites a report that states

> [t]his meant injustice and great hardship to the people. Ninety-five per cent of the land was graded as *Abal.* Downgrading in the course of subsequent settlements was prohibited, although upgrading was permitted (HMG/N, n.d.: 1, cited in Regmi, 1978a: 61).

Regmi goes on to suggest that these practices were not limited to the Terai but may have extended to Kathmandu as well.

Land Tenure and the Development of Irrigation in Nepal

Irrigation in Nepal has developed through several different forms of land-tenure and circumstances. These included guthi or religious trusts, land deeded for the maintenance of a religious institution, such as a temple or priest. According to Regmi

> The Guthi system has its origin in the endowment of land and other forms of property for the establishment and maintenance of religious and charitable institutions such as temples, monasteries, schools, hospitals, orphanages, and poorhouses (Regmi, 1978a: IV, 629).

In the case of Raj Kulo, the Sen raja endowed a temple with produce from land he had irrigated. U. Pradhan discusses irrigation on guthi lands:

> As certain temples, both Hindu and Buddhist, were endowed with land by someone influential, irrigation systems were built for lands endowed to the temple . . . . Temples needed a steady income for financing the services of a priest, some caretakers, its maintenance, and for daily offerings. The irrigation system would irrigate the endowed lands and the resulting higher produce could finance the needs of the temples better. The priests and the caretakers would sometimes be the very tenants of the land endowed in this manner and the yield would be shared among them as remuneration for their services (U. Pradhan, 1990: 42).

Common people too could form a guthi. Alternatively, it is possible that members of a guthi, and not just the priests and caretakers, who might also have been tenants on land that endowed charitable purposes, could have augmented the value of their charitable investment by building an irrigation system. The farmers would thereby help themselves and increase the income of their guthi as well.

Individual initiatives, not so much the rugged entrepreneur characterization familiar in the west, but of a courtier or soldier rewarded by the king for service with a birta grant, were the basis for construction of irrigation systems as well. Birta was a land tenure system in Nepal that Regmi notes has sometimes been defined as "an assessment of land revenue to the Birta land holder" (HMG/N, 1956: 254, cited in Regmi, 1978a: 254). Regmi points out, however, that a birta grant often endowed the grantee more privileges than just the right to appropriate land tax; they included other taxes and duties, and "monopoly export duties on hides and skins and revenues from the sale of liquor" (Regmi, 1978a: 256). A *birtawal* (holder of a birta land grant) could also evict a tenant and was "entitled to exact unpaid labor from the people inhabiting the area mentioned in their grant" (Regmi, 1978a: 257). The birta owner also possessed judicial authority and could collect fines. Birta owners could be said to have performed governance functions for the state; Regmi outlines the nature of this authority:

> In an age when transport and other difficulties constituted a serious impediment to the adequate expansion of the administrative system, such a practice enabled the government to provide for the fulfillment of an elementary obligation at the local level without any financial encumbrance. On the other hand, it not only buttressed the Birta owner's influence and authority within his

area, but also brought in a welcome increment to his earnings in the form of fines. Since fines imposed by the Birta owner accrued to him as personal income, the Government was assured that justice would be meted out and enforced rigorously (Regmi, 1978a: 258).

With this authority, a holder of a birta, particularly a large birta grant,[7] could draft tenants to provide labor in the construction of an irrigation system. The accumulation of capital from land revenue and fines would allow him to finance it. The increase in agricultural production of the land would increase his own tax revenue, which was based on a percentage of the crop. It is likely that a majority of irrigation systems were constructed by holders of birta grants and what otherwise Robert Yoder has called "the coercion of the state" (Yoder, 1984). Slave labor may have played a part in the construction of irrigation systems, particularly those of birta holders. Schroeder writes that "slaves and indentured servants at one time did much of the wet field plowing and other heavy work in middle hills Hindu communities" (Schroeder, 1985: 39). If such slaves were involved in plowing of khet, they probably were also involved in construction of irrigation systems as well. *Jhara*, a form of compulsory and unpaid labor exacted by the state in its capacity as landlord, was utilized in the reclamation of wastelands and the repair of irrigation channels in Kathmandu Valley after the Gorkha conquest in 1775 (Regmi, 1978a: 504-505).

Another form of land tenure was *jagir*. Jagir was a "temporary assignment [of land] intended to compensate the *Jagirdar* for specific services rendered by him, and terminable at the discretion of the government" (Regmi, 1978a: III, 465). The security of tenure of these lands was generally less; they were not heritable nor was it possible to alienate ownership rights to this land. There were cases where jagir lands were held on an inheritable basis, "in order," Regmi states, "to provide for the performance of specific services on a continuing basis" (Regmi, 1978a: 469). Included in these services was maintenance of State-owned irrigation channels. It seems likely, therefore, that jagirdars were involved in the development of irrigation systems, although perhaps not to the extent of owners of birta land grants.

Irrigation systems were also constructed by local elites and royal directives. Raj Kulo of Argali in Palpa district, as noted above, was built on the basis of a royal directive and is still in use today.

Although farmer-managed irrigation may have had its origins in birta or jagir and the coercion of the state, there remains evidence that some were built by farmers themselves. Chherlung Thulo Kulo in Palpa was built through the entrepreneurial efforts of two or three farmers and continues to expand today through the efforts of the organization of irrigators there. Another interesting case, also comes from Palpa and from around the same time, the 1930s. This material was found by Dan Edwards in a *binti patra*[8] submitted by peasants who were having difficulty with a district officer while they were constructing an irrigation canal:

> In order to cultivate lands in our village, we peasants applied for and receive[d] a signed directive from the Palpa Gaunda [the governor, appointed by the prime minister in Kathmandu] in [B.S.] 1989 ([A.D.] 1932). The lands were cultivated at our own expense. When we started to dig an irrigation ditch ourselves, the Gaunda, claiming that it damaged a public trail, put a stop to it. We came to the Center (Kathmandu), submitted a petition to the Government, and permission was given for us to continue digging the canal in order to cultivate the land (Edwards, n.d.: 77).

In addition to systems that were built by farmers themselves, there is plenty of contemporary evidence to suggest that the vast majority of irrigation systems in Nepal are now self-governing (GTZ, 1991). The historical transition of governance of irrigation from a figure such as a birtawal or jagirdar to a group of farmers is one that has not been documented beyond a few systems as yet. Robert Yoder, however, has written about the changes that occurred in a system he studied in Palpa.

Much of the improvement in the Argali Raj Kulo has taken place in the past 25 years. Prior to that, most of the land had been farmed by tenants who were reluctant to invest in improvements to the system because of the insecurity of their tenancy. They were responsible for operating the system, and the organization fined persons who were absent from work and who were caught stealing water. At the end of the year, the money collected in fines was spent for a feast for the members. After the tenant operators became land owners, the practice of spending the fine money on a feast was discontinued. Since then, this money has been invested in improvements in the system. The canal has been widened, areas with high seepage have been lined, and skilled labor has been hired to cut tunnels through some areas where landslides often damaged the canal (Martin and Yoder, 1983b: 11).

In the case of Raj Kulo, it is evident that farmers, when allowed the opportunity to establish a more secure "stake in the system," were motivated to improve the irrigation system. Benefits accrue more directly to the farmers now and revenue that accumulates annually is applied to improvement of the system.

An Historical Sketch of Irrigation Development in Nepal

We might then, in the absence of a well researched history of the development of irrigation in Nepal, sketch an outline. Cultivation of rice dates from ancient times; archeological investigations in Asia have established that rice was domesticated as early as the fifth millennium B.C. (Barker, Herdt, and Rose, 1985: 14). Rice may have been cultivated in the Harrapan civilization (circa 2,500 to 1,500 B.C.) along the Indus River but it does not appear to have been important (Vishnu-Mittre and Savithri, 1987: 216-217). Basham states that "wild rice is known in Eastern India, and it is here, in the swampy Ganges Valley, that it was probably first cultivated by the neolithic contemporaries of the Harappa people" (Basham, 1954: 25). Irrigation was done in what is now northern Uttar Pradesh and Bihar about the time of Buddha, circa 500 B.C., and rice was apparently a major crop (Ling, 1973; also Singh, 1967). Buddhist sources reveal that there were engineers who constructed canals for watering fields and other references are made to the making of "little embanked squares for water" (Singh, 1967: 201), which must have been irrigated rice fields bordered by bunds.

Hindu civilization existed 2,500 years ago in southern Nepal, we know, for that is where the Buddha was born, in a kingdom known as Kapilvastu.[9] Although the Terai and Inner Terai have been malarious until recently, it is likely that 2,500 years ago malaria did not exist in this region. Rice cultivation was probably opportunistic, using naturally occurring wetlands and neighboring springs and small streams to provide a wet environment to grow rice, although irrigation with the use of canals may have been used, such as was suggested above.

Skipping past over 2,000 years, to about 200 years ago, irrigation probably did not expand during wars of unification in Nepal, or during wars with the British, the Chinese, and Tibetans, despite various incentives given to it. Perhaps beginning sometime in the mid-1850s, especially after the promulgation of the Muluki Ain in 1853, irrigation likely expanded once again with a general, albeit autocratic, peace. Aside from opportunistic irrigation, development of more irrigated area probably occurred through the auspices of birta and jagir grant holders to enhance revenue as a percentage of the crop that was available from the tenants. Birta and jagir grant holders were able to mobilize tenants, probably slave labor, capital, and land to construct irrigation systems. Guthis, as noted above, were also a means to augment an agricultural surplus for the purpose of endowing the construction of a temple or to sustain a priest; irrigation was developed on those lands as well. Additionally, a variety of incentives, mostly in the form of tax breaks, were used to encourage the expansion of land under cultivation, particularly irrigated land.

As indicated above, the relatively low population of the country and the relative abundance of land probably provided little impetus for further expansion of irrigation, except where it was most easily accomplished. Pressure from the state and birta and jagir grant holders may have promoted the expansion of cultivated land and irrigation during the 19th century. Not long after the beginning of the 20th century, however, the population of Nepal reached a point where, as Robert Schroeder expressed it for more recent times,

> [l]and ownership has become much more central in village life than it was in times of relative land abundance. When new land was available for both slash and burn and for fixed field agriculture, control over labour was relatively more important than control over land. As agricultural intensification has proceeded in Nepal, land ownership has become relatively more important and control over labour relatively less important (Schroeder, 1985: 43).

Schroeder notes, for example, that the institutions of slavery and indentureship were abolished in the 1920's in Nepal because "owning slaves and keeping bound agricultural workers was no longer economically advantageous in Nepali agriculture" (Schroeder, 1985: 43). Labor, in other words, was no longer scarce. With increasing population and with the release of 50,000 slaves to become potential tenants, pressure for intensification and irrigation must have become greater. Also, with the increasing security of tenure on the part of the cultivator after 1906 legislation,[10] the willingness and ability of cultivators to invest in irrigation must have grown too. We can speculate, then, that beginning sometime in the decades either side of the turn of the twentieth century in Nepal, tenants and cultivators themselves may have become increasingly active in the development of irrigation system in Nepal.

The example of Chherlung Thulo Kulo irrigation system may be illustrative here. This system was begun by farmers themselves in 1928. Two or three farming households began the construction of the canal, but eventually many households came together to support the work. Robert Yoder recalls that when members of these families were asked, years later, why they risked a huge investment in a canal that was over 6 kilometers long through landslide prone terrain, he was surprised at the response he received. These farmers replied frankly that they had no choice, that without the added production that irrigation could give them, that they would have starved. They were no longer capable of feeding themselves without irrigation. They, like the residents of the small village in Kavre Palanchok discussed in Chapter 1, were faced with food deficits and considered the alternatives of migrating to another area or building an irrigation system.[11]

Other Basis for the Development of Irrigation in Nepal

With regard to the governance of irrigation systems in Nepal, a basis for self-governance was established in the 18th century. At that time, a king of Gorkha, the principality that was to give a unified Nepal her kings for the next two hundred years, complained that "trivial disputes" from irrigators were being brought before his court. The king proclaimed some general principles but then declared that henceforth these "trivial disputes" would not be heard in his court (Riccardi, 1977: 45). They were not matters that the court would decide. This edict provided a foundation for autonomous and non-political governance of irrigation resources. Favor within the court would not come to bear on the settlement of local dispute and irrigators themselves would have to solve their own problems.[12]

Conflict in irrigation systems, perhaps of the kind M.C. Regmi has suggested as the reason for the lack of irrigation facilities in Nepal, has been resolved locally according to customary law by institutions irrigators themselves have established. We will stress that resolution of local conflict and the means to structure incentives for efficient and equitable operation of irrigation systems but that Nepali farmers have been remarkably successful in crafting irrigation institutions. We are not saying that farmers have always and at every location been successful at resolving the disputes and litigation that Regmi states were obstacles to construction of irrigation systems. Over time, however, many have. Irrigation systems established by farmers have had considerable autonomy and operated without much oversight by the national government. Communities of irrigators have been able to institute their own rules, *bidhan* (charters), schedules of operation, and sanctions. According to Pradhan, "[t]he legal tradition and local administrative structures over a period of time have permitted farmer-managed irrigation systems to operate without interference from an irrigation agency or other administrative units" (P. Pradhan, 1989: 1).

At the national level, jurisprudential infrastructure was established in 1854 with the Muluki Ain, the Law of the Realm. The code retained customary practices relating to irrigation, and also traditional customs of different local and ethnic communities in Nepal. Ujjwal Pradhan states that the "present Law on Reclamation of Wastelands (effective ever since 1853) outlined . . . the basis for all acts [and] portrays some of the resource mobilization obligations and property rights to be honored at the local level" (U. Pradhan, 1990: 52). One of these rules was cited, with regard to incentives to irrigation, earlier. Two more, as cited in Regmi (Regmi, 1978a: 244):

1. Water shall not be available for others until the requirements of the person who constructed the irrigation channel at his own expenses or with his own physical labor are first met. In places where water has been shared in the past, no one shall be allowed to withhold the usual share of the water, thus making a field uncultivatable. After the field at the source of the water is irrigated, the next field shall use the water. If the owner of the field at source is confronted with any difficulty, the owner of the next field shall use the water for cultivation. A new irrigation channel may be constructed at a point higher than the existing one only if the amount of water available to the field irrigated by the old channel is not reduced.

2. If an irrigation channel tumbles down or the field is damaged by streams or washouts, the landowners themselves shall repair it as far as possible, or do so by jointly providing laborers. They shall not share in the water simply unless they themselves make repairs or provide laborers. If the strength or resources of the landowners prove inadequate, the Talukdar (landlords or rent collectors) shall ascertain the resources required to repair it and report to the government office. When the channel is repaired with means provided by government, the existing landowners shall not be evicted. If the irrigation channel is not repaired by either the government or the tenants for three years, and the local Talukdar repairs the land or channel at his own cost after reporting the matter to the central government office, he may take eviction measures. The existing landowner shall not be allowed to complain that he has been evicted from the land.

Although there was a national judicial framework for irrigation, it should be recalled that the fundamental nature of governance in Nepal for a century and a half was central neglect. For most of the 19th century and the first half of the 20th, Nepal was ruled by families whose fundamental interests were, to put it charitably, law and order and the revenue collection. There was little distinction between private funds of the rulers and public funds; the function of the state was not to produce public goods but to extract wealth from the populace. Mahesh Chandra Regmi characterized the administrative policy of Prime Minister Bir Shumshere in the following way:

> . . . the criterion for adopting any measure was whether or not it would increase revenue without inflicting undue hardships on the people. Little attention was paid to measures for improving their general condition. For instance, repairs to a damaged irrigation channel in the Tarai region were, in one case, justified on the ground that the damage was causing loss to the government.[13] The potential increase in agricultural production and improvement in the

condition of the peasantry that the irrigation would bring were apparently not relevant factors influencing the decision to sanction funds for the project. Even the desire to avoid hardships to the people was motivated not by a sense of accountability for their welfare, but by the realization that it might be difficult to collect taxes from a dissatisfied peasantry. The Rana government was careful not to kill the goose that laid the golden eggs, but neither did in let the goose grow fat (Regmi, 1978b: 26-27).

In an environment of central neglect, Nepali farmers or birta owners, if they were interested in irrigation for their crops had to provide irrigation facilities by their own efforts. Although they may have taken advantage of tax-incentives offered by the state, the systems were built by their own efforts. Most villages in Nepal were remote from Kathmandu. Whatever laws as existed in the capital, with the exception of those pertaining to taxation and order, were not necessary structures by which village people guided their lives. The national government, such as it was, was remote from village Nepal and the thousands of irrigation systems extant in Nepal today are due to local efforts.

Notes

1. The most important of Regmi's work on land tenure and taxation is the *Land Tenure and Taxation in Nepal* (1978a). See also Regmi (1978b).

2. Cronin comments on the formation of these tar or plateaus:

> Occasionally, a landslide will dump its debris into the river or one of its tributaries and form a natural dam across the waters. The massive quantities of silt carried by the currents settle out to build a flat bed of sediment in the still water behind the dam. When the current finally cuts a channel through the debris, a small plateau is left standing beside the river; in time, the river channel is cut deeper and deeper until the plateau stands high above the waters. . . . Most are quite small, but a few are several miles long, and all seem completely out of place in this land of angles.

3. Birta will be discussed below but for now we can define it as a tax free grant of land.

4. Most of Regmi's work has been on 19th century land tenure and tax policies.

5. Yoder: personal communication.

6. Stiller (1976) states:

> The new system, called *kut*, assigned lands on a contract basis. The *kut* system introduced a note of competition into land tenure. Under contract conditions, farmers who were wiling to pay higher rents had access to better lands, unless those who already farmed such lands were willing to pay more. Obviously, this system please the landlords. Rents were higher, and they were taken before the farmer received his share of the crop. The new system intended to provide both the government and landlords a guaranteed income for the first time and also to insure higher revenues from the land (1976: 59).

7. Regmi (1971) writes:

> Birta owners or Jagirdars whose holding comprised one or more villages suffered little from labor scarcity. But where the holding comprised only a field, the owner had no control over manpower (1971: 43).

8. A binti patra is a petition or request common people could direct to the ruling sovereign or prime minister. Edwards reveals how these binti patra were a means rulers in Kathmandu used to find out what was going on and otherwise keep an eye on their representatives in outlying areas.

9. There is a story of the Buddha when he returned to his parent's kingdom, after he had achieved enlightenment. He was called upon to solve a problem between two villages that were arguing about water for irrigation. This story would indicate that there was irrigation in the area of southern Nepal 2,500 years ago. The Buddha's mediation efforts involved counseling the disputants that water was an immaterial thing and not worth fighting about.

10. Regmi (1978a: 324-329). Whereas the legislation was enacted at that time, this is not to say that it was everywhere applied. In this regard, Regmi remarks dryly that "no arrangements were made to create the administrative machinery necessary for their effective implementation, and it is safe to conclude that these measures remained largely ineffective" (324). The legislation of 1906 might be viewed, not in terms of absolute security of tenancy, but as a point along the way, where tenants and cultivators had somewhat more security.

11. Robert Yoder: Personal communication.

12. Regmi (1971: 18) has a different interpretation of this edict on "trivial disputes." He suggests that it represented a lack of concern for irrigation because of its unimportance in the Gorkha area. Comparing the Gorkha area to Kathmandu, Regmi states that "irrigation facilities did not play an equally important role in agriculture in Gorkha and other areas in the hill region. This is shown by the directive of King Ram Shah of Gorkha (1605-1633) that complaints regarding the use of water for irrigation should not be heard." Because Ram Shah prohibited trivial disputes regarding irrigation his court does not mean irrigation was unimportant in Gorkha. Ram Shah could just as well have been a wise king and realized that problem solving for irrigation best

remain at the local level. With regard to his capability as a ruler, earlier Regmi states that Ram Shah "introduced the first legal code in the hill region to regulate economic and social relations among his subjects, most of whom belonged to non-Hindu tribal communities. The code had a tremendous impact upon surrounding areas. . ." (1971: 5).

13. A comment here on Regmi's text; since tax would be taken as a percentage of the harvested crop, broken irrigation facilities would result in less harvest and consequently less would be available for government revenue.

Chapter 3: NATIONAL GOVERNMENT INVOLVEMENT IN IRRIGATION

Paul Benjamin and Ganesh Shivakoti

We have seen in Chapter 2 that historically, the state in Nepal has been involved primarily in irrigation through the encouragement of expansion of agriculture. This encouragement, mostly through land taxation incentives and birta land grants, was aimed at generating increasing amounts of revenue which would be used at the sovereign's discretion. There is some historical record of other activity, which will briefly be discussed before turning to the modern period of government involvement in irrigation.

Although the Government of Nepal has been involved in irrigation since the 19th century, the vast majority of irrigation systems in Nepal are farmer-managed. Significant government involvement has not come until the middle of this century. Since 1950, when Nepal began a new era as a nation and when *bikash* (development) came to be a fundamental theme in Nepali life, the plans and efforts of the Government of Nepal have become increasingly important. Outlined here is a history of the government involvement in irrigation.

Mahesh Chandra Regmi has documented the existence of state-operated irrigation canals in Kaski, Nuwakot, Palpa, and Syangja during the 19th century (Regmi, 1978b: 11). He states that "[t]hese canals were maintained and repaired through the compulsory labour of the peasants whose rice fields they irrigated. The government appointed superintendents to supervise such maintenance and repair operations and arrange for the equitable and maximum utilization of the available irrigation facilities" (Regmi, 1978b:11). Regmi concludes this discussion by suggesting that the areas under irrigation in this way were not large. Pradhan writes that the "[f]irst public sector irrigation system Chandra Nahar was constructed in 1923 before which there were only a few *Raj Kulos* (Royal Canals) which had state patronage" (P. Pradhan, 1989: 1). It was managed by the independent Canal Management Section of HMG under the Public Work Division (Adhikary, 1964). The raj kulos Pradhan mentions apparently include what Regmi called "state operated irrigation canals" in Kaski and other districts. From 1926 to 1951, an Agriculture Council was responsible for government irrigation activities. In 1946, the Judha Canal was built in Rautahat District in the Terai to irrigate 810 hectares of land (Donner, 1967). Tulsi Narayan Shrestha reports that the Rana administration of Dhir Shamsher appointed *dhalpas* (Superintendent of irrigation canals) for management of raj kulo and that Manusmara irrigation canal was constructed during the time of Juddha Shamsher (T. N. Shrestha, n.d.: 255-256).

Government Involvement in Irrigation after 1950

In 1951, a revolution occurred in Nepal which was to alter the purposes of government and would, naturally, affect thinking about how and what a government would do in agriculture. The Department of Irrigation (DOI) came into existence only in 1952 with technical assistance from India. This department was given an additional responsibility of looking after drinking water supply projects in 1955. During subsequent years, in 1966 and 1968, DOI was assigned additional responsibilities of undertaking minor irrigation projects and ground water project components. In 1972 DOI's name was changed to Department of Irrigation, Hydrology and Meteorology (DIHM). It became the principal government agency involved in planning, design, construction and management of most government-owned irrigation projects in Nepal.

Since 1956, Nepal has established a series of National Five-Year Plans, with specific goals and objectives for each sector of the economy. Irrigation, as a part of the government's efforts at bikash, has assumed increasing importance in each successive plan. The objectives of irrigation development in Nepal from the Planning Commission perspective are: (a) to achieve increased agricultural production through investment in the irrigation sector, (b) to recover the cost of the investment and have operation and maintenance costs borne by the users, and (c) to promote the active participation of the farmers in the management of the systems. During the First (1956-1961) and Second Plan (1962-1965) periods, irrigation construction was concentrated on small projects in Kathmandu Valley and on medium scale Terai projects. Pradhan notes that the First Five-Year Plan "did not even recognize the existence or contribution of farmer-managed irrigation systems" (P. Pradhan, 1989: 2). Before the year 1956, the total area irrigated by government built irrigation system was 17,000 hectares; by the end of the Second Plan in 1966, that had increased to 52,000 hectares. Little was done during the Third Plan due to limited resources of the Department of Irrigation. In the Fourth Plan period (1970-75), the irrigation target was increased by 500 percent over the Third Plan period (Water and Energy Commission Secretariat, 1981). The Fifth Plan period (1975-80) was the same, except for two ground water projects, the Bhairahawa Lumbini Project and the Kanchanpur Project. During the Fifth Plan period, the net area having irrigation facility was increased by 24,900 hectares; the total irrigated area therefore was 72,500 hectares by the end of Fifth Plan.

Table 3.1 lists the area irrigated by projects undertaken by the government during the various development plans. Whereas the figures in this table show a substantial increase in irrigation interest on the part of the Government of Nepal, the accuracy of the figures and those in the tables that follow, given the wide discrepancy they show, is questionable.

TABLE 3.1 Government Developed Irrigation (cultivable command area in hectares)

PLAN		TARGETED DEVELOPMENT	COMPLETED IRRIGATION
First Plan	1956-1961	20,785	11,428.*
Second Plan	1962-1965	32,544	1,035
Third Plan	1965-1970	50,645	52,860
Fourth Plan	1970-1975	253,711	37,733
Fifth Plan	1975-1980	230,220	95,425
Sixth Plan	1980-1985	233,482	172,918
Seventh Plan	1985-1990	235,000	98,705.**
Total		1,056,387	420,104

Source: HMG/N, 1990.
* Includes 6,338 ha completed before the first plan
** Achievement to the end of FY 1988/89

Prachanda Pradhan has also assembled data for irrigation in Nepal, published in 1989. His table, with some modifications, has been reproduced below (P. Pradhan, 1989: 2).

TABLE 3.2 Irrigation Systems by Management Type (in hectares)

LAND AREA (estimated)		MANAGEMENT TYPES		TOTAL IRRIGATED AREA
Cultivatable Area	Irrigatable Area	FMIS	Agency	
3,100,000	1,900,000	714,000	350,000	1,064,000

There is a discrepancy between Tables 3.1 and 3.2 of approximately 70,000 hectares for "agency" or government developed irrigation. Precisely how many hectares have been irrigated by the government is probably a matter of considerable uncertainty.[1] The same could be said with greater emphasis for the totals for farmer-managed irrigation.

There has been a steady increase in government funding for irrigation in Nepal. Table 3.3 shows irrigation development expenditures for the first four five plans. As a percentage of total national development expenditures, investment in irrigation increased six times between the third and the sixth plans.

TABLE 3.3 Irrigation Development Expenditure (in million Rs.)

PLAN		IRRIGATION DEVELOPMENT	PERCENT OF DEVELOPMENT EXPENDITURE
THIRD PLAN	1965-1970	61	2.4
FOURTH PLAN	1970-1975	265	4.9
FIFTH PLAN	1975-1980	864	9.8
SIXTH PLAN	1980-1985	3130	14.4

Source: Water and Energy Commission Secretariat (1981).

By 1988, government involvement in irrigation development had grown to include several agencies including: (1) the Department of Irrigation, Hydrology and Meteorology (DIHM), (2) the Farm Irrigation and Water Utilization Division (FIWUD) of Department of Agriculture, (3) the Ministry of Panchayat and Local Development (MPLD; now the Ministry of Local Development), (4) the Agricultural Development Bank of Nepal (ADB/N), and (5) Project Boards. Table 3.4 shows the distribution of irrigation intervention or expansion carried out by different government agencies until the end of fiscal year 1984/85.

TABLE 3.4 Irrigation Development According to Institutions (until the end of FF 1984/85)

INSTITUTIONS	AREA IRRIGATED (HA)	PERCENTAGE OF IRRIGATED AREA
DIHM	179,000	27.8
FIWUD	15,000	2.3
MPLD	2,000	0.3
ADB/N	48,000	7.5
Farmer-Managed	400,000	62.1
Total	644,000	100.0

Source: Based on Small, Adriano, and Martin, 1986, cited in U. Pradhan, 1990.[2]

There were major differences in working policies and mandates among these agencies. DIHM was supposed to undertake projects with command areas of larger than 500 hectares in the Terai and larger than 50 hectares in the hills. On completion of construction works by DIHM, operation and maintenance remained a full function of the department and the beneficiaries were expected to pay a water fee to meet a part of operation and maintenance costs. DIHM has coordinated construction activities with the International Labor Organization (ILO), World Bank, Asian Development Bank, USAID, and other donor agencies' irrigation development projects.

FIWUD identified its projects for assistance based on the collective decisions and requests of the users. If a project met criteria for approval of the scheme, the project was approved (Shivakoti, 1992). Farmers deposited five percent of the estimated cost in the bank in the name of scheme and committed another 20 percent of the estimated cost in the form of labor from the anticipated beneficiaries. The remaining 75 percent came as a FIWUD grant from the government. When the construction was complete, a users' committee was formed, and they took over the operation and maintenance of the system.

The Ministry of Local Development (MLD), formerly the Ministry of Panchayat and Local Development (MPLD), activities concentrated mainly on low-cost technologies for the improvement of farmers' systems of less than 50 hectares command area in size. Participation of the anticipated beneficiaries was a requirement although the proportion of participation was not fixed in this case. Construction contracts were awarded to the beneficiaries' groups who were responsible for operation and maintenance. The bases for the selection of projects were mainly political.

The Agricultural Development Bank of Nepal (ADB/N) has also played an active role in providing irrigation facilities to farmers. It has been mainly responsible for providing credit to farmers for agricultural activities and it has collaborated with CARE/Nepal to finance several irrigation systems. The narrative that began this book is about an ADB/N/CARE financed irrigation system. Agricultural Development Bank of Nepal maintains a staff of technicians at the central level who supervise the overall activities of irrigation development. At the district level, middle-level technicians (overseer-who have two years of training after high school education) supervise the construction and rehabilitation works related to irrigation and other technical matters. ADB/N maintains sub-branch offices at many places within a district; a technician (sub-overseer--three years training at pre-high school level) is posted there to supervise irrigation technical matters. According to P. Pradhan (1989: 2), ADB/N has supported the development of about 106,000 hectares; these systems are mostly user controlled.

Some of the larger irrigation projects in Nepal have been carried out through semi-autonomous organizations called "Project Boards." Management under this system gave autonomy in personnel recruitment and financial flexibility (M. Shrestha, 1987). Pradhan states that

> [t]hese board are made up of representatives from departments of water resources, finance, Planning Commission, agriculture, and irrigation. . . . A major purpose of the boards is to provide coordination among the various agencies involved in a particular project during the construction and implementation phases (U. Pradhan, 1990: 69).

Besides larger projects, the Department of Agriculture also launched integrated programs, such as the Hill Food Production Program, where each project maintained its own staff of irrigation technicians for the project period.

Reorganization of National Irrigation Bureaucracy

In the late 1970s and early 1980s, reports dealing with irrigation were published that were critical of the performance of government-sponsored irrigation projects. A series of reports from the Agricultural Projects Service Center (APROSC) were fundamental in drawing attention to the frailties of government sponsored irrigation systems (APROSC, 1978a, 1978b, 1978c) and to successes of irrigation systems that farmers themselves operated (APROSC, 1983a, 1983b).

In 1982, the Water and Energy Commission published a study of four large irrigation projects, the Kankai, Narayani, Mahakali, and Bhairahawa (Water Resources and Energy Commission, 1982). They concluded that "on-farm irrigation and drainage works [were] deficient in all the four projects. This is partly responsible for the under-utilization of these irrigation systems and in some cases like Narayani even for declines in production" (Pant and Lohani, 1983: 23).

In the summer of 1983, the seminar--Water Management Issues in Nepal--dealt with many different water issues but included several papers devoted to irrigation. In a paper presented at that seminar, Takur Nath Pant and Jyoti Lohani summarized major problems associated with government intervention in irrigation; among the points they made are:

> Irrigation coverage of the command areas has been partial in almost all the projects. Effective irrigated area did not exceed, on the average, 50 per cent of the project command. This is largely due to incomplete development of project infrastructure, including distribution and drainage systems.
>
> System maintenance and management is deficient, and projects have not ensured timely, reliable and adequate supplies of irrigation water. Farmers' production risk has not been reduced and their response to irrigation in terms of fertilizer and other improved input use is less than satisfactory.
>
> Farmers' participation has been neglected. Even projects that are extensions of the communal irrigation system have failed to solicit farmers' cooperation in system maintenance and operation (Pant and Lohani, 1983: 16-17).

These authors also discussed "communal irrigation," that is, irrigation systems "managed with full farmers' participation" (Pant and Lohani, 1983: 28). They cited APROSC reports that had just come out that year and discussed some of those findings. Given the theory elaborated in this study, these findings are interesting to review at this point:

> Communal irrigation systems and farmers' organizations are need-based and the initiative for organizing them has invariably come from farmers themselves.
>
> Communal irrigation systems are management intensive. Technical deficiencies of systems have largely been compensated by intensive management, backed by flexible and strong organizations.
>
> Organization structures are largely determined by the size and needs of the systems. Complex hierarch[ical] and decentralized organizational structures have also been devised whenever necessary. Even advanced forms of organizations embodying some features of joint stock company are found.

Though many communal irrigation schemes are small, no in-built bias towards smallness was established. There are schemes having an irrigated area as large as 15,000 hectares. The size of the river source and the extent of resource requirements are factors determining the size of systems.

Members of communal irrigation systems usually exercised some sort of property right or membership in the systems. Selling water or selling shares or charging relatively higher fee (than justified by canal expansion requirements) to the late-comers were noticed.

Communal irrigation systems are dynamic--they are continually improving and expanding. Their service areas are usually determined by hydraulic boundaries.

Even in a small area, many independent communal irrigation schemes, sometimes using the same river are found. Household sometimes have multiple memberships because their land fall[s] under different schemes.

There is variation in leadership among the projects. All types of leadership--participatory, author[itarian], and laissez-faire--have produced results depending on the situation. One common feature is that leadership is accountable to members in all the schemes. The decision making pattern often conforms to the local socio-economic situation. Political organizations have roles only in some schemes.

Community irrigation is based on local resources and, therefore, is labor intensive. Modern construction materials are used only in a few cases, and that has been for some specific purposes such as use of pipes in . . . land-slide . . . zones.

Rules, roles, and social group in system maintenance, conflict management and the water allocation process are different from scheme to scheme. The factors determining this variation are complex, but communal irrigation schemes, conforming by and large to the broad pattern governed by economic forces, vary in organizational details largely as a result of specific local characteristics (Pant and Lohani, 1983: 27-29).

These authors conclude by asking what differences exist between farmer-managed systems and government irrigation systems. They cite three attributes present in farmer-managed systems: (1) local initiative has met the need for irrigation water; (2) the farmers enjoy ownership or property rights, and (3) the systems themselves are unstable, that is, the farmers require the help of one another to keep the system running (Pant and Lohani, 1983: 36-38). These authors noted that government systems had few "conventional incentives" for forming water users' groups.

At the same seminar in 1983, B. Pradhan pleaded for recognition of farmers' contribution to the organization of effective performance of irrigation systems. He wrote that "[a]n irrigation system . . . needs an effective management organization to maintain the system and deliver the water to the fields in both an adequate supply and timely fashion to meet crop requirements" (B. Pradhan, 1983: 61). He pointed out that this often was not happening in government sponsored irrigation systems. On the other hand, non-government irrigation schemes, he noted, were often successful in dealing with many of the same problems that modern systems were unsuccessful in solving. Worst of all, Pradhan concluded, was the "erosion of self help." He cites a project report:

After the involvement of the Department in the project, people's initiative that existed before has stopped since it is now assumed by the people that the Government is there to provide them services. The apathy of the people with regard to cooperating with the Department can be traced in that the people who now participate in repair and maintenance of the project claim wages from the Department (B. Pradhan, 1983: 70).

Pradhan went on to compare this situation with a farmer-managed system where:

> It is interesting that in the Chinne Khola Canal (farmer built and operated), the farmers are quite willing to maintain these, small repairs being carried out immediately by the farmer who found the problem and larger repairs communally (B. Pradhan, 1983: 70).

Pradhan went on to plead for a reappraisal of the approach and strategy of irrigation development. Other research began to appear at this time. Highly detailed descriptions of farmer-managed irrigation systems began to emerge from the work of Robert Yoder and Edward Martin who did research in the early 1980s in Palpa District along the Kali Gandaki River in Nepal. Particularly interesting was their study of three farmer-managed irrigation systems and the reasons for the differing performance characteristics of each one (Martin, 1986; U. Pradhan, 1990; Yoder, 1986).

The International Irrigation Management Institute (IIMI) opened an office in Kathmandu in 1986 and served as a venue for the discussion of important management and governance issues in irrigation. The primary focus of IIMI's office in Nepal was on the Farmer Managed Irrigation Systems (FMIS). One of the first activities IIMI engaged in was with the Water and Energy Commission Secretariat (WECS) to assist existing farmer-managed irrigation systems in Sindhu-Palchok district. They produced detailed rapid appraisal reports of the Sindhu-Palchok systems and intervened in an innovative way, through farmer-to-farmer training. There were also several baseline surveys undertaken by different integrated rural projects (mainly through the auspices of national and international consultants) and also non-governmental organizations (NGOs) such as CARE/Nepal, and also ADB/Nepal and ILO/Food for Work Programs.

By mid-1980, Department of Irrigation, Hydrology and Meteorology established its Irrigation Management Center with its main focus on participatory management of irrigation systems involving users and also started conducting applied research studies on contemporary irrigation related issues. Institute of Agriculture and Animal Science at Rampur, Chitwan also formed "Irrigation Management Systems Study Group" among its faculty which undertook several field studies in the Chitwan Valley.

In 1986 and 1987, there were three national seminars and conferences dealing with water and irrigation issues. Most of the papers were field based case studies rich with information and containing valuable observation with implications for irrigation policy, design, implementation, operation and maintenance.

In 1986, an international conference hosted by IIMI on water issues was held, this one on public intervention in farmer-managed irrigation systems (IIMI/WECS/Government of Nepal, 1987). M. M. Shrestha, in a paper about irrigation bureaucracy in Nepal, stated that there were many different agencies involved with irrigation, each of which had separate goals and working policies. Shrestha concluded his paper by suggesting that unified policies emanating from a single bureaucratic structure would be better than the patch-work of authority and policy that existed up to that time (M. Shrestha, 1987).

New ground was broken with a series of field studies presented at a seminar in Bharatpur in June of 1987 on irrigation management in Nepal, "Irrigation Management Research Results" at Bharatpur in Chitwan. Prior to this date, field studies of irrigation systems were rare. Among many important papers given at this conference, Ratna Sansar Shrestha and Nirmal Kumar Sharma presented one entitled "A Comparative Study of Farmer-managed and Agency-managed Irrigation Systems" and stated that "[o]ur study has clearly revealed that farmers/users will not consider an irrigation network their property unless they have been consulted" from the inception of the project (R. Shrestha and Sharma, 1988: 77). Some of the early Irrigation Management Center applied studies and field reports also clearly indicated that user participation was necessary to improve performance of agency systems. Impact evaluation studies of different government managed systems emphasized the lack of effective water management and meager people's participation in construction, repair, maintenance and management of agency managed systems in Nepal (APROSC, 1978a, 1978b, 1978c). The process by which farmers were to request assistance in the development of irrigation was unclear, which meant that political favoritism would determine priorities in irrigation. There was no methodical system of water use; farmers in agency-managed system head end areas applied excessive amounts of water in their fields, while tail-enders did not get sufficient water (APROSC, 1979). The capacity utilization was low, and maintenance of the systems was inadequate or non-existent (APROSC, 1978a, 1978b, 1978c, 1979).

By the late 1980s, there was increasing concern regarding chronically poor performance in the agency-managed irrigation systems. Donor agencies and the irrigation bureaucracy both became alarmed at the poor performance of these systems and what that meant in terms of public investments in the irrigation sector. HMG was also having difficulty financing operation and maintenance work, so few projects were completed. That is, if they remained incomplete, they could still be allocated a construction budget to do operation and maintenance. Finally, some donors began to perceive that many irrigation systems they had invested in were not productive, and, as a consequence, cut back on funding. Engineers at the Department of Irrigation began to reconsider how they went about the irrigation business and have begun to appreciate existing systems and improving management.[3]

As irrigation research in Nepal was published, it began to appear that performance effectiveness of the systems was adversely affected by the lack of proper management and, more so, by lack of participant involvement in operation and maintenance of the irrigation systems. Considering the relatively large numbers of well managed farmer-managed systems, thinking began to turn to the involvement of beneficiaries in agency-managed systems. With this thinking, attention then turned to the problem of preserving the responsibility of the beneficiaries to perform operation and maintenance after government intervention.

As a means to address these issues, irrigation policies were changed. In 1988, the Government formulated new policies on irrigation development, the main points of which are listed below:

> Beneficiaries' participation and consent has been made compulsory for project identification, selection, design, construction, operation and maintenance. . . .
>
> The Department of Irrigation (DOI) and the ADB/N are named the main implementors of irrigation development activities. Whatever the executing agency, the government contribution or share for each particular type of project has been fixed, and ADB/N has to provide loans to the beneficiaries based on a fixed formula. . . . A high level 'National Irrigation Committee' is formed by the government under the chairmanship of the Minister of Water Resources which is responsible for formulating working procedures, establishing priorities, fixing targets and coordinating all tne agencies concerned (HMG/N, 1988: 1).

Presently, the Department of Irrigation (DOI) and the Agricultural Development Bank of Nepal are the main implementing agencies for major irrigation development activities.

Organizationally, DOI under Ministry of Water Resources maintains five divisions at the central level to look after specific division activities. These five divisions include: (1) Small Irrigation and Water Utilization Division, (2) Large and Medium Irrigation Division, (3) Ground Water Division, (4) Planning, Design and Research Division, and (5) River Training and Environmental Division. The Regional Irrigation Directorate (RID) at each of the five development regions are strengthened to provide technical assistance and supervision to the District Irrigation Offices (DIO). The Regional Irrigation Directorates supervise and provide support to all of Nepal's 75 districts through District Irrigation Offices. These DIOs, coordinated by a Chief District

Officer (CDO), are staffed by technicians who are to construct, supervise, operate and maintain the irrigation systems within the district.

Recent Changes in Irrigation Policy; The Future

At least since 1988, and especially after the promulgation of the new constitution in 1991, the Nepali government has taken a more active role in irrigation management in an effort to improve agricultural productivity and alleviate poverty. Although increased government intervention is not necessarily equivalent to an increase in number of agency-managed irrigation systems, assessing how irrigation can be better governed and managed in the process of intervention does require that serious thought be given to the viability of government agencies as a policy tool.

Inefficiency of agency-managed systems is not unique to Nepal. Ample empirical evidence has shown that government agencies in many developing countries have failed to manage irrigation systems in an effective manner. A variety of research has suggested that inadequate local participation in the processes of governing and managing irrigation systems is a major reason for the ineffectiveness. Hence, enhancing farmers' participation has been a major component in many reform programs in developing countries.

Notes

1. B. Pradhan (1983) said much the same thing:

> The irrigated area at the end of the Fifth Plan was reported to be 198,481 ha as noted in the Sixth Plan. However, in the annual programme of 1982/83, the area under irrigation has been shown as 90,000 ha for summer crop and 24,000 ha for winter crop. Such a large discrepancy in the irrigated area has not been accounted for and the authorities concerned seem to take little note of it. Indirectly referring to this matter, the Asian Development bank sector study has remarked, 'Data and information regarding irrigation development in Nepal are seriously deficient' (1983: 64-65).

2. Although this table shows a wide range of government activity in irrigation, it shows once again confusing data with regard to how much is actually irrigated in Nepal. This data, referring to the end of Fiscal Year 1984/85, indicates that some 448,000 hectares are irrigated by farmer-managed systems. It combines both the ADB/N total of 48,000 and the farmer managed total of 400,000. Pradhan, whose work was published in 1989, combined these two categories for this total for "FMIS" (farmer-managed irrigation system) in Table 3.2 where his total was 714,000 ha. It is highly unlikely that the total area irrigated by farmer-managed systems increased from 448,000 hectares to 714,000 hectares in five years.

3. Robert Yoder: Personal communication.

SECTION II

INSTITUTIONS, ENGINEERING INFRASTRUCTURE, AND PERFORMANCE IN THE GOVERNANCE AND MANAGEMENT OF IRRIGATION SYSTEMS: THE CASE OF NEPAL

Discussion in Section I has shown that irrigation development in Nepal has happened in two domains. On the one hand, farmers in disparate locations of Nepal have organized themselves to construct, govern, maintain, and operate a large number of farmer-managed irrigation systems to provide water for agricultural development (P. Pradhan, 1988; Yoder, 1986). On the other hand, since the 1950s, the government of Nepal, in many instances with the assistance of international donor agencies, has invested substantial amounts of money to construct many large-scale and high-cost agency-managed irrigation systems.

A major characteristic of FMIS is their primitive infrastructure. Most of these systems have temporary headworks, which are often made out of stones, mud, leaves, and tree branches. Canals in many of these systems are either partially-lined or even not lined at all. Although most of these FMIS do not command a substantial amount of *physical* capital in terms of sophisticated engineering infrastructure, many of them are characterized by the presence of a substantial amount of *social* capital. Many prior studies have found that, on many of these systems, farmers are able to arrange good working relationships among themselves to operate and maintain the systems (P. Pradhan, 1988; Yoder, 1992; Shivakoti, 1991; Pant and Lohani, 1983; APROSC, 1983a, 1983b; Martin, 1986; U. Pradhan, 1990). Most AMIS built in the last several decades are designed to serve thousands of hectares of cultivated land and to provide water to large numbers of water users. Sophisticated engineering infrastructure is the hallmark of these systems; permanent headworks and lined canals are commonplace. Despite sophisticated engineering infrastructure and the presence of professional irrigation staffs, many AMIS perform inadequately. Many prior case studies indicate that poor maintenance, severe deprivation of tailenders, and low productivity are often found in these systems (B. Pradhan et al., 1983; Pant and Lohani, 1983; APROSC, 1978a, 1978b, 1978c; WEC, 1982).

These findings from case studies of irrigation systems in Nepal showing that FMIS frequently outperform AMIS pose serious puzzles to many government officials and researchers. Why do many AMIS, which have been given large amounts of resources and investments and been managed by professional engineers, have lower levels of performance than many FMIS? On the other hand, how can local farmers in many instances be able to overcome a series of collective-action problems to organize themselves for O&M activities? Putting the questions in a broader perspective, how does one understand the diversity of performance among irrigation systems? If institutions are a key to understanding irrigation performance, what is the linkage between institutions and performance? Why has sophisticated engineering infrastructure failed in many instances to bring about improvement in irrigation performance as expected? If engineering infrastructure is a major component of irrigation governance and management, what can be done to make it complementary to institutions and other components of the irrigation system? These puzzles concerning irrigation governance and management are not unique to Nepal, but are commonplace in many less-developed countries (Hart, 1978; Coward, 1980; Barker et al., 1984; Wade, 1987; Chambers, 1988; Tang, 1992; Ascher and Healy, 1990; E. Ostrom, 1990, 1992).

This section addresses these puzzles by focusing on how (1) different governance structures affect individuals' incentives and capabilities to cope with collective-action problems involved in system operation and maintenance, and (2) diverse combinations of institutions and engineering infrastructures affect irrigation governance, management, and performance. Chapter 4 first examines and compares the governance structures of AMIS and FMIS with reference to how they affect the incentive structures faced by irrigation officials and farmers on the systems. The focus is on how incentives affect actions and interactions of officials and farmers that in turn affect irrigation performance. Chapter 5 discusses how various physical and socio-economic attributes of irrigation systems might condition, or interact with, the effect of institutions on individual actions and interactions and, hence, irrigation performance. In Chapter 6, data about 127 irrigation systems in the initial Nepal Irrigation Institutions and Systems (NIIS) database is analyzed and used to examine the arguments about how various institutional, physical, and socio-economic attributes affect irrigation performance. Lessons learned from this study and their implications on irrigation governance and management are summarized and discussed in Chapter 7.

Chapter 4: INCENTIVES FACING IRRIGATION OFFICIALS AND FARMERS IN NEPAL

Wai Fung Lam

Individuals are more likely to contribute to collective action if they perceive that (1) they will reap the long-term benefits of engaging in collective action, (2) a set of rules is in place which facilitates cooperative activities by inducing information and by counteracting perverse incentives for opportunistic behaviors, (3) the set of rules is effective in that it is well-enforced, commonly understood and agreed upon by a community of individuals, and responsive to changing environments, and (4) the set of rules has equilibrating mechanisms built in so that it can sustain and reinforce itself by continuously strengthening individuals' interests, mutual understanding, and agreement pertaining to the viability of the rules. Institutional arrangements which have characteristics pertaining to these four conditions are more likely to enable individuals to build up productive working relationships and result in the realization of their fuller potentials. On the basis of these arguments, this chapter examines the incentive structures facing irrigation officials and farmers in Nepal. The focus will be on how these incentives influence patterns of action and interaction of farmers and officials and, hence, the performance of irrigation systems.

Incentives Facing Irrigation Officials as Governors of AMIS

In agency-managed irrigation systems (AMIS), irrigation officials are essential actors affecting how irrigation systems operate. The ways that these officials behave not only affect how much productive potentials they contribute to irrigation governance and management, but also how successful farmers' self-organizing and agricultural effort will be. Thus, understanding the incentive structures facing irrigation officials, particularly those with origins in institutional arrangements, is of major importance in understanding irrigation performance of AMIS. The Nepali civil service system which affects the payoffs to and the careers of irrigation officials, and the work environment in which officials carry out their day-to-day activities, constitute important sources of incentives affecting officials' behavior.

The Civil Service System. Most of the irrigation officials serving on the Department of Irrigation (DOI) in Nepal are employed within a civil service system. The civil service of Nepal is classified into two levels: gazetted and nongazetted. The former is the higher level of civil service whose appointment, promotion, and transfer are published in the Nepal Gazette. The nongazetted class is the lower civil service or clerical staff; and beneath the nongazetted are the peons. Within both the gazetted and nongazetted levels, civil servants are further divided into four classes, ranked as I, II, III, IV, with class I being the highest. Different entry requirements, levels of salary, and types of tasks are assigned to different ranks.

In the DOI, staff at or above the rank of section officer belong to the gazetted level. Almost all officials in this group have a baccalaureate in engineering and regard themselves as professionals. It is this group of irrigation officials who are charged with the authority and responsibility for governing and managing irrigation systems; they are the key to determining the performance level of the systems. The recruitment of these officials is through civil service examinations conducted by the Public Service Commission (PSC). A baccalaureate is required to sit for these examinations. Below the gazetted officials are lower ranking nongazetted officials including Overseer and Sub-overseer. These junior staff are mostly working near the field and doing accounting and administrative works. Education requirements at the nongazetted level include a minimum of ten years of education or the equivalent; recruitment is also through open examinations.

Promotion in the DOI, like that in many other government agencies in Nepal, is largely based upon the evaluation of superiors, seniority, and qualification. Irrigation officials up to gazetted second class are subject to annual evaluation. A confidential report will be filled out by an official's immediate superior or the Director General of the DOI as the basis for the recommendation for promotion. An official is eligible for promotion after he has served at the same grade for at least four years.

There are only four grades in both the gazetted and nongazetted level. Because of this shallow range of grades, promotion is slow. The average number of years in the same position ranges between ten to fifteen years. Promotion from nongazetted grades to gazetted grades is even more difficult, though possible. An overseer (nongazetted level) must have at least fifteen years of relevant working experience to be eligible for promotion to Assistant Engineer.

Based upon the set of civil service rules described above, several features can be summarized which affect the behavior patterns of irrigation officials and their relationships with farmers. First, results of civil service examinations and formal qualifications are the two major criteria for the recruitment of irrigation officials and the career advancement of the officials. But neither of these are directly relevant to the recruits' ability to work with farmers, their knowledge about the systems they serve, and their success in solving some of the key day-to-day problems in irrigation. From the perspective of the recruits, their jobs and status derive from their profession rather than whether they can serve the farmers well.

Second, farmers do not participate at all in the hiring of irrigation officials. Farmers frequently do not have any say even in the hiring of the lowest level government employees such as *dhalpa* (gatekeeper) and *chaukidar* (messenger or watchmen) — people with whom farmers will have the most frequent contact. For the farmers, DOI officials are a group of strangers who presumably have many resources but know almost nothing about the local situation.

Third, promotion, as a motivational tool, is rendered ineffective by its glacial speed. From the perspective of a civil servant, good performance *might* pay off *only* after a long period of time. But then again it might not. For officials whose discount rate is high, short-term comfort may be preferable to long-term career advancement through hard work. Why work when the payoff is so remote and, at any rate, is not dependent on hard work.

Fourth, performance evaluation works only if it can affect the incentives of civil servants. The sluggish promotion structure, however, deprives performance evaluation of its reward mechanism. If civil servants can observe that good evaluations are not accompanied by an appropriate reward, they are not likely to treat evaluations seriously. Superiors, who are responsible for evaluating their subordinates, will also be aware of this situation. That sense of powerlessness likely affects their morale as leaders in their own departments. In fact, the superiors seldom bother to go to the field office to understand what the official is actually doing. In such a situation, the evaluations are no more than routine bureaucratic paper shuffling.

Fifth, seniority has become the more important criterion for promotion while evaluation has been increasingly abandoned by superiors as a motivational tool. Using seniority as the criterion for promotion, however, has given little incentive for officials to be actively involved in solving farmers' problems. This incentive structure suggests that only if irrigation officials do not commit serious mistakes or offend their superiors, they will be promoted when the time comes. Individual initiative and creativity have thereby been discouraged.[1]

Sixth, low levels of salary of the officials mean that they often need a second job to supplement their meager income. Usually, an engineer in the DOI would set up a consulting firm under the name of a relative or a friend; then he would do the consulting work himself to make money. The extent to which the second job distracts the energy and time of the official from his job at the DOI is hard to measure. Yet it is likely that the engineer would not be able to put as much effort in his work at the DOI as he would have without the second job.

Furthermore, low levels of salary also make the DOI officials vulnerable to the temptations of engaging in corruption. For an irrigation official, the amount of money from an illegal transaction could be equivalent to several years of his salary. This substantial amount of money, together with the fact that corruption has been so widely practiced that the government seems not to bother to monitor or sanction it seriously, poses an overwhelming temptation for officials to join the bandwagon of corruption.

More serious corruption in the use of public funds came from large government contracts. It has been reported that many departmental and ministerial officials could direct funds to trusted contractors. These contractors would then provide the correct percentage of "commissions" to the appropriate field representative of the government, who, after taking his cut, would pass on the rest up the hierarchy to the higher level government officials who arranged the "commissions" in the first place. The higher an official went up the government hierarchy, the more likely one could appropriate lucrative "commissions." In irrigation, it has been reported that the standard percentage of "commissions" was about ten percent of the total budget. A result of these corrupt activities was poor construction and maintenance of irrigation infrastructures. When less materials were put into a physical structure than required, the structure was likely to be less sustainable than expected. Further, when irrigation officials, who were presumably responsible for making sure the quality of construction work was up to standards, were the ones who engaged in corrupt activities, quality control was likely to be sacrificed (Chambers, 1988). Of course, not all civil servants in Nepal were corrupt; but a civil servant working in an agency where corruption was widespread would find that the only options open were to cooperate in the corruption, be isolated by colleagues, ask for a transfer, or quit. If he did not cooperate, he would likely be harassed by his co-workers or transferred by superiors anxious that their share of the illicit money arrived as promised. The pressure to conform was often overwhelming.

The Work Environment. In addition to the civil service system and the prevalence of corruption, the work environment of irrigation officials also create perverse incentives that discourage the officials to do their job conscientiously and to establish working relationships with farmers. In Nepal, like many other LDCs, amenities such as good housing, schools, and commodities may only be found in big cities, especially Kathmandu. In rural areas where roughly 90% of Nepal's population live, the living conditions are austere. For highly educated and ambitious professional engineers working for the DOI, being assigned to a remote irrigation system is not perceived as a good assignment. Cities provide more job opportunities and promotions for civil servants. Staying away from cities will mean losing touch with important political, bureaucratic, family, and personal connections. These are essential to career advancement for a civil servant in Nepal. As most irrigation officials in the field are not willing to stay there long, a high priority for them will be to seek jobs in either cities. The greater the urgency for the transfer, the more active the search for transfer opportunities will be. Those who are unable or unwilling to engage in the search have to endure an unsatisfying work environment for an indefinite period of time.

Professional engineers have undertaken higher education in order to gain the status associated with the profession of engineering. Engineers build things and that is where the status is in engineering. Being assigned to the O&M part of irrigation is undesirable both from the perspective of the status of that position and the financial support given to the division. Funding is weak in O&M. In most AMIS, the annual funding allocated for the O&M is not even enough to pay for the basic operation of the systems. When getting resources for basic operation is problematic, one can imagine how little resources would be left for maintenance and repair works. Given these incentives, morale is likely to be low. A demoralized and uninterested official is unlikely to identify with local communities which they are supposed to serve. For farmers witnessing this neglect, it only serves as another example of arrogant Kathmandu officials who can afford to ignore their needs.

Most government systems are seriously lacking in the number of personnel assigned to operation and management activities. This is due to the severe budgetary constraints involved. In Nepal, water charges are legally based on a per hectare/per crop assessment for those areas served by the DOI or other government-owned systems (T. Shrestha, Shakya and Shrestha, 1985). The District Land Revenue Office is responsible for collecting the water fees, and have the collected fees submitted to the national treasury. There are very few incentives for the District Land Revenue Office to see to it that the water fees are paid. Since the DOI and the District Land Revenue Office belong to different ministries and the coordination between the two departments has been minimal, the DOI can do almost nothing to make the District Land Revenue Office to do a good job in water fee collections. In fact, since the water fees collected will go directly to the national treasury, even the DOI has few incentives to ensure a high level of fee payment. As of 1985, the level of water charges collected by projects were negligible and below the overall level needed to support O&M activities. There was "not one government project in the country where funds collected [met] the recurrent costs involved" (T. Shrestha, Shakya, and Shrestha, 1985: iv).

Adding to this generally unfavorable work environment, the specific assignments made to DOI officials in the field are rarely personally rewarding. It is not uncommon that AMIS are constructed in areas where farmers have not been able to organize their own systems, either because of poor physical settings, or a lack of physical and social capital among farmers. In anticipation of the project, farmers in the potential service area could be substantially disorganized. Without cooperation from the farmers, even capable officials with good intentions will not be able to manage systems well. On government organized systems where there are no effectiveintermediate farmer organizations, irrigation officials assigned responsibility for managing the main system are frequently faced with the type of impossible dilemma described by David Freeman (1990) as a choice between whether "(1) to maintain as much distance as possible from local patterns of privilege and 'free riding,' or (2) to become entangled in countless energy-absorbing local conflicts, complaints, and demands in relation to which their training, knowledge, and organizational resources are grossly inadequate" (1990: 118).

Effective management is further hindered by the organizational structure of almost all the large-scale national irrigation agencies. The DOI, like many other government agencies in Nepal, is highly centralized.[2] Many important decisions are made by higher level officials at Kathmandu. Decisions made without time and place information may not suit the local needs very well. Moreover, given all of the uncertainty involved, effective management of irrigation systems requires a high degree of flexibility and timely decisions. These items are in short supply to lower level irrigation officials. As agents of the government, and thus a representative of the inefficiencies that farmers witness daily, it is all the more frustrating for irrigation officials in the field. It is they who face the farmers and their complaints everyday. They are the ones blamed for the inefficiencies.

Given the absence of almost any intrinsic or extrinsic rewards assigned to government officials for keeping an irrigation system in good condition or for trying to encourage effective rule conformance on AMIS, the findings observed by many irrigation scholars regarding the difference in performance of FMIS as contrasted to AMIS are not so surprising. Even though most AMIS are designed by professional engineers, have sophisticated physical infrastructures, and would work well with a lower level of resources devoted to maintenance, the officials assigned the responsibility to operate and maintain these systems have no intrinsic and few extrinsic incentives to do their work effectively.

Incentives Facing Farmers in AMIS

As irrigation officials assigned to govern and manage AMIS are not given positive incentives to see to it that the systems are well-managed, whether O&M in these systems will be carried out properly, or at all, depends largely upon whether farmers are able to organize themselves to take on the O&M responsibilities. As many prior studies found, in most of the government-managed irrigation systems in Nepal, farmers are often unwilling or unable to organize themselves to manage their systems. Such unwillingness is often diagnosed by government officials as a result of farmers' selfishness, and seen as evidence for the non-viability of self-governance and for the need for greater government intervention. Such a diagnosis, however, fails to explain why farmers in many FMIS are found to be able to overcome a series of collective-action problems to organize themselves effectively. Thus, instead of simply asserting that farmers are selfish, an analyst needs to examine the kinds of incentives embedded in the governance structure of AMIS that prevent farmers from working with one another for mutual benefits.

Irrigation Officials as Governors of AMIS. Although assigned the role of governors, irrigation officials usually do not have the relevant expertise and capability to micro-manage irrigation, nor to design rules for the organization of farmers. In fact, given the engineering background in their training, irrigation officials usually put strong emphasis on the technical and engineering aspects of problems involved in irrigation, and neglect the socio-institutional aspects of the problems (Repetto, 1986). Robert Wade (1987) points out that the O&M in many LDCs in South Asia is undertaken by irrigation agencies

> whose primary function has been construction. That is why few of the professional staff members on a particular canal will have had much prior experience of O&M. It is also why they are not especially interested in O&M, because the O&M budget will be a tiny part of the overall irrigation department budget, and its allocation will be given little attention. Also, because professional reputations will be anchored firmly in construction, officers will then tend to behave while doing O&M work in the top-down hierarchical control mode that is appropriate for construction but inappropriate for O&M. (1987: 179)

Given a lack of capability and incentives, irrigation officials frequently adopt three strategies to cope with the task of governing and managing irrigation systems. First, they might design rules that are as easily administered as possible. Rules that are uniform in scope and applicability are especially appealing to the officials because these rules fit very well the administrative procedures of irrigation bureaucracies.

Rules which are designed solely upon the premise of easy implementation are not likely able to take the information about the characteristics of the local situation into consideration. Instead of helping farmers reduce uncertainties, the uniformity and rigidity of these rules often becomes a source of problems for farmers. In many instances, uniform rules and rigid schedules used for water distribution do not allow timely delivery of water to different areas of the system which might differ significantly in physical characteristics. As farmers on AMIS perceive that the chance of having the rigid rules changed is slim, and that complying with the rules might mean a serious crop loss for themselves, breaking the rules frequently appears to be the only viable alternative. Moreover, irrigation officials usually do not have adequate resources, nor in most instances the will,[3] to monitor or enforce the rules. Consequently, breaking the rules does not involve high costs for farmers. In fact, since these rules are not perceived by farmers as appropriate on the one hand, and are not enforced on the other, a rational farmer would not expect others in the system to follow these rules. The calculus that others would break the rules at the expense of his benefits anyway poses a strong incentive to a farmer to break the rules before the others do (Hart, 1978).

The second strategy that irrigation officials might adopt is to avoid engaging in rule-making activities as much as they possibly can. This strategy is especially appealing in irrigation systems where several powerful rival political groups exist and compete with one another. For irrigation officials in highly politicized irrigation systems, allying themselves to a particular political group is a dangerous gamble to take. Although pleasing powerful politicians could be a way to build up connections which are instrumental to their career advancement, it could also mean provoking politicians of other factions. As rival politicians could have many leverages to affect the careers of officials, officials who are affiliated with a losing political faction could face adverse consequences to their careers. A safe way to avoid being implicated in local factional politics, then, is to avoid engaging in activities which might affect the distribution of benefits among politicians.

As irrigation officials are not willing to provide rules for farmers to coordinate their activities, farmers often find themselves trapped in a common-pool resource dilemma where the dominant strategy for everyone is to restrain from contributing to system maintenance and from following rules in water allocation. In AMIS, since irrigation officials are perceived by themselves and farmers as the governors of the systems, farmers usually do not have incentives to engage in self-governing or self-organizing activities. In many instances, farmers perceive that it is not their responsibility, nor within their capability, to make rules to govern themselves in regard to day-to-day irrigation activities. Of course, not all farmers in AMIS adopt a passive attitude. In some AMIS, farmers do try to take up the responsibility of governing and managing the systems themselves; and some of them have actually succeeded in doing so. Despite successful cases, farmers' self-organizing effort in AMIS is by no means easy. The reasons that farmers in some AMIS have succeeded in crafting rules for themselves while some others have failed may vary from one system to the next, depending on particular contextual factors. There is, however, a fundamental problem that farmers in *all* AMIS who are trying to govern themselves have to face. As the irrigation officials are the *de jure* governors of the systems, they could assert their power to "govern" whenever they choose to. Farmers in AMIS always face the possibility that irrigation officials might show up one day and declare farmers' self-organizing efforts "illegal." Such a possibility poses to farmers a high level of uncertainty concerning the payoffs of their costly self-organizing efforts. This uncertainty frequently makes farmers hesitate to invest in self-governing and self-organizing activities.

The third strategy that irrigation officials might adopt is to establish formal water users groups (WUGs) in AMIS as proxies to govern and manage the systems. Although these groups could potentially serve as the intermediate link between irrigation officials and farmers in the AMIS, the experience of establishing a WUG in an AMIS in Nepal has been discouraging. While the number of these groups has been increasing, not many of them are active, let alone effective. This experience seems to be evidence consistent with what Robert Hunt (1989) has warned about concerning the possible pitfalls of establishing WUGs by administrative fiats in agency-organized irrigation systems. Although Nepali irrigation officials always insist that they have only served as the "facilitator" in the process of establishing WUG, they, in practice, have often acted more like the "creator" than the "facilitator." In many AMIS, it was irrigation officials who declared the establishment of a WUG, specified the structure of the WUG, appointed officials in the WUG, and set the agenda for the WUG; the officials literally imposed a WUG on farmers in these systems.

The structure of a WUG which is mandated by irrigation agencies is not likely to be suitable to the local situation of particular systems (E. Ostrom, 1990, 1992). More importantly, as farmers see a WUG as something imposed by the government, they are not likely to be enthusiastic about investing their resources to make the WUG effective, nor following rules made by the WUG. In many instances, the situation is further exacerbated by officials' practice that powerful local farmers are appointed into the functionaries of the WUG, and that poorer farmers are neglected. Such a practice further increases the asymmetries of powers and interests between powerful farmers and their powerless neighbors in irrigation systems. As rules made by

WUGs often become a tool for the powerful to exploit the powerless, it is not so surprising that the level of rule conformance in many AMIS is low.

Irrigation Officials as Non-Credible Coproducers. Farmers are more likely to contribute to the collective effort of operating and maintaining their systems if they perceive that a set of *credible* rules is in place which helps them resolve problems involved in collective action. Thus, for farmers in AMIS to follow rules that are made by irrigation officials, the officials must be able to make a credible commitment that the rules will be effectively enforced. Ironically, the dominant position of irrigation officials deprives them of the power to make credible commitments to farmers. As argued by political economists, a commitment to an action is credible only if the interests of the one who makes the commitment will be affected by the results of the action (Williamson, 1985, 1990; North, 1990). Given that the payoffs to irrigation officials have nothing to do with how well they serve farmers one way or another, officials' commitments are not likely to be treated seriously by farmers. When officials cannot make credible commitments, trusting relationships between farmers and officials are not likely to develop. A result is the prevalence of the syndrome of anarchy identified by Hart (1978) in which neither farmers nor irrigation officials have confidence on one another, and the mutual distrust reinforces itself over time. Working around irrigation officials, then, is likely to become a way of life of farmers in these systems.

The mutual distrust between irrigation officials and farmers significantly hinders cooperation among them. In large-scale AMIS, farmers will be willing to take charge of O&M activities at the sublateral level only if they are assured that the main canal at the system level is able to provide reliable and adequate supplies of water (Chambers, 1988; Uphoff, 1986; Tang, 1992). The farmers understand that their organizing effort at the sublateral level will pay off only if main canal management is effective enough to complement their effort. Yet in most of the AMIS, the ones who are responsible for main canal management are irrigation officials over whom the farmers do not have any control. Under such a situation, farmers tend to be skeptical of the viability and value of their organizing efforts at the sublateral level, and often find themselves left with two options. They can either refrain from investing in any organizing effort and leave the situation to chaos, or cooperate with farmers in the same village to try to get whatever amounts of water they can at the expense of other villages in the system. No matter which option the farmers might adopt, the result is a deficient pattern of relationships which does not allow the realization of the full potentials of the systems.

The Destruction of Social Capital. In constructing new AMIS, it is commonplace that irrigation officials do not give recognition to the prior property rights, institutions, and the common understanding evolved and developed by local farmers (Curtis, 1991). Farmers are more likely to invest their efforts in O&M if they see the link between their self-interests and the outcomes of the collective efforts of operating and maintaining irrigation systems. When a new system is built, and the rules and common understanding that has been the basis for farmers to relate to one another are declared invalid, farmers are no longer sure about whether their contributions to O&M will pay off; or if they do, who will enjoy the benefits. Further, without a set of rules-in-use in place, farmers will not be able to develop mutual expectations on the behavior of one another. The resulting uncertainty often drives farmers to pursue their short-term self-interests at the expense of the interests of the others.

The extent of the destruction of social capital can be comprehended only if one recognizes that the rules-in-use, and the common understanding that underlies these rules, are the product of years of social experience of farmers in a community interacting and working with one another in dealing with problems they collectively face. These rules represent a body of shared social knowledge accrued to the community. Irrigation officials frequently assume that formal rules can be made simply by declaration, and that, once these formal rules are made, they would be automatically understood and followed.[4] What they often do not realize is that the meanings of rules can be construed only with reference to the common understanding developed among individuals in a community. The officials may be able to provide formal rules in the form of words on paper, yet they can never "provide" years of social experience among farmers on which a community of common understanding takes root. Thus, once social capital is destroyed, the costs of rebuilding it in terms of time, effort, and human artisanship are immensely high.

Perhaps the most disastrous damage to social capital by the introduction of irrigation officials is its impact on farmers' habits of hearts and minds. When farmers in AMIS perceive that the governance and management of the systems is a responsibility of irrigation officials, they see no obligations to contribute their efforts to O&M activities. Before irrigation officials came to the scene, farmers who were facing problems in irrigation or in other aspects of life understood that the only ones who would come to help was one another in the community. Although there is no guarantee that the farmers would actually organize themselves to solve the problems, farmers' strong awareness of interdependency makes it more likely for them to recognize the importance of working with one another. Moreover, since farmers need the helps from one another, farmers who are in comparatively advantageous positions are less likely to fully exploit their positions so as to avoid alienating their comparatively less-advantaged neighbors (E. Ostrom and Gardner, 1993; E. Ostrom, 1994). Consequently, a set of more equitable rules is more likely to be worked out. When farmers did resolve the problems themselves, working with one another for problem-solving was likely to become an important component of farmers' daily life (Uphoff, 1992).

Once irrigation officials declare that they will be responsible for operating and maintaining the systems, farmers will begin to think that whenever they have problems in irrigation, they can ask the officials to fix the problems *for* them. From the farmers' perspective, seeking help from officials seems to save them from the trouble of problem-solving in daily exigencies, hence they are normally quick to adopt this new mode of "problem-solving" (Curtis, 1991). Consequently, farmers lose the visions of what they could possibly achieve by working with one another, and a mind-set which emphasizes farmers' dependence on officials is likely to develop among farmers. As farmers are no longer willing to engage in collective action, they increasingly lose the capability and skills of working with one another. Once the capability and visions are lost, it is hard to have them rebuilt.

It is warranted, however, to point out that government assistance does not necessarily destroy farmers' organization in AMIS, and that farmers in AMIS are not doomed to fail. In fact, government assistance could be extremely helpful if it is designed in the way that it enhances farmers' productive working relationships.[5] Recent studies (Ambler, 1990; E. Ostrom and Gardner, 1993; E. Ostrom, 1994; Lam, Lee and Ostrom, 1994) indicate that the *design* of government intervention has significant implications on the pattern of working relationships among farmers. Assistance in the form of grants that do not need to be paid back by farmer, for example, tends to create an illusion that unconditional help could be expected from the outside (Pant, Valera, and Pradhan, 1992). Such an illusion often leads farmers to give up self-organizing activities.

Incentive Structures in FMIS

Self-Governance and Human Artisanship. The most essential characteristic of the governance structure of FMIS is that farmers are able to engage in rule-crafting activities from time to time to restructure the day-to-day situations in which they find themselves. The incentives to prey upon others in irrigation do not simply disappear when farmers are to participate in irrigation management. The establishment and maintenance of a viable and effective working order relies upon farmers being able to continuously craft effective rules that counteract perverse incentives, and provide positive incentives for cooperation. It can be attained if farmers are given the opportunities to change the situations they face.

Since farmers are the ones who have to face the consequences of poor O&M, they have very interests to prevent the poor O&M from happening. Note that these interests exist for farmers in *all* systems. Yet as discussed earlier, farmers in AMIS usually do not see they can do much to change the situation that they think might result in poor O&M. Such a sense of inability dampens the farmers' faith and incentives to organize. Farmers in FMIS, on the contrary, are able to change their rules-in-use from time to time. In other words, they possess the *means* to restructure the situations in which they find themselves. Of course, there is no guarantee that these farmers would actually use the means, or if they do, in an effective manner. There is nothing automatic about the self-organizing process among farmers in FMIS. Farmers' incentives to organize and cooperate with one another depend on their visions and expectations about the benefits and costs of the collective endeavor as well as the viability of the institutions that they are to develop. However, the very existence and availability to farmers in FMIS of the means to change their situations opens up the possibilities of problem-solving which are literally denied to farmers in AMIS, and of the development of a vision that emphasizes the viability and importance of working with one another. When farmers perceive that there are opportunities for them to do something to improve their well-being, they are likely to give it a try. These opportunities of which farmers act upon conceptions and ideas to pursue joint benefits are a prerequisite to the unleashing of their social energy and productivity.

Farmers' conceptions and ideas might not be the best and, hence, lead to success every time; disagreements and failures are not uncommon in farmers' organizing efforts. Problem-solving for fallible human beings is a continuous process in which ideas are worked out and acted upon, human artisanship, which connotes the skills and capability of acting upon ideas and conceptions in an effort to work with one another, is of utmost importance. The strength of self-governance in FMIS is not that farmers' ideas are necessarily better and guarantee success, but that farmers are given opportunities to work with one another which, in the long-run, would make them better organizers and governors of their own affairs. One would, then, expect that farmers in FMIS, when compared with their counterparts in AMIS, to be more capable of associating with one another by crafting a large array of rules to facilitate their interactions.

When a presumably resourceful government is not there to help, farmers in FMIS are likely to have a higher level of awareness of their interdependency. These farmers understand that effective irrigation can be attained only by working with one another. Consequently, they tend to be more willing to invest their resources in self-organizing activities, and to communicate, discuss, and compromise with one another. Such an willingness to reason with one another, in the long-run, is a building block of farmers' problem-solving capability. Further, as helps from one another are essential, farmers who are in comparatively advantageous positions, whether it is given rise by their locations along the canal or by the size of their landholding, are less likely to fully exploit their positions at the expense of the less advantaged. Farmers in less-advantageous positions can threaten to withhold their effort, which would make the collective effort impossible, as a means to press the more advantaged to agree on rules which give them better terms and benefits. Of course, the rules, or the terms of the distribution of costs and benefits among farmers, that would actually be adopted depend upon such parameters as the bargaining powers among farmers and the total benefits and costs of the collective effort. Readers who are interested in how these parameters might affect the outcome of the rule-making process are referred to recent studies by E. Ostrom and her colleague (E. Ostrom and Gardner, 1993; E. Ostrom, 1994).

<u>Self-Governance and Effective Institutions</u>. Rules that are made by farmers are more likely to take information and knowledge about the local situation into consideration. Since farmers are the ones who deal with problems in regard to irrigation in their daily exigencies, they are likely the ones who understand the problems best (Freeman, 1990). Rules that are designed with close reference to the problems they are intended to resolve are likely to be more effective. Further, rules that incorporate local knowledge about the physical and socio-institutional characteristics of a community are likely to be more suitable to particular local

situations. Rules that fit in the larger setting are likely to enjoy a higher level of conformance (E. Ostrom, 1990; 1992).

Rules used for O&M in Lothar Irrigation System in Chitwan District illustrate how farmers are able to craft rules that are congruent to the local situation. Laitos and his colleagues (1986) describe the physical characteristics of the system as follow:

> The Lothar irrigation system receives water from two sources, the Lothar and Rapti rivers. The Lothar and Rapti rivers are approximately 4 km east of the irrigation system. The two rivers run in a southwesterly direction parallel to each other. Near the command area they merge and share a mutual floodplain. The Lothar irrigation system lies west of the Lothar-Rapti floodplain. The Lothar River is closer, but does not supply enough water to meet the irrigation needs of winter crops and early paddy. To obtain additional water, the farmers constructed a canal through the floodplain to capture water from the Rapti River, which lies approximately 2 km east of the Lothar River. The approach canal from the Rapti River is washed out yearly during the monsoon floods. (1986: 179-80)

As suggested in the above description, the physical setting of the Lothar system is rather fragile. To maintain the system effectively requires that farmers spend a large amount of labor effort to repair the approach canal every year and to clear the silt in the system frequently. To mobilize labor for maintenance, a rule stipulates that every owner-cultivator in the system, regardless of the size of his landholding, is obliged to contribute one laborer for maintenance work. As there are about 300 owner-cultivator households in the system, about 300 laborers are mobilized. However, given that the task of maintaining the system is tremendous, a labor force of 300 does not meet the labor demands for maintenance.

Mobilizing enough labor for maintenance is not the only problem facing farmers in Lothar Irrigation System. While tenancy is uncommon in the Lothar system, there is a large number of landless farmers in the system. How to sustain these landless farmers has always been an important "social" issue there. To deal with the problems of insufficient labor for maintenance and of sustaining landless farmers in the system, an extraordinarily clever rule concerning water allocation and system maintenance was designed.

> Before the early paddy season [when water is inadequate to irrigate the entire service area], the General Assembly decides what percent of the entire command [service] area can be irrigated. Larger landholders are limited to this percentage of their particular landholdings. Thus, if the water users decide that only 20 percent of the command [service] area can be irrigated, a farmer who owned 5 *bighas* [1 *bigha* equals to .67 hectares] would be limited to irrigating one *bigha*. However, the association's decision to irrigate only part of the command [service] area may be altered if larger landholders agree to rent some part of their land to landless farmers.
> ... In return, the landless laborers must contribute to the system maintenance and repair in exchange for the temporary opportunity to cultivate a field. Perhaps such an arrangement was considered necessary because the labor contribution is not in proportion to landholding size. (Laitos et al., 1986: 184-185)

Such a rule, by reconciling the owner-cultivators' need for laborers for maintenance on the one hand and the landless farmers' need for a means to earn a living on the other, relates the resources that different groups of individuals in the system possess in a complementary and mutually beneficial way. Obviously, such a clever rule can only be designed by the farmers who understand the social and physical characteristics of the local situation best, and are able to comprehend the possible complementarity of different components in their system.

Given the inherent complexity in irrigation systems, a high degree of congruence between rules and local situations often requires that different rules are used in specific time and place exigencies. Consequently, one would expect that a high degree of diversity of rules could be found within and among FMIS. This diversity is a source of strength. Not only does it make the rules more relevant to specific exigencies, it also facilitates farmers' learning about rule-crafting by letting different rules to be tried out. The larger the repertoire of rules, the more likely effective rules could be crafted.

Further, farmers' rule-crafting effort is usually not only confined to operational rules, but also rules at collective-choice and constitutional-choice levels. Collective-choice rules are decision-making arrangements in which operational rules are to be crafted, monitored, and enforced. The design of the collective-choice arrangements affect the quality and viability of operational rules (E. Ostrom, 1986a). When the collective-choice arrangements are so designed that it is congruent to local socio-institutional situations, rules that come out of these arrangements are more likely to fit specific time and place exigencies. The federated water users organization in Chhatis Mauja Irrigation Systems in Rupandehi District, as described by Martin and Yoder (1983a), illustrates how a complex set of collective-choice mechanisms designed by farmers enables them to deal with the tasks of rule-making and conflict resolution at different levels. The system's water users organization has a three-tier structure. There is a Village Committee for each Mauja (village), nine Regional Committees each for six Village Committees, and one Central Committee for the whole system. At the system level, there is also a general assembly to serve as a representative body of farmers in the system. Committees at different levels have difference jurisdictions and responsibilities. For instance, while village committees are to make rules for the allocation of water after it flows into the villages from the main canal, regional committees are to coordinate water distribution, and resolve conflicts, among different villages. The central committee, of course, has jurisdiction over the coordination of irrigation governance and management for the whole system. Such federated collective-choice arrangements allow farmers in different localities to develop rules for water distribution that fit in the characteristics of specific environments. As a consequence, these collective-choice arrangements enable the farmers to craft and carry out rigorous operational rules for water distribution during the times when water is scarce. As Martin and Yoder (1983a) note, the cycle of water distribution during times of scarcity as developed in these collective-choice arrangements is able to match the amounts of water available to the fields with water requirements of plants at different stages. This effective water distribution is an important factor that contributes to high levels of agricultural productivity in the system.

When farmers in a system are all involved in the design of a collective-choice structure, every farmer will have an incentive to craft the structure in the way that there are channels for him to influence future decision-making in the structure (Moe, 1990, 1991). Consequently, chances that the resulting structure would give a particular group a permanently dominant position could be significantly reduced. A corollary is that the probability that the structure will be used by one group to exploit others is decreased.

Further, irrigation staff in FMIS are usually chosen and hired by farmers. In many instances, these irrigation staff are themselves farmers in the systems. They not only know the systems well but also have incentives to work to satisfy the farmers in order to keep their jobs. In many FMIS where the salary to the staff is dependent on how well they carry out their assigned tasks, the staff are given positive incentives to contribute their best efforts. Also, as these staff are themselves from the community, they can work closely with farmers in operating and maintaining the systems. Such a close working relationship also makes the monitoring of the behavior of the staff more effective.

Constitutional-choice rules stipulate the basic terms and conditions of the collective effort as well as how collective-choice arrangements are structured. Since these rules pertain to the basic conceptualization of how the collective endeavor is organized, they directly pertain to the issues of legitimacy and, hence, the viability of the endeavor. Unless the basic terms and conditions of cooperation, such as who constitute the membership of the effort, what rights and obligations are for the members, and what are the principles for establishing decision-making mechanisms, are sorted out, any cooperative effort is impossible. Farmers who are to commit substantial amounts of labor input in O&M frequently debate about the rules they will use to decide on how much labor is needed each year and the formulae by which the amount of labor input of each farmer will contribute. Once agreements on these and other important aspects of rules are reached, farmers usually put these agreements into writing and sign or affix their thumbprint to this document (E. Ostrom, 1992, 1993). The farmers might not be aware of the constitutional character of their seemingly ritualistic action, yet their understanding that they are committed to the collective effort is the foundation for their working with one another. When farmers could agree on the order of working relationships that they have designed, they are more likely to perceive it as fair and, hence, more likely to conform to it. That farmers are able to craft their constitutional rules does not guarantee that all participating farmers will receive the same level of benefits. In an asymmetric situation where some farmers are in stronger bargaining positions than others, some farmers might be better off than others. Yet as long as the less well-off perceive that the positive gains from joining the collective effort are greater than not joining, that they have been given opportunities to bargain for an acceptably fair deal,[6] and that they can agree on the terms and conditions, their relatively low but positive benefits might still lead them to commit to the collective effort.

Self-Governance and Common Understanding. Since the meanings of rules can be construed only with reference to common understanding among individuals, the level of congruence between rules and common understanding determines the effectiveness of the rules. When farmers in a community who have had years of experience of interacting with one another are to make rules, they are likely to craft the rules on the basis of the prevailing conceptualization of rule-ordered relationships they share. Consequently, these rules would be better understood by the farmers. Such an understanding greatly reduces the costs involved in interpreting and monitoring the rules and resolving conflicts.

Scholars have long noticed that a high level of common understanding is essential to effective irrigation management (Taylor, 1987; Pant and Lohani, 1983; Martin, 1986). What is not as well recognized is that common understanding alone is insufficient for irrigation organization. For the common understanding to be useful, it has to pertain to the daily lives of farmers. A way to do this is to let farmers develop institutional arrangements which regulate their interactions based upon their common understanding. By acting upon the common understanding, the common understanding reinforces itself over time. It is this reinforcing process that sustains and develops the trust and social accountability of a community of farmers. And such a reinforcing process is made possible only when farmers continuously craft and monitor a set of rules that pertains to problem-solving activities in daily exigencies.

That farmers are able to continuously craft rules ensures high levels of flexibility and responsiveness of the rules to the changing environment. Like many other collective endeavors, irrigation governance and management is an ongoing concern. New contingencies might arise that make existing institutions ineffective. Constant remedial activities are needed to keep the ongoing concerns in the right track. Further, given that the cognitive ability of human beings is limited, new ideas, visions, and information could give rise to new possibilities from time to time.[7] Whether these new possibilities are given an opportunity to be tried out significantly affects the effectiveness and the long-term viability of irrigation governance and management. These new possibilities are more likely to be acted upon when farmers are allowed to shift the levels of action from time to time to restructure their action situations.

Conclusion

This chapter reconstructs and deciphers the action situations in which Nepali irrigation officials and farmers in FMIS and in AMIS find themselves. By examining what kinds of incentives are embedded in these action situations, I sought to understand why these officials and farmers are making choices, acting, and interacting in the ways they are, and what are the links between various institutional arrangements and the patterns of action and interaction of individuals.

In analyzing the incentive structure of irrigation officials, I focused on depicting the stressful environment in which these officials have to work and live, and also on many strong temptations and incentives that they have to face daily. It is almost too easy to denounce irrigation officials for their inefficiency. The over-simplified diagnosis that "the officials are inefficient" is often used as a justification for a policy recommendation that reduces the role of irrigation officials by turning over agency-organized systems to farmers. Yet as emphasized repeatedly, although the self-governing potentials of farmers are an important asset to effective irrigation governance and management, one cannot expect farmers to be able to resolve all kinds of problems they face all by themselves. Many tasks in irrigation management involve large amounts of resources and expertise that are beyond the capabilities of local farmers; in many instances, the effort of irrigation officials is instrumental to effective irrigation governance and management. Once one recognizes that irrigation officials have important roles to play, an important policy question, then, turns to how one understands why irrigation officials behave in the ways that they do.

The analysis of the incentive structures faced by farmers in AMIS and in FMIS focused on how different governance structures impinge upon farmers' ways of life in regard to irrigation governance and management. Without asserting that AMIS are doomed to fail or FMIS always succeed, it is argued that the governance structure of FMIS, which is based upon the ideas of self-reliance, reciprocity, and diversity of institutional arrangements, is more conducive to the development and sustenance of social capital and social energy among farmers for problem-solving activities. Such social energy and social capital are essential to high levels of performance in irrigation governance and management. Of course, there is nothing automatic about the success of FMIS. In some instances, farmers may fail to perceive the opportunities of working with one another, or fail to work out a set of effective rules to sustain productive working relationships.

On the contrary, the governance structure of AMIS, which is based upon the ideas of professional management, top-down control, and uniform organizational structures, tends to create relationships of dominance and dependence between irrigation officials and farmers. Since effective irrigation governance and management often requires recurrent care and effort of farmers to operate and maintain the systems, a group of uninterested farmers is not likely able to manage the systems effectively. When irrigation officials who are presumably the managers of these systems also face few incentives to see to it that the systems operate in an effective manner, low levels of performance are likely results.

Notes

1. Emphasizing the criterion of seniority itself does not necessarily affect irrigation agencies adversely. Wade (1982a) reports that in parastatal irrigation agencies in South Korea and Taiwan where the relationships between staff are structured on a somewhat more equitable basis, emphasizing seniority can enhance the development of the sense of continuity and community among the staff. Thus, how a particular attribute of irrigation agencies affects performance depends on how the organization of the agencies are conceptualized and structured and how the particular attribute is combined with other attributes.

2. A World Bank (1989) document reports that, in 1989, almost 60% of first-class gazetted officials and nearly a half of second and third gazetted classes work in Kathmandu. Such a disproportionate number of senior staff posted in the capital strongly suggests a high degree of centralization of authority in the public administration of the country (1989: 74).

3. The DOI does not have the power to punish farmers who break rules related to irrigation. All what irrigation officials can do is to report the instances of rule-violation to the police, and request for actions. In fact, most of the irrigation officials with whom I interviewed did not consider monitoring irrigation rules their responsibility.

4. Numerous personal conversations with irrigation officials in Nepal during my fieldwork indicate that most of the officials believe that farmers are able to make rules and follow rules only if they are given suitable guidance from irrigation specialists. Problems involved in organizing farmers are often perceived as farmers' lack of information and knowledge about management.

5. Pithuwa Irrigation System, an AMIS in Chitwan District, is a case in point. In this system, government assistance is confined only to activities which the farmers are unable to resolve all by themselves. The major one of these activities is repairing the intake structure before the monsoon season every year. Usually, the DOI provides a bulldozer as well as a certain amount of money to subsidize for the fuel for the bulldozer. While the bulldozer will clear up the rubble at the intake, farmers will take care of the maintenance and clearing of field canals in the system. In recent years, helping maintain the intake has basically become the only activity that the DOI has to do with the system. Farmers in the system are able to organize themselves to carry out the tasks of governing and managing the system. A comprehensive set of rules is in place which provides a framework in which farmers in sixteen branch canals, who are organized into sixteen branch management committees, interact and work with one another to operate and maintain the system. The practices of irrigation governance and management in Pithuwa have achieved great success in terms of water delivery as well as agricultural productivity. The system has become an exemplar of effective AMIS management. Note that, in the case of Pithuwa, the involvements of the DOI are of limited scope, yet complementary to the efforts of the farmers. On the other hand, the farmers there are well aware that government assistance is only supplementary to their governing efforts. A major reason that farmers in Pithuwa are able to resist the temptation of totally relying on the government is the presence of a prominent farmer in the system who provided effective entrepreneurship and leadership to mobilize the farmers to organize themselves on the one hand, and was politically powerful enough to resist the intervention from the DOI on the other. As the farmers in Pithuwa were given opportunities to craft rules for themselves, they began to see the viability of working with one another. Once the organizing effort was set in motion, it tends to reinforce itself (Laitos et al., 1986; personal interviews).

6. A "fair" distribution rule does not necessarily assign equal benefits to every individuals. Instead, the principle of "fairness" which is most commonly adopted in irrigation systems in Nepal is that the distribution of benefits is correlated to the distribution of costs. The constitution of Chhattis Mauja, a large-scale FMIS in Nepal, is a case in point. In this system, the basis for the distribution of water is water shares which are calculated according to the size of the landholding and the location of the village in the system. Thus, villages which are smaller, or are located at the tail end of the system are receiving less water. Yet because their contributions to maintenance are assessed according to the number of water shares they have, these villages contribute much less to system maintenance than villages which receives more water.

7. Letting farmers in systems that are facing difficulties learn from farmers in more successful systems has been identified to be an effective way to improve the levels of performance of less effective systems. In 1990, for example, Water and Energy Commission Secretariat (WECS) and the International Irrigation Management Institute (IIMI) in Nepal conducted an intervention effort of farmer-to-farmer training in irrigation systems in Sindhu Palchok District. The great success of such an effort suggests the importance of facilitating farmers' learning in the process of irrigation organization (WECS/IIMI, 1990; Shivakoti, 1992; Lam and Shivakoti, 1992).

Table 4.1
Issues Associated with Recurring Costs and O&M of Irrigation Projects by Country, 1984

Issue	Nepal	Sri Lanka	Philippines	Maharashtra (India)
A. Institutional and Organizational Arrangements				
i. Link between fees and funds used for O&M	No	After 1984	Yes, in communal projects	No
2. High priority for efficient water use	No	Starting 1978-79	Yes	Yes
2. High priority given to maintenance	No	Changing	Improving	Improving
2. High priority given to fee collection	No	Starting 1983-84	Yes	Yes
3. Encourage high farmer participation	No	Yes	Starting 1976	No
3. Good communication among farmers and government	No	No	With active WUO	N.C.
4. Uncertain water and land rights	N.C.	N.C.	No	No
5. Adequate organization for fee collection and O&M	No	No	Yes	Yes
5. Clear responsibility for O&M	No	No	Improving	Yes
B. Facilities and Inputs				
1. New projects take resources away for O&M	Yes	N.C.	[1]/	N.C.
1. Adequate funds and trained staff for O&M	No	No	No	N.C.
2. Adequate project design and/or construction	No	No	No	No
C. Implementation Tools				
1. Adequate data on area irrigated and crops grown	No	No	Most cases	N.C.
2. Penalties for nonpayment of water fees	Not enforced	Starting 1984	Yes	Yes
2. Incentive for high rates of collection	No	No	Yes	No
3. Penalties on those not maintaining the project	No	No	Communal projects	Some

Source: Easter, 1990: 223
N.C. = Not clear from country reports;
[1]/NIA is considering a shift in its program to emphasize O&M and de-emphasize new construction.

Chapter 5: PHYSICAL AND SOCIO-ECONOMIC ATTRIBUTES AND IRRIGATION GOVERNANCE AND MANAGEMENT

In addition to institutions, various physical and socio-economic attributes also affect the incentives faced by individuals and hence the individuals' capability of organizing collective action. In irrigation, particularly, physical attributes such as the size of an irrigation system or the characteristics of physical infrastructure have always been treated in the circles of irrigation specialists and irrigation officials as important factors affecting, if not determining, irrigation performance. Largely as a result of the emphasis given to physical attributes of irrigation systems, constructing or upgrading irrigation engineering infrastructure has long been perceived to be an essential policy tool to improve irrigation performance. Yet, while large amounts of money have been spent on building large dams, weirs, and lined canals, these infrastructural investments in many instances have not brought about high levels of irrigation performance as expected. To understand such an anomaly, a need exists that the ways through which engineering infrastructure impinges upon irrigation performance be given a careful examination. Before taking a closer look at the effect of engineering infrastructure, several physical and socio-economic attributes which are thought to have a significant effect on the outcomes of collective efforts will first be examined in the literature of theory of collective action and of irrigation management.

Size of Irrigation Systems

In theory of collective action, group size has always been considered an important variable affecting the likelihood of success of collective action. Mancur Olson (1965), in his well-known *The Logic of Collective Action*, suggests that the larger the group, the less likely the group effort will succeed. In a review of Olson's work, Russell Hardin (1982) identified three arguments that Olson gave to explain why large groups will fail: (1) the larger the group, the less likely that the group is privileged, in which at least one individual or a subset of individuals exists whose benefits from engaging in collective action exceed the associated costs. Even when these individuals are to provide collective goods or collective action, the level of these collective goods or collection action is likely to be less than efficient (2) the larger the group, the less noticeable the individual effort will be and (3) the larger the group, the higher the costs involved in various coordinating and organizing activities.

These arguments seem to be parallel to the arguments posed by some irrigation scholars and government officials who suggest that large-scale irrigation systems can be managed effectively only by an irrigation agency. As pointed out by Barker and his colleagues (1984), many irrigation policies in many less-developed countries in Asia have been based upon the presumptions that farmers are not able to organize themselves when the number of farmers involved is large, and that self-interested farmers are only concerned about the interests of their families or their villages. As a consequence, it is often argued that the organization of large-scale irrigation systems can only be effectively carried out by a powerful central government. Such a perception is still popular among irrigation officials and irrigation specialists in Nepal. Furthermore, if rich farmers are to invest resources in constructing and maintaining irrigation systems, they are likely to construct the system on a scale that only their fields are irrigated. Poor farmers are left to receive seepage water from the systems. Such a situation not only means that the potentials of irrigation resources have not been fully utilized but also exacerbated the economic inequality between the rich and the poor (see N. Pant, 1984).

As pointed out by political economists (Hardin, 1982; E. Ostrom, 1987; Sandler, 1992), the arguments presented by Olson are more hypothetical propositions than "empirical truth." For instance, situations can exist in which large groups are privileged. An obvious example in irrigation is that many large irrigation systems in Nepal were constructed under the initiatives of rich local farmers; more interestingly, these systems irrigate not only the fields of the rich farmers who took the initiatives, but also those of other farmers in a community. Also, group size affects the context in which individuals organize for collective action in various ways *simultaneously*. Hardin (1982) writes,

> It is not logically possible to increase group size, *n*, *ceteris paribus*. As *n* increases, something else must change: for instance, average cost (especially for perfectly joint goods), individual valuation, total cost, or level of supply. (1982: 44)

Hence, how group size affects collective action in a particular situation depends upon how various group effects are combined. From a policy analysis perspective, what is more important is that the effects of group size can be conditioned by the design of rules that govern the activities of individuals within the group. For instance, rules that enable individuals to exercise monitoring activities in their daily exigencies can reduce the level of organization costs involved in the organization of collective action. Large-scale irrigation systems are not doomed to fail. A federated institutional arrangement, for example, has been shown to enable farmers to organize large-scale irrigation systems themselves (Yoder, 1986, 1992; E. Ostrom, 1990, 1992; Tang, 1992).

Storage Facilities

As irrigation largely concerns the manipulation of water spatially and temporally so as to improve agricultural productivity, the degree of control that an irrigation system allows for is of utmost importance (Small and Svendsen, 1992). This is an important reason why storage is regarded as a major component in an irrigation system. Storage facilities such as dams and reservoirs provide inventories of water which can serve as a buffer for uncertainties. Furthermore, the existence of inventories of water has important implications to irrigation management. On the one hand, it provides a cushion to potential errors in irrigation management; on the other hand, it reduces the possibility that officials might manipulate the uncertainty of water supplies as a means to extract favors from farmers (Wade, 1987, 1988).

Systems with storage, compared to those with run-of-the-river type of diversion works and canals, give individuals more leverage to control water flow. For instance, the implementation of rotation schemes is more viable in systems with ponds and reservoirs. As a consequence, whether storage exists in a system or not significantly affects the kinds of irrigation management structure and procedures adopted in the system (Levine 1977).

Existence of Alternative Water Sources

Whether alternative water sources exist or not affects the degree of dependence of farmers on irrigation systems. Some scholars argue that the extent to which an individual is willing to contribute his effort to a collective effort is largely determined by the extent to which his well-being is affected by the goods provided by the collective effort (Hechter, 1987). The more the individual depends on a collective effort, the more likely he will make contributions to that effort. Thus, a casual application of this logic to understanding irrigation management would suggest that the existence of alternative sources of water would make farmers less dependent on the irrigation system, which in turn would likely dampen their incentives to work with one another.

It is important, however, to note that although the level of dependence is likely to affect individuals' incentives to participate in collective action, the relationship between the existence of alternative sources of water and the level of dependence is not as determinate as it might appear. At least three scenarios could happen. First, in systems where the water supply has been adequate given that farmers are able to govern and manage the system in a relatively effective manner, an alternative source of water could reduce farmers' dependence on the irrigation system.* As farmers perceive that keeping their system well-managed and well-maintained is not as important as it was before, they are likely to make correspondent adjustments by reducing their levels of contribution to system O&M.

Second, in systems where water supply has been inadequate, alternative sources of water could supplement the supply of irrigation water. Farmers who did not see engaging in irrigation O&M activities as cost-effective before will now see the potential benefits as well as the viability of contributing to these activities. In other words, the additional supply of water from alternative sources increases farmers' expected payoffs of contributing to collective action.

Third, the existence of an alternative source of water might create a certain degree of asymmetry between farmers who have access to the source and those who do not. As the former are much better assured of water supply, they might not be willing to contribute as much effort as the latter would want them to.

Therefore, the existence of alternative sources of water does not necessarily dampen farmers' incentives to work with one another. Which one of the three scenarios will actually happen depends on contextual factors in particular situations. Moreover, the existence of alternative sources of water is only one of many factors affecting farmers' dependence on irrigation systems. One of these other important factors is the extent to which farmers' income depends on agricultural activities. One would expect that if farmers are able to earn incomes from other more lucrative activities than farming, they are not likely to spend much time and effort in operating and managing their irrigation systems. As a consequence, the physical condition as well as the managerial order of the irrigation systems are likely to be in a less desirable condition. Such a situation underlies the policy concern of how the sustainability of rural infrastructure such as irrigation systems can be maintained amid the process of economic development. In fact, some systems in Nepal that are located near cities are facing difficulties in getting farmers involved in system O&M.

Composition of Irrigators

Scholars interested in collective action problems have long noticed that homogeneity of group can affect the outcomes of collective action (Taylor, 1987; Singleton and Taylor, 1992; Hechter, 1987; Marwell, 1993). Generally speaking, the more heterogeneous the group is, the less likely the group will succeed in organizing for collective action. In irrigation, many scholars have observed that differences in socio-cultural attributes among farmers in an irrigation system, such as caste, religion, and race, might constitute difficulties in interactions among farmers. In Nepal, farmers of the same ethnic backgrounds, while they are closely-knitted and well-organized among themselves, are often found to be unwilling to work with farmers of different backgrounds. Such a situation is especially common among ethnic groups which have a high level of solidarity.

Economic inequity is another major source of heterogeneity among farmers in many irrigation systems in Nepal. It has often been argued that rich farmers who have large landholdings are often unwilling to work with their poor neighbors; or if cooperative effort exists, rich farmers often reap a disproportionately large proportion of benefits from the cooperative effort (Chambers, 1988; Ascher and Healy, 1990). While economic inequity might actually create a certain degree of asymmetry between farmers, which in turn might dampen farmers' incentives to cooperate, poor farmers are not necessarily the ones who are disadvantaged, nor the rich farmers are necessarily the ones who refuse to cooperate. If poor farmers are able to reap the residual benefits from the collective goods provided by rich farmers, and perceive that the expected additional benefits from working with rich farmers are not worth their efforts, they are likely to refuse to cooperate (E. Ostrom, 1994; E. Ostrom and Gardner, 1993). In such a situation, the poor farmers are free-riders preying upon the efforts of the rich farmers. Of course, no matter whether the poor or the rich are the ones who refuse to cooperate and prey upon the other, the level of collective action and the collective outcomes are less than efficient because those who organize cannot fully utilize the productive potentials of individuals involved in the collective effort and to capture all potential benefits.

Individuals of different economic and socio-cultural backgrounds, however, are not necessarily unable to work with one another. Instances exist in which a heterogeneous group of farmers are able to overcome their differences to work with one another. A variety of rules can be used to construct an institutional setting in which individuals are able to communicate with one another, to resolve conflicts, and to work out operational rules to share the benefits and costs involved in irrigation governance and management.

Engineering Infrastructure

Until the last twenty years, the term "irrigation system" in much irrigation research and policy analysis solely referred to irrigation engineering infrastructures such as dams, canals, and water control structures; the socio-institutional components of irrigation systems were largely ignored. Although there has been a growing awareness of the importance of social and institutional elements in irrigation, many irrigation specialists and irrigation officials in Nepal and elsewhere are still preoccupied with the engineering elements of irrigation governance and management. Such a preoccupation is understandable. Engineering infrastructure is tangible, and hence, easily recognized; it is instrumental to enabling individuals to control water flow.

One of the major concerns of irrigation is to divert water from a naturally concentrated source to cultivated areas (Small and Svendsen, 1992). An effective headworks with a high level of water diversion capacity is instrumental to effective irrigation. In many irrigation systems in Nepal, especially those governed and managed by farmers, headworks are temporary and made out of simple materials such as boulders and leaves. These temporary headworks look primitive to outside observers, but they may operate relatively well. Many of the headworks are fragile, and they may be washed out once a year if not more frequently. However, as many rivers in Nepal often change their course, frequent rebuilding allows the farmers to align the rebuilt headworks to the changed river course. Consequently, many of these temporary headworks are rather effective in terms of water diversion capacity. These "primitive" infrastructures indeed crystalize local farmers' skills and artisanship in the construction of irrigation facilities, which have been passed on from generations to generations. One drawback of these temporary headworks, however, is that they are prone to damages by floods and various natural disasters and hence require frequent maintenance. Moreover, temporary headworks typically do not have water adjustment devices such as water gates. Adjusting water flow must be done with less elegant methods including mud and timber walls. These methods are labor intensive and, during the monsoon season, ineffective. A low level of flexibility in water control is a likely consequence.

A permanent headworks with concrete dams, weirs, and control structures is often said to be a prerequisite to effective irrigation. From an irrigation engineering point of view, a properly constructed permanent headworks has a higher level of water diversion capacity in comparison to a temporary one. In many instances, such a capacity is further complemented by the presence of water gates at the headworks which give farmers or irrigation managers better control on the timing and amounts of water entering the system. With larger amounts of water diverted in a more controlled manner, a permanent headworks can potentially serve a large service area. Moreover, since permanent headworks are constructed with concrete materials, they presumably require less maintenance effort.

Canals are another important irrigation infrastructure. Once water is diverted into a system, how much of it can reach the service areas depends significantly upon the conditions of canals in the system. Other conditions being identical, canals that are lined are more likely to have lower levels of water seepage than the ones that are partially lined or not lined. In other words, lined canals are likely to have a higher level of water delivery efficiency. This not only allows more water available to farmers, but also helps alleviate water scarcity at the tail end. A lined canal can reduce water seepage and hence increase water delivery efficiency. The increased efficiency will compound itself as water flows further downstream in the canal, which in turn can result in a significant increase in the amount of water available to tailenders.

Blind Spots in Understanding the Effects of Engineering Infrastructure

The potential benefits of engineering infrastructure to irrigation governance and management are many. These potential benefits are often used as the justification for many irrigation policy recommendations which assign high importance to constructing and upgrading engineering infrastructure. Often neglected in these policy recommendations, however, is that the expected benefits do not automatically follow the construction of the engineering infrastructure. These potential benefits are likely to be generated only when two conditions are fulfilled: (1) the design of the engineering infrastructure fits in the larger physical and socio-technical setting of the irrigation system as a whole, and (2) the infrastructure is properly operated and maintained by individuals who manage or appropriate water from the system. In many irrigation policy analyses in Nepal and elsewhere, these two conditions are often, implicitly or explicitly, presumed to exist. Consequently, the construction of sophisticated engineering infrastructure is often seen as the major policy instrument to improve the performance of irrigation systems.

Presuming *a priori* the existence of the two conditions is problematic. Not only does the presumption not reflect realities, but it assumes away major problems that significantly affect the extent to which the potentials of irrigation engineering infrastructure can be realized. A major defect of policy analyses based upon such a presumption is not simply that various socio-institutional variables have been missed out, but that the interrelationships between the engineering design and socio-institutional aspects of irrigation systems, and their possible effects on the operation of the infrastructure, have not been taken into consideration. A consequence is that irrigation specialists and irrigation officials are often led to draw the conclusion that sophisticated engineering structures are *unambiguously* beneficial to the operation of irrigation systems, and misdiagnose that problems found in many irrigation systems can be "resolved" by a continual investment of physical and monetary capital.

Engineering Infrastructure and Local Environments

Sophisticated irrigation engineering infrastructure can help farmers control water flow only if it fits in the larger physical setting of irrigation systems. Before an engineering infrastructure is constructed in a particular area, two questions must first be addressed. First, do farmers in the area really need the infrastructure? Water diversion is undoubtedly a major concern of irrigation, but the ways that water can be effectively diverted from a source *vary* across systems, depending on a system's topography, the size and condition of the watershed, the quantity of rainfall, and so on. Thus, a permanent headworks is *not* necessarily useful in water diversion for particular systems. Prachanda Pradhan (1989), for example, reports that there are small river systems in Tanahu District which do not have a high discharge of water regularly. Yet in the monsoon season, heavy rains frequently flood the river systems. Farmers in irrigation systems near these rivers usually construct temporary dams or intakes to divert flood water to their fields prior to the heavy monsoon rains. When high floods come, however, farmers often need to break the dams or intakes to avoid unnecessary flood water getting into their systems. For these irrigation systems, the temporary nature of their dams or intakes is part of the mechanisms to control water flow in the systems. The construction of a permanent headworks in these systems would only reduce the systems' capacity in coping with water intakes during some part of the year and no intake during the flood season.

Another question that needs to be addressed is whether the unique physical characteristics of the potential sites are taken into account when engineering infrastructure is constructed. Engineering infrastructure which does not fit in local physical environment is likely to distract rather than enhance farmers' capability to manage irrigation.

In many cases in Nepal, sophisticated engineering infrastructure built at a substantial cost has failed to produce expected benefits due to inadequate attention being paid to the local physical environment. It might seem obvious to suggest that information about the local environment is essential to the construction of effective engineering infrastructure; and a most effective way to gather the information is to consult farmers, who live in the area for generations, in the stages of planning and construction. Unfortunately, many engineers in the DOI who are responsible for the construction of the infrastructure have frequently been unwilling to learn from farmers. As indicated previously, few incentives exist that would encourage irrigation officials to maintain productive working relationships with farmers.

Engineering Infrastructure and Managerial Orders

With few exceptions, most engineering infrastructures built in Nepal are designed solely according to engineering standards; how the engineering design might affect subsequent managerial practices has been gravely ignored. In many government-constructed irrigation systems in the country, it is frequently assumed that as long as an infrastructure is well-built, irrigation managers can figure out how to manage the infrastructure effectively. Engineering design and managerial design are frequently perceived to be two different domains insulated from each other.

One of the most notorious manifestations of such a (mis)perception is the urge for constructing huge irrigation infrastructure and systems (see Ascher and Healy, 1990; E. Ostrom, Schroeder, and Wynne, 1993). It is frequently asserted that constructing big infrastructure and systems can reap the benefits of economies of scale. As the size of an infrastructure or system increases, the marginal cost of serving an additional water user decreases. Putting aside the question of whether economies of scale can actually be generated, the increase in system size often results in greater demands for management. In systems where farmers and irrigation officials do not possess adequate managerial capability in terms of resources and institutional infrastructure, the potentials of the systems, no matter how promising they might have been designed to be, are not likely to be fully realized. Such a situation is further exacerbated in systems where engineering infrastructure is designed in the ways that they are difficult to operate. Wade and Seckler (1990) report that in many South Asian countries such as India and Sri Lanka, many irrigation systems are designed and constructed to be highly "articulated" in that many water control mechanisms, such as adjustable gates, are built along canals at distributory level. From an engineering perspective, this design looks attractive because a more articulated system allows a high level of water control by farmers. In practice, however, the usefulness of the water control mechanisms is far from clear. Effective operation of the gates requires a very good coordination between gates at different points of a canal. Farmers and irrigation managers who do not possess adequate managerial capability often find it difficult to organize for actively adjusting the gates as the design required. Consequently, the gates are seldom actively adjusted by farmers or irrigation managers, and are often kept open. During fieldwork in many large-scale irrigation systems in Nepal, two phenomena were observed that were very much consistent with what Wade and Seckler observed in South Asian countries. First, idle and broken water gates were commonplace in the systems. In fact, most, if not all, of the gates were not functioning. When the gates were not actively operated as they were supposed to be, they hindered rather than enhanced farmers' appropriation activities. This explains why many of these gates, in fact, have been broken by farmers themselves in order to make water available. Second, irrigation managers and farmers in many of these systems found the operation of the large number of water gates difficult, if not impossible.

Constructing manageable, and hence sustainable, irrigation engineering infrastructure requires that the strengths and weaknesses of irrigation managers and farmers who are to manage the infrastructure be recognized. In Nepal, where material and monetary resources are severely limited, the resources that are most available are manual labor of local farmers and various other locally available resources. Given this, individuals managing a "less-sophisticated" irrigation infrastructure, of which the maintenance relies more on local resources, are more likely to be able to mobilize necessary resources for the maintenance of the infrastructure. In Nepal, the fad of constructing lift irrigation systems, in which large electric pumps are installed at the intake to divert water from a source, in the last decade has been proven to be a serious mistake. While these high-powered pumps have high levels of water diversion capacity, their O&M requires a large amount of technological and monetary inputs which are beyond the capability of farmers, irrigation managers, or even the Nepali government. In these systems, the "sophisticatedness" of the infrastructure renders the use of local resources, such as manual labor of local farmers, for the O&M of these systems impossible. When all that an infrastructure needs is electricity for its operation and technological inputs for its maintenance, and neither electricity nor technological inputs is easily available, farmers and irrigation officials managing and using the infrastructure find themselves in a very much helpless situation.

Engineering Infrastructure and Patterns of Relationships

Constructing "manageable" engineering infrastructure also requires that serious attention be paid to the pattern of relationships among individuals in a system, and to how infrastructure might pertain to the pattern of relationships. Irrigation engineering infrastructure, if not properly designed so as to make them complementary to the pattern of relationships prevailing among farmers, is likely to adversely affect the relationships. There have been numerous instances in which after a permanent headworks has been constructed to replace a temporary headworks by external sources, the once well-organized system has turned into a chaotic situation in which farmers are no longer willing to cooperate with one another. While the typical diagnosis is that farmers are not yet ready to organize themselves for the operation of the newly-constructed permanent headworks, little attention has been given to why it could ever happen to some farmers who have had years of experience of working with one another effectively to manage irrigation and many other activities.

E. Ostrom and Gardner (1993) argue that a pitfall of the construction of a permanent headworks in a system is an increase in inequality of water availability to farmers located at the head end and those at the tail end. This increased inequality is likely to enhance the comparatively advantageous position of headenders in relation to tailenders which, in turn, dampens headenders' incentives to work with tailenders. When headenders perceive that water available to them is better assured by the newly-constructed permanent headworks, they are less likely to recognize the mutual dependencies between themselves and tailenders. Before the construction of the permanent headworks, frequent repair work by farmers was often required for the maintenance of temporary headworks. Headenders often found the contributions of tailenders to the maintenance work indispensable. To a significant extent, tailenders' maintenance contributions are a major basis of their bargaining power vis-à-vis headenders. As observed by Ambler (1990), tailenders' maintenance contributions are essential in supporting their claims of portions of water in the system and in reminding the headenders of the interdependencies between headenders and tailenders. When the level of effort for maintenance decreases as a result of the construction of a permanent headworks, tailenders find themselves deprived of the basis of their bargaining power. An even worse scenario is that farmers who have been "given" a permanent headworks by an external agency perceive the headworks be owned by the external agency, and consequently, see the maintenance of the headworks a responsibility of the agency.

Summary

While engineering infrastructure can potentially enhance farmers' capability of irrigation management, such potentials do not follow the construction of the infrastructure automatically. As discussed earlier, farmers and irrigation managers who do not possess adequate managerial capabilities are not likely to be able to utilize the potentials of engineering infrastructure. The development of such capabilities depends significantly upon whether individuals are able to craft and use various institutional arrangements to relate themselves to the physical world and to one another in a complementary and productive manner. The processes of crafting and establishing productive rule-ordered working relationships are by no means easy. Ironically, engineering infrastructure itself often poses serious difficulties and disincentives for individuals to organize for collective action.

Conclusion

This chapter examined various physical and socio-economic variables that might affect individuals' incentives to contribute to the collective action of operating and maintaining irrigation systems. Although these variables are important components of the action situation faced by individuals, they do not determine the result of collective action. Various rules can potentially be used to alleviate the possible negative effects of these variables. Also, constructing sophisticated engineering infrastructure does not necessarily bring about good performance. How much productive potentials of the infrastructure can be realized depends upon whether effective institutions are in place to support the O&M of the infrastructure.

Chapter 6: STATISTICAL ANALYSIS OF IRRIGATION PERFORMANCE IN NEPAL

As argued in this paper, the performance of irrigation systems, to a large extent, depends upon whether individuals involved in system operation and maintenance (O&M) are able to relate to one another in a productive manner. Whether such a productive pattern of relationships can be worked out, in turn, hinges on how various institutional, physical, and socio-economic attributes constitute an incentive structure that counteracts opportunistic behavior and provides positive incentives for individuals to cooperate. These attributes frequently combine in a configurational manner, and the structure of the configuration often varies significantly across particular systems. Such a variety is a source of the diversity of empirical processes and outcomes often observed by researchers. Every system might be unique in the way that multiple attributes get put together. One would, however, expect that the logic of cooperation (and non-cooperation) discussed in earlier chapters would manifest itself into commonalities in the relationships between particular combinations of these attributes and the consequential patterns of human action and interaction in various empirical experiences of irrigation governance and management. One would also expect that these commonalities are likely to be observed as patterns of regularities recurring in data collected from field settings.

Collective Outcomes of Irrigation Governance and Management in Nepal

Many past studies have suggested that, in Nepal, farmer-managed irrigation systems (FMIS) generally have higher levels of performance than agency-managed irrigation systems (AMIS). The data in the Nepal Institutions and Irrigation Systems (NIIS) database provides ample evidence for the difference in performance. To evaluate the agricultural productivity of irrigation systems, cropping intensities are good indicators. Cropping intensities are measured in percentage. A 100 percent intensity means that the land of a system is put to full use for one season, or partial use of multiple seasons amounting to the same coverage. A 300 percent intensity, then, means that a system is able to achieve three crops a year. In the initial NIIS database, there is information about both the head-end and tail-end cropping intensities of 118 systems. In Table 6.1, this information is displayed. While FMIS have an average head-end intensity of 246 percent, AMIS achieve only an average of 208 percent (p=.00). A similar pattern can also be found in tail-end intensities. The average tail-end intensity for FMIS is 237 percent, and for AMIS it is 182 percent (p=.00).

The disparity in cropping intensities between FMIS and AMIS is likely a result of the difference in availability of irrigation water to farmers in FMIS and in AMIS. In Table 6.2, the measures of average water availability in different portion of a system in different seasons are arrayed for both FMIS and AMIS. In the monsoon season when precipitation is heavy and, hence, the source of water supply is presumably abundant, only 44 percent of AMIS can get adequate water to their tail end, as compared to 88 percent of FMIS. In the spring season when the source of water supply is tight, the difference in water availability between FMIS and AMIS becomes more conspicuous. With 23 AMIS about which information is available, only 2 of them (9 percent) can get adequate water to their tail end. Eighteen of these 23 systems (78 percent) receive scarce or even no irrigation water to the tail end in the spring season, as compared to 40 percent of FMIS that receive little water in the same period of time.

The difference in performance between FMIS and AMIS can also be found in the level of technical efficacy of physical irrigation infrastructure. One of the variables in the initial NIIS database concerns whether the physical condition of the system is as well-maintained as is economically feasible given the terrain and technology available to the farmers or agency managing the system. This variable is coded as a four-point scale, with 1 being "very bad condition" and 4 being "excellent condition." While FMIS have an average score of 3.09, AMIS achieve only a score of 2.39 (p=.00) (Table 6.3). Substantively, it suggests that the condition of physical infrastructure of an average FMIS is "moderately good," while that of an average AMIS is "moderately poor."

In an effort to accurately measure the performance of irrigation systems, a measurement model has been developed for evaluating irrigation performance (Lam, 1994). In this model, three dimensions of irrigation performance have been identified:

1. Physical: the condition of the physical structure of irrigation systems,

2. Delivery: the water delivery effectiveness,

3. Productivity: the agricultural productivity of the systems.

On the basis of the measurement model, a factor score is calculated to measure each of these three dimensions of performance for each of the systems in the initial NIIS database. Each of these factor scores integrates information of multiple variables. Complete information on all three dimensions is available for 89 cases in the initial NIIS database. The description of these dimension variables is shown in Table 6.4. Note that since the factor scores do not have a unit of measure, the "magnitude" of the scores for a particular system can only be construed with reference to comparison with the scores of other systems. In Table 6.5, the average scores of these three dimensions for both AMIS and FMIS are arrayed. In each of these three dimensions, FMIS out-perform AMIS, and the differences are all statistically significant at the .01 level. This suggests that an average FMIS has better physical condition of system, more effective water delivery, and higher levels of agricultural productivity than an average AMIS. Note that while the average scores of the three dimensions of FMIS are all above the means of all 89 systems about which information is available, all those of AMIS are far below the means. Such a pattern of relationships generally holds even when physical terrain is controlled for (Table 6.6).

Explaining Irrigation Performance

An investigation of what and how various physical, institutional, and socio-economic attributes affect irrigation performance in a large number of irrigation systems requires that statistical models be specified and analyzed so as to decipher patterns of regularities in the data. For data analysis to have a greater chance of coming up with useful results, the limitations of the database to be analyzed must be recognized and taken into account when a strategy of analysis is designed. Although the initial NIIS database is one of the largest and most comprehensive databases on irrigation systems in Nepal that has ever been collected, it would be considered a small database for the purpose of analyzing the kind of institutional questions that this study addresses. When phenomena under investigation involve a large number of variables and complex relationships, a small sample is likely to suffer the drawback of low levels of statistical power. In other words, the information given by the data is inadequate to allow for a precise estimation of the effects of various variables in the models.

As an effort to cope with the problem of a small sample and to get the most out of the data, a two-step strategy in the analysis of the NIIS data was adopted. The first step of the strategy involves the specification and estimation of a regression model for each of the three dimensions of performance. The major purpose of this step is to provide an overview of the effect of various institutional, physical, and socio-economic variables on irrigation performance. To make a good use of the information in the data, the models will be specified in as parsimonious a manner as possible. To keep the number of variables to be included in these models as small as possible, aggregate variables will be used to connote the effect of a larger number of related variables. For instance, the variable of Governance, which is concerned with whether a system is governed and managed by the Department of Irrigation (DOI) or by farmers, will be used to represent institutional arrangements in general. Analysis using such an aggregate variable, of course, is not likely to give much insight on how different kinds of institutional arrangements get put together in a particular setting to affect performance. However, such an analysis does provide valuable information regarding how institutional arrangements compete with other variables to affect performance. This information, then, can serve as the foundation for subsequent analysis of a smaller number of variables in a more detailed manner.

Based upon the findings of these regression models, the second step will be taken in which a smaller number of variables will be analyzed. Specifically, the mechanisms and processes through which these variables manifest their effects, the ways that these variables interact with other explanatory variables to affect performance, and the extent to which their effects on performance might be conditioned by other variables will be examined.

The two-step strategy, which emphasizes addressing a small number of variables at a time, does *not* increase information contained in the database one way or another. Although the specification of more parsimonious models and, hence, a higher degree of freedom could bring about an increase in "statistical power" in analysis in terms of smaller standard errors of estimates, such an increase could be an illusion paid for by a higher degree of inconclusiveness of the analysis. Given the inconclusiveness, no pretense is made that these results are formal tests for hypotheses or propositions. Although various statistics will still be reported in the course of analysis, these statistics should be treated as a yardstick that helps one understand and evaluate the patterns of relationships recurring in the data, rather than formal tests of theoretical conjectures.

Although the two-step strategy does not increase information in the data, it does enable one to look at various aspects of a handful of more important variables from different angles. While a particular piece of information about a variable, or about its relationships to others, may be fragmented and inconclusive, many pieces of information about different aspects of the variable, when carefully put together and interpreted, can constitute a rich body of information essential to the understanding of the patterns of regularities in the data. This is the strength of the two-step strategy.

Regression Models of Irrigation Performance

Based upon the discussion in earlier chapters, a regression model is specified for each of the three dimensions of performance as follows:

Dimensions of Performance = (Governance, Headworks, Lining, Alternatives, Variations in Income, Terrain, Canal Length, System Area, Number of Appropriators)[1]

In these models, Headworks (coded as 0 for temporary headworks, 1 for permanent headworks) and Lining (coded as 0 for unlined canals, 1 for partially or completely lined canals) are variables concerning the effect of engineering infrastructure on irrigation performance. Governance is a dichotomous variable (coded as 0 for FMIS, 1 for AMIS) which pertains to the *aggregate* effect of institutional arrangements. The total length of canals in a system, the size of system area measured in hectare, and the number of appropriators are all concerned with the effect of the size of group, or the size and complexity of the collective task to be dealt with, on the outcomes of irrigation governance and management.[2] Terrain (0 for systems located in the Hills and the River Valley, 1 for systems in the Terai) takes into account the effect of natural physical environment on irrigation and agricultural activities. Among different geographic terrains in Nepal, natural physical characteristics such as topography, soil types, and availability of water sources vary significantly.[3] Hence, individuals in different physical terrains are likely to face drastically different environmental settings in which they organize for irrigation and engage in agricultural activities. Other conditions being equal, one would expect that systems in the Terai area, when compared to those in other physical terrains in Nepal, are likely to face a *relatively* less challenging natural physical environment for irrigation organization, and tend to be associated with higher levels of performance.

Alternatives (coded as 0 for no alternative source of irrigation water, 1 for the presence of alternative sources) is another physical variable included in the models. The existence of alternative sources of irrigation water may affect individuals' perception on the costs and benefits involved in organizing irrigation and, hence, their incentives to cooperate with others in regard to irrigation governance and management. Although many prior studies have given much attention to this variable, they have not come to an agreement on the direction of its effect on the outcomes of irrigation organization (see Meinzen-Dick 1984; Wickham and Valera, 1979; Uphoff, Wickramasinghe, and Wijayaratna, 1990; Tang, 1992). Another factor that may affect individuals' incentives to participate in collective action is the degree of asymmetries existing among individuals. In irrigation, asymmetries might exist in different guises. Differences in caste and in the size of landholding are two examples. In the regression models, the possible effect of asymmetries on irrigation performance is taken into account by including a socio-economic variable which measures the variation of incomes among appropriators in a system.

The regression models are estimated by Ordinary Least Squares (OLS). The results are reported in Table 6.7. The variable of Terrain is shown to have a significant positive effect on irrigation performance. Systems in the Terai area generally have higher levels of performance than those in the Hills and River Valley. Since physical terrain poses the task environment in which individuals organize irrigation, such a result is not surprising. As one would expect, physical terrain is especially significant, both substantively and statistically, in the productivity model. This significant effect reflects the fact that the level of success of agricultural activities and, hence, of agricultural productivity, is highly dependent on such components of natural physical terrain as topography, climate, and soil types.

Consistent with what many irrigation specialists have suggested, the estimates show that engineering infrastructure can make a big difference in irrigation performance. The two variables of engineering infrastructure, Headworks and Lining, are shown to have a substantial effect on various dimensions of performance. Except for Lining in the productivity model, the effects of Headworks and Lining in the models are all statistically significant at the .1 level. While these significant effects support the conventional wisdom on the importance of engineering infrastructure in irrigation, the directions of the effects of Headworks and Lining show an interesting pattern that might challenge the belief of many irrigation specialists and irrigation officials. The estimates show that while partially or completely lined canals are likely to improve performance, permanent headworks tend to bring about lower levels of performance. Moreover, the magnitude of the effect of Headworks is close to that of Lining, suggesting that much of the positive effect of having canals lined in a system is likely to be offset by the presence of a permanent headworks. Such a counterintuitive result indicates that engineering infrastructure may not *necessarily* bring about an improvement to irrigation performance.

Such an interesting result does not simply suggest that lining is a "good" engineering investment while permanent headworks a "bad" one, as it might appear. Instead, this result highlights the fact that while improvements in engineering infrastructure are potentially of considerable value, the potential may not necessarily be attained to improve irrigation performance. While permanent headworks may increase the water diversion capability of an irrigation system, they could also exacerbate the asymmetries of both interests and bargaining power between headenders and tailenders (see E. Ostrom and Gardner, 1993; E. Ostrom, 1994). Such an unintended consequence could adversely affect farmers' incentives and capability of working with one another and, hence, irrigation performance. Therefore, whether permanent headworks can improve irrigation performance or not, to a large extent, depends upon whether individuals are able to craft and enforce rules to cope with the asymmetries. In other words, the utilization of physical capital such as permanent headworks and lining often requires complementary support of social capital in forms of appropriately-crafted institutions and the associated productive patterns of working relationships. The ways that physical capital and social capital are put together and, hence, their net effect on irrigation performance, vary across systems, depending on contextual and historical factors in particular systems. With appropriate rules legitimately accepted and followed by irrigation officials and farmers, a permanent headworks could be an asset for irrigation management. Yet the negative coefficient of Headworks in all the three models suggests that, among systems in the initial NIIS database, systems with permanent headworks tend to have lower levels of performance than those with temporary headworks, controlling for other factors.

Whether the canals of a system are lined or not also affects how well the system is maintained and how effectively irrigation water is delivered. As completely or partially lined canals, when compared to unlined canals, are less prone to damage and have a lower level of water seepage, systems with completely or partially lined canals tend to be more efficient in O&M. The estimates show that Lining has a significant effect on the physical condition as well as water delivery of irrigation systems, both substantively and statistically. Unlike Headworks, the effect of Lining on irrigation performance is positive. A major reason is that the benefits of better maintenance and water delivery brought by lining are not likely to be offset by an increase in asymmetries between headenders and tailenders, as what a permanent headworks might bring about. In fact, having canals lined has a positive effect of helping farmers get water to the tail end. Issues related to the effects of engineering infrastructure will be discussed more fully in next section.

The negative effect of asymmetries among appropriators on irrigation performance can also be indicated by the negative coefficient of the variable of "Variations in Income" in the delivery model and the productivity model. In systems where wealth is not evenly distributed, farmers who are more well-off often find themselves able to provide and maintain the systems by themselves without the help from their poor neighbors. Frequently, these rich farmers are unwilling to cooperate with poor farmers. As a result, although a certain level of collective action may be organized and provided by the rich farmers, such a level is likely below the optimal level at which the full potential of the whole system is utilized. In cases where cooperation among farmers does exist, it is not uncommon that rich farmers use their stronger bargaining power to claim a disproportionately large share of benefit from the cooperative effort at the expense of poor farmers. Consequently, poor farmers are often not enthusiastic about engaging in the cooperative effort. As the estimates show, systems in which wealth distribution is highly uneven tend to be associated with low levels of performance.

The estimates indicate that whether alternative sources of irrigation water exist or not does not have a statistically significant effect on irrigation performance. As discussed earlier, although the presence of alternative sources of irrigation water might affect the level of asymmetries among farmers in a system, its effect is not determinate, depending on such contextual factors as the level of water adequacy in the system and the location of the alternative sources. In the regression models, such an indeterminate effect of alternative sources is reflected by the statistically insignificant coefficients of the variable of Alternative.

The variable of Governance is shown to have a highly significant effect on performance, both in statistical and substantive terms. In each of the three models, the coefficient of the variable is negative, meaning that FMIS are on average more likely to bring about high levels of performance. Note that the coefficient of Governance in the physical model and in the delivery model has a magnitude larger than a standard deviation of the dependent variable in respective models; even in the productivity model, the coefficient is almost as large as a standard deviation of the variable of productivity. (The standard deviations of the three dimensions of performance are shown in Table 6.4.) It suggests that, controlling for other factors, FMIS outperform AMIS by about one standard deviation on each of the three dimensions of performance. This result attests to the proposition that the governance structure can make a substantial difference in irrigation performance.

The estimates show that the size of irrigation systems, no matter whether it is measured by system area, number of appropriators, or total length of canals, does not have a statistically significant effect on physical condition and water delivery. In the productivity model, the Number of Appropriators is the only size variable that has a statistically significant effect on performance. Results of F-tests[4] show that even the combined effect of all these three variables is not statistically significant in the models. This result seems to be consistent with what prior studies on the effect of group size on collective action found. Caution is warranted, however, when one interprets the statistically *in*significant coefficients of the size variables. Instead of rejecting group size as unimportant, one should pay attention to possible reasons that might account for the insignificant effects; understanding how group size manifests its effect is itself of importance for one to understand irrigation performance.

A possible reason for the statistically *in*significant coefficients of the variables of group size is that group size is largely one of the "background variables" which constitute a task environment in which individuals interact. The extent to which the background variables affect irrigation performance depends largely upon how institutional arrangements in particular systems are designed so as to enable individuals to cope with problems associated with the task environment. Instead of affecting irrigation performance directly, group size influences the mode of institutional arrangements adopted by individuals in particular systems. Thus, when the effect of institutional arrangements is controlled for, one would expect that the effect of group size on irrigation performance becomes much less significant statistically. Therefore, instead of rejecting group size as an unimportant variable, one can conjecture that group size matters when individuals are pondering what kinds of institutional arrangements they will adopt in organizing activities concerning O&M.

Effects of Engineering Infrastructure

To better analyze how engineering infrastructure affects performance, one needs to pay attention to how various components of engineering infrastructure get put together to constitute an "Infrastructural Environment" (IE) in which individuals organize themselves for irrigation governance and management. To construct a categorization of IE, Headworks by Lining is arrayed. As these two variables are coded as dichotomous (permanent headworks versus temporary headworks; completely or partially lined canals versus unlined canals), arraying them by each other gives a two by two categorization of IE (Table 6.8). Since a system which has a permanent headworks normally has its canals lined at least partially, the category for systems with permanent headworks but unlined canals is not very useful empirically. In fact, in the initial NIIS database, there are only three such systems. Thus for the purpose of analysis, the categorization and classified systems is simplified into three IEs: IE I includes systems that have a temporary headworks and unlined canals; IE II includes systems that have a temporary headworks and lined canals; and IE III includes systems that have a permanent headworks. The distribution of systems in different IEs is shown in Table 6.9.

To investigate the relationships between different IEs and irrigation performance, the mean scores of the three performance dimensions in different IEs are arrayed in Table 6.10. In the initial NIIS database, there is complete information on engineering infrastructure and performance for 88 systems. Consistent with what has been found in the regression analysis above, engineering infrastructure does make a difference in irrigation performance. Information in Table 6.10 indicates that systems in different IEs do have different average scores in all three dimensions, and the differences are all statistically significant at the .01 level. Interestingly, systems with permanent headworks are shown to have the lowest scores in all three dimensions compared to other systems. On the other hand, systems with temporary headworks and at least partially lined canals are shown to outperform other systems in terms of the physical condition of systems and the effectiveness of water delivery. In terms of agricultural productivity, systems that do not have lining nor permanent headworks achieve the best performance.

The pattern of relationships in Table 6.10 would appear counterintuitive to many irrigation specialists. Why are systems that have received high levels of infrastructural investments outperformed by systems with more "primitive" engineering infrastructure? Part of the reason is that many modern engineering infrastructures in Nepal were not well-constructed to fit in local environment as they were warranted. In many instances, engineering infrastructure is designed solely upon "scientific" engineering standards without taking specific local conditions into consideration. Consequently, it is not uncommon to find a modern engineering infrastructure laid idle soon after its construction because the source of water that the infrastructure was supposed to capture has changed its course, or because not enough resources have been mobilized for its maintenance.

One of the major benefits of constructing sophisticated engineering infrastructure in irrigation systems is a decrease in maintenance costs. If properly operated and maintained, a permanent headworks made of concrete is more resistant to damage than a temporary headworks made of stones, mud, and tree branches; similarly, a lined canal is likely to be less prone to leakage and seepage than an unlined one. Thus, the maintenance of systems with more sophisticated engineering infrastructure would presumably require a smaller amount of resources. In most of the irrigation systems in Nepal, such a decrease in maintenance costs often means a smaller amount of labor devoted to routine maintenance. In Table 6.11, the average numbers of total labor days devoted to routine maintenance, of labor days standardized by the number of households in a system, and of labor days standardized by the number of hectares in a system are arrayed by the three IEs. As expected, while systems with temporary headworks and unlined canals have the highest level of labor mobilization for maintenance, systems with permanent headworks require the least amount of labor for routine maintenance. For the measures of labor days per hectare and per household, their relationships with IEs are statistically significant at the .1 level.

Although systems in IE II mobilize lower levels of labor for routine maintenance than those in IE I, such a difference is *not* very substantial. It suggests that while having canals lined can somewhat help reduce routine maintenance costs, farmers using the systems still have to contribute a significant amount of labor for maintenance. On the other hand, when one compares the level of labor input of systems with permanent headworks with that of other systems, the difference is very substantial. It indicates that the construction of permanent headworks can result in a substantial drop in the amount of labor for system maintenance. Given that the maintenance of headworks in many irrigation systems in Nepal usually takes up a major proportion of maintenance effort, such a pattern is not that surprising.

A decrease in the amount of labor devoted to routine maintenance could free farmers from tedious maintenance works. Presumably, time that has been spared from maintenance works could be spent on other productive activities. A significant drop in the amount of labor for maintenance, however, could also have serious impacts on the balance of bargaining power between farmers in a system, as well as on farmers' perception on the need to work with one another in irrigation management. As pointed out by many scholars (Ambler, 1990; E. Ostrom and Gardner, 1993), contributing one's labor to system maintenance is a major way for a farmer in FMIS, where *de jure* water rights often do not exist, to establish his *de facto* claim to a portion of water from the system. For farmers at the tail end of a system, being able to make such a claim is especially important because a reliable supply of irrigation water for them largely depends upon headenders to allow adequate water to flow down the canal.

Headenders are more likely to concede to the water claims of tailenders when the labor contribution of tailenders is essential to keeping the system operable. In other words, the necessity of organizing for routine maintenance is an equalizer which prevents headenders from exploiting their strategic physical position at the expense of tailenders. As suggested by information in Table 6.11, constructing a permanent headworks is likely to bring about a substantial decrease in the amount of labor input required for maintenance. With lower costs of maintenance, headenders might find themselves able to bear the costs of maintenance all by themselves without the labor contribution from tailenders. When the labor contribution of tailenders is not needed, headenders do not feel the need or obligation to give attention to the well-being of tailenders. Such a situation could go to the extreme where tailenders are not considered by headenders as legitimate partners in the governance and management of the system, and are left to take whatever amount of water is left behind by headenders.

Furthermore, before the construction of a permanent headworks, headenders, like their neighbors at the tail end, often face the uncertainty of whether adequate water will be diverted from a source into the system. (Note that headenders can enjoy the comparatively advantageous position only *after* water is diverted into the system.) To deal with such an uncertainty, headenders often find it necessary to work with tailenders in fixing and operating their temporary headworks to make sure that adequate water will be diverted into the system. When headenders and tailenders are working with one another, their interdependency becomes most obvious to them. Such an awareness of interdependency is the foundation upon which farmers cooperate and develop reciprocal relationships with one another. Once a permanent headworks is built, however, headenders find themselves better assured of a water supply without the labor contribution of tailenders. With the more reliable water supply, headenders no longer see the necessity of working with tailenders. The unraveling of the working relationships between headenders and tailenders is a likely result.

Thus, the existence of a permanent headworks often exacerbates the asymmetries between headenders and tailenders. When headenders do not see the need of working with tailenders, they tend to take as much water as they want to, that in turn reduces the quantity and reliability of irrigation water available to tailenders. As the tailenders perceive that they are not part of the governance and management of the system, they are not likely to take a good care of the physical structures of the system, nor to follow rules concerning water distribution and allocation. In such a situation, low levels of performance are not at all surprising. To look for evidence concerning the effect of engineering infrastructure on the degree of asymmetries, the relationship between different IEs and the difference in availability of water at the head end and at the tail end of irrigation systems is examined. As shown in Table 6.2, information about water availability at the head end and at the tail end of an irrigation system is available. By subtracting the scores of water availability achieved at the tail end of a system from the scores achieved at the head end across three seasons, a score of difference in water availability to headenders and tailenders is calculated (Table 6.12). Of course, the higher the absolute score, the higher the level of difference in water availability to headenders and tailenders.[5] For the purpose of analysis, the score is transformed into a dichotomous variable by coding 0 for systems which have no difference in water availability to headenders and tailenders (systems with a score of zero), and 1 for systems which have difference in water availability of various degrees (systems with a score other than zero, including those with a negative score). In Table 6.13, this dichotomous variable is arrayed by the three IEs. The pattern shown in Table 6.13 indicates that IE III has a larger percentage of systems that have difference in water availability to headenders and to tailenders than the other two IEs. On the other hand, IE II has the lowest percentage of systems that have the difference. A chi-square test which gives a value of 6.58 suggests that the pattern is statistically significant at the .05 level. Such a pattern of relationships, when interpreted with reference to the relationship between IEs and labor for maintenance (Table 6.11), attests to the argument that a drastic decrease in labor input for maintenance resulted from the construction of permanent headworks is likely to bring about a higher level of asymmetries between headenders and tailenders. In Table 6.14, the average scores of the three dimensions for both systems that have difference in water availability to headenders and tailenders and those that do not are arrayed. Information in Table 6.14 indicates that, in each of the three dimensions of performance, systems that do not have difference in water availability have outperformed systems that have difference in water availability; and the differences in performance are all statistically significant at the .05 level. Thus, the presence of permanent headworks tends to exacerbate the asymmetries between headenders and tailenders, and such an exacerbation, in turn, brings about low levels of performance.

Effect of Governance Structure and Institutions

An Earlier Effort in Understanding Institutions and Performance

In an earlier effort to explore the effect of institutional arrangements on irrigation performance in Nepal, Lam, Lee, and Ostrom (1993) (hereafter LLO) examined several key variables of institutions in the initial NIIS database that might affect farmers' capability to organize themselves for various collective actions required for effective irrigation governance and management. In the study, seven institutional variables were identified and arrayed individually by the variable of agricultural productivity within different infrastructural environments.[6] Using the same categorization of infrastructural environments used here, LLO find the following:

- In regard to each of these institutional variables, systems in IE I that have temporary headworks and unlined canals are more likely than systems in the other two IEs to adopt the particular institutional arrangements.

- The institutional variables were shown to have statistically significant effect on productivity only among systems in IE I. For systems with temporary headworks but lined canals (IE II), and those with permanent headworks (IE III), the institutional variables did not show statistically significant effect on productivity.

- Systems in IE I were more likely to have developed a more comprehensive set of rules than other systems.

- For systems in IE I, a more comprehensive set of rules tended to bring about a higher level of productivity. For systems in IE III, as the productivity of most of them was generally low, the existence of a comprehensive set of rules did not improve productivity. Contrary to the pattern found in IE III, systems in IE II generally had a high level of productivity, no matter whether a comprehensive set of rules existed in a system or not.

These findings in LLO suggest that there might exist a trade-off between engineering infrastructure and institutional arrangements in irrigation governance and management. For systems in IE I that do not have sophisticated engineering infrastructure such as permanent headworks and lined canals, individuals in the systems find it more necessary to develop a large array of institutional arrangements to better organize themselves to cope with various tasks involved in irrigation governance and management. In fact, given a lack of major infrastructural investment, whether individuals in these systems are able to craft and enforce a comprehensive set of rules to maintain an effective working order significantly affects the performance and even the viability of the systems. Also the findings clearly indicate that, even in a challenging environment where physical capital is lacking, farmers *can*, and in fact many of them did, attain a high level of productive potential if they are able to generate and sustain social capital in forms of well-crafted rules and productive working relationships to make up for the lack of physical capital.

The set of rules that is used in systems with a certain level of infrastructural investment is frequently not as comprehensive as the one found in systems without modern engineering infrastructure. As argued earlier, in systems where a permanent headworks has been constructed, the exacerbated asymmetries between headenders and tailenders often dampen farmers' incentives to organize. A less comprehensive set of rules is a likely result. Moreover, given that appropriators are not willing to work with one another, even when a set of rules is in place, it is not likely followed by appropriators. It explains the finding in LLO that the existence of a comprehensive set of rules in systems in IE III has not brought about a high level of productivity.

On the other hand, engineering infrastructure, if properly operated and maintained, can enhance the technological efficacy of an irrigation system which, in turn, makes the governance and management of the system more tractable. If this benefit is not offset by other adverse unintended effects, individuals in the systems might find that a less sophisticated set of rules is adequate for the purpose of irrigation governance and management. This is attested by the finding in LLO that many systems that have a medium level of infrastructural investment—temporary headworks but lined canals—can attain a high level of productivity with a relatively less comprehensive set of rules.[7]

Governance Structure, Pattern of Interaction, and Irrigation Performance[8]

Most of the analysis in LLO focused on relationships between *individual* institutional arrangements and irrigation performance. As an initial effort to explore the effect of institutions in irrigation governance and management, LLO adopted an analytical strategy that emphasizes addressing the effect of one institutional arrangement at a time. Although the analysis in LLO has offered many important insights on what and how particular institutional arrangements affect performance, it stopped short of addressing the broader question of why the governance structure of FMIS, compared to that of AMIS, is more conducive to good performance. Specifically, how does the governance structure of FMIS differ from that of AMIS in terms of the ways that it impinges upon the patterns of action and interaction among individuals in regard to O&M?

A governance structure is more than a summation of rules used in a particular situation; instead, it is a configuration of institutional arrangements in a particular setting that reflects a particular common understanding of rule-ordered relationships in regard to irrigation governance and management. Thus, to analyze how a governance structure affects irrigation performance, a researcher needs to examine how rules, common understandings, and enforcement mechanisms in the particular system combine together configurationally to affect the incentives, and hence the patterns of action and interaction, of individuals in the particular setting. To capture the characteristics of, and also the differences between, the governance structure of FMIS and of AMIS, the analysis focuses directly on the patterns of action and interaction among individuals in FMIS and in AMIS. Since patterns of action and interaction are the manifestation of the perceptions of rule-ordered relationships underlying a governance structure, an examination of these patterns can enable one to better understand how the ideas behind different types of governance structure, when acted upon, impinge upon the working relationships among individuals.

In earlier discussion, it has been argued that a major advantage of the governance structure of FMIS is that farmers in FMIS are more likely able to continuously engage in rule-crafting activities to develop and sustain working relationships to operate and maintain their systems. On one hand, the absence of help or intervention from governments or external agencies is often a strong reminder to the farmers of their interdependency, of their vulnerability when acting alone, and of the importance of working with one another. On the other hand, the availability to the farmers of opportunities to craft rules by and for themselves can facilitate the development of shared norms that emphasize the importance and viability of self-reliance and cooperation in dealing with collective problems. As shown in Table 6.15, farmers in FMIS, when compared to their counterparts in AMIS, are more likely to engage in entrepreneurial activities in trying to achieve coordinated strategies in regard to the O&M of irrigation systems. These entrepreneurial activities include the crafting of rules, discussion of issues of common concerns, persuasions, adjudication and interpretation of rules, and other activities that facilitate the organization of various collective actions concerning irrigation governance and management. The information in Table 6.15 conveys the image that farmers in FMIS, in comparison with their counterparts in AMIS, are more active in trying to develop working relationships with one another. In fact, the existence of entrepreneurial activities implies that, in many instances, local farmers are willing and able to play the role of entrepreneurs and to exercise entrepreneurship.

As farmers in FMIS are given opportunities and incentives to engage in rule-crafting activities, one would expect that a larger array of rules could be found in FMIS than in AMIS. To measure the extent of institutional development in irrigation systems, six institutional variables in the initial NIIS database have been identified. These variables are concerned with rules in regard to (1) information on water appropriation (2) information on individual farmers' contributions to maintenance (3) penalty for rule violations (4) water withdrawal rights (5) monitoring rule conformance and (6) variations in levels of sanctioning (see Appendix B). For each of these variables, a 1 is assigned if the particular rule exists in a system, and a 0 is assigned if it does not. An index of institutional development is then created by adding up the values of these six variables. The index, as shown in Table 6.16, is a seven-point scale, ranging from 0 to 6. For the purpose of analysis, irrigation systems are classified into two groups by the score of the index, one for the systems with a score of less than 4 in the index, and the other for those with a score of at least 4. In Table 6.17, these two groups are arrayed by the type of governance structure. The pattern of relationship shown in Table 6.17 provides strong evidence that FMIS are more likely to have a large array of rules than AMIS. While 75 percent of FMIS have scored at least a 4 in the index, only 29 percent of AMIS have achieved the same level. A chi-square test which gives a value of 11.05 suggests that the pattern in Table 6.17 is statistically significant at the .01 level.

Rules that are crafted by farmers who live and work in an irrigation system for years are more likely to fit particular local situations than rules imposed by irrigation officials who seldom care to visit the system. Furthermore, rules made by local farmers are frequently based upon ideas, norms, or understandings that are commonly-shared in the community. These commonly-shared ideas and understandings not only serve as common denominators upon which rules are understood and interpreted, but also in many instances embody the values prevailing in the community upon which commonly-agreed standards on what is right and what is wrong are based. Since these rules are commonly-understood and agreed upon on the one hand, and are appropriate for specific local situations on the other, they are more likely to be followed by farmers. In Table 6.18, the relationship between the type of governance structure and the level of rule-following among farmers of the 122 systems in the initial NIIS database about which information is available is displayed. While more than half of the FMIS achieve a high level of rule-following, less than 20 percent of the AMIS are able to do so ($p=.01$). Of course, a higher level of rule-following does not imply a perfect compliance. Given that rules are by their very nature soft constraints to which individuals can choose to comply or not, rule violations do happen from time to time. Yet as information in Table 6.19 indicates, when rules are violated in FMIS, the level of violation is generally low. On the contrary, in about half of the AMIS, rule violation is generally of a medium or high level.

Since irrigation governance and management often involves a high level of uncertainty and unexpected changes, a high level of information and knowledge on an irrigation system is instrumental to farmers' dealing with uncertainties and changes. Given that information and knowledge about an irrigation system is often scattered and time-specific, its acquisition and utilization requires that farmers be actively involved in system governance and management, and that rules be in place to facilitate the collection and sharing of information. Since farmers in FMIS are better able to participate in various governing activities and to craft rules that are suitable to particular local situations, one would expect that farmers in FMIS are more likely to be better informed of what is going on in their systems than farmers in AMIS. As shown in Table 6.20, farmers in 71 percent of FMIS have intimate knowledge on their systems, as compared to 35 percent of AMIS (p=.00). This shows that the governance structure of FMIS is better able to induce information than that of AMIS. Note that the relationship between institutions and knowledge about the systems is mutually reinforcing. While the structure of a governance structure might affect the ability of farmers to acquire information, the level of information that farmers possess often affects farmers' ability to craft effective institutions to govern their systems.

The information presented in this section portrays a clear picture on how the ways of life in FMIS differ from those in AMIS. In many FMIS, farmers are more likely to be actively involved in a process of rule-crafting in an effort to achieve coordination with one another in dealing with problems involved in O&M. A large array of rules is frequently used by these farmers to establish and sustain effective working relationships with one another. With continuous practice of human artisanship, these farmers are able to learn from experiences of working with one another. This learning process often results in an accumulation of a body of skills and knowledge of human artisanship accrued to the community of farmers. This body of skills and knowledge then supplant and reinforce the common understanding and common agreement prevailing in the community to serve as the foundation upon which more effective rules can be crafted. The farmers' vision of working with one another, when acted upon through the processes of crafting and of working by a large array of rules, can release a huge amount of social energy and social capital that significantly enhances the productive potentials of the community. While social capital is hard to operationalize and measure conclusively, Table 6.21 does provide information on the relationship between the type of governance structure and the level of mutual trust among farmers in a system. Consistent with what one would expect, farmers in FMIS, when compared with their counterparts in AMIS, are more likely to have developed a high level of mutual trust with one another.

In many AMIS, on the contrary, farmers are less likely to perceive engaging in self-governing and self-managing activities a viable way to deal with problems they face. Given the perception that the prerogative of governance rests in the hand of government officials, farmers in many of these systems do not have the passion nor incentives to establish effective working relationships with one another. Of course, in many of these AMIS, a set of rules has usually been established by the declaration of irrigation officials or by farmers themselves under the auspice of the officials. These rules, however, are often perceived by farmers as administrative commands to be worked around or ignored, than commonly-agreed covenants regulating relationships with one another. Consequently, the ways of life involve less of the productive levels of trust that help farmers counteract incentives to free-ride and act independently.

The patterns of interaction associated with the governance structure of FMIS are more conducive to cooperative activities among individuals, and are a major factor contributing to their generally high levels of performance. In Table 6.22, the relationships of patterns of interaction and the three dimensions of irrigation performance are arrayed. As expected, systems in which farmers are able to craft and use a large array of rules to coordinate their activities related to irrigation governance and management, and to enforce these rules so as to attain a high level of rule conformance, are more likely to have better physical condition of systems, more effective water delivery, and higher levels of agricultural productivity than those in which rules are less well-developed and are largely not followed. Also, systems with a low degree of rule-violation perform better than those with a medium or high degree of rule-violation in all three dimensions; and the difference is statistically significant at the .1 level in the dimensions of physical condition and water delivery. Further, farmers' intimate knowledge about their systems and their high level of mutual trust are also shown to be associated with high levels of performance.

Interestingly, although systems in which farmers have engaged in entrepreneurial activities to coordinate activities related to irrigation governance and management have higher levels of performance in terms of the physical condition of system and water delivery than those in which these entrepreneurial activities do not exist, such differences are not very significant statistically. One possible reason for this pattern is that farmers' entrepreneurial activities do not necessarily succeed all the time. Given that the tasks of irrigation governance and management are arduous, nothing guarantees that farmers' self-governing and self-organizing activities will pay off. Of course, that the relationships between entrepreneurial activities and levels of performance are statistically insignificant in the analysis does not mean that farmers' self-governing and self-organizing activities are of little importance. Through engaging in these activities, farmers are able to learn to work with one another to resolve various collective problems they face in daily exigencies. Such problem-solving capabilities are social capital that enables farmers to better realize their productive potentials. This might help explain why systems in which farmers have engaged in entrepreneurial activities are more likely to have a higher level of productivity than those in which such activities do not exist (Table 6.22).

Engineering Infrastructure, Governance and Performance

So far the effect of engineering infrastructure and of institutional arrangements on irrigation performance have been discussed separately. In this section, both components are taken together in an effort to understand the way that engineering infrastructure relates to governance structure in affecting irrigation performance. Hopefully, this analysis will shed lights on issues related to the trade-off between physical capital and social capital in irrigation governance and management.

To examine how governance structure might affect the relationship between engineering infrastructure and irrigation performance, Table 6.23 arrays the mean scores of the three dimensions of performance by the three IEs for FMIS and for AMIS separately. The p-values indicate whether the mean scores of particular dimensions associated with different IEs are significantly different from one another. Several patterns in Table 6.23 are noteworthy. First, the levels of performance of AMIS are generally lower than those of FMIS, even though the effect of IEs is controlled for. Second, while IEs still show significant effects on all the three dimensions of performance among FMIS, the effects of IEs on performance are shown to be statistically *in*significant among AMIS. Third, FMIS that have achieved the highest levels of performance in terms of physical condition of system and effective water delivery are those with at least partial lining and temporary headworks; FMIS that have permanent headworks have achieved the lowest levels of performance. On the contrary, AMIS that have permanent headworks are shown to have higher levels of performance in terms of the condition of physical structure and water delivery than AMIS that have temporary headworks.

Several interesting insights in regard to how engineering infrastructure and governance structure affect irrigation performance can be drawn from the patterns of relationships shown in Table 6.23. In AMIS where the levels of performance are generally low, building more sophisticated engineering infrastructure is *unlikely* to bring about an improvement in irrigation performance. As argued in earlier chapters, the governance structure of AMIS often creates perverse incentives to both irrigation officials and farmers in the systems that prevent them from cooperating with one another in system O&M. Without effective institutional arrangements which sustain a pattern of productive working relationships, increasing the amount of physical investment alone is insufficient for improving irrigation performance. As pointed out by many scholars, achieving success in any private or collective endeavors requires a high degree of complementarity between physical capital and social capital (Lachmann, 1975; E. Ostrom 1992; Uphoff, 1986). Neither one can completely substitute for the other. In irrigation, E. Ostrom (1992) writes,

> "But even with the most modern irrigation system, complete with automatic measurement and distribution mechanisms, cannot run indefinitely without human operators. If human operators

do not follow regular patterns of behavior that are expected and understood by others, especially system users, the potential flow of income from the physical capital will be severely curtailed or even eliminated. Productive patterns of behavior do not just happen." (1992: 27).

By providing strong evidence for the importance of complementarity between engineering infrastructure and effective institutional arrangements in irrigation governance and management, the information in Table 6.23 poses a serious challenge to the viability of a rationale behind many past irrigation policies in Nepal and elsewhere which assigns extreme importance to the construction of engineering infrastructure in improving irrigation performance and ignores the importance of institutions. In fact, the patterns in Table 6.23 imply the contrary, that an effective working order is prerequisite to engineering infrastructure being able to manifest its effects.

While engineering infrastructure does not show significant effects on performance among AMIS, it is a different story among FMIS. As shown in Table 6.23, while the FMIS that have an intermediate level of infrastructural investments—at least partially lined canals with only temporary headworks—have achieved a higher level of performance in terms of better physical condition of the systems and more effective water delivery than FMIS in other IEs, the FMIS that have permanent headworks have achieved the lowest levels of performance. The difference in irrigation performance associated with different types of engineering infrastructure is shown to be statistically significant at the .01 level. In FMIS where farmers have a greater control as well as responsibility over their systems, how well they are able to organize themselves significantly affects the performance of their systems. Unlike farmers in AMIS who are generally insensitive to what has happened to their systems due to a sense of inability and reliance on government officials, farmers in FMIS are more sensitive to changes in their environment. A change in the engineering environment can seriously impinge upon farmers' incentives to work with one another.

To better understand what goes behind the patterns shown in Table 6.23, the effects of engineering infrastructure on the amount of labor input for routine maintenance in FMIS and in AMIS are examined. In Table 6.24, the average numbers of total labor days, of labor days per household, and of labor days per hectare within each of the three IEs for AMIS and FMIS are displayed separately. The information in Table 6.24 indicates that, among FMIS, while having canals lined brings about moderate decrease in labor input for routine maintenance, constructing permanent headworks results in a more drastic drop in labor input. Among AMIS, the effect of the existence of permanent headworks on the amount of labor for maintenance is especially substantial.

If one examines the patterns shown in Table 6.24 with reference to Table 6.23, a serious puzzle arises: why a decrease in labor input for maintenance brought by the construction of engineering infrastructure appears to affect performance differently in different settings? Among FMIS, while a decrease in labor input brought by lining canals has improved performance, a decrease brought by the construction of permanent headworks has brought about low levels of performance. Yet among AMIS, a decrease brought by the construction of permanent headworks seems to have slightly improved the physical condition and water delivery of the systems.

It has been argued earlier that whether the benefit of lower maintenance costs brought by the construction of engineering infrastructure can be transformed into productive potentials depends upon how the construction of infrastructure might impinge upon farmers' relationships with one another. One may then infer that how a decrease in labor for maintenance affects performance is likely to be conditioned by the extent to which different governance structures are able to sustain productive working relationships among farmers. In Table 6.25A and 6.25B, the difference in water availability at the head end and at the tail end are arrayed by different IEs for FMIS and for AMIS, respectively. While Table 6.25A indicates that, in each of the IEs, a high percentage of FMIS do not have difference in water availability between headenders and tailenders, Table 6.25B suggests the contrary for AMIS. The contrast between the patterns found in these two tables is consistent with one's expectation that the governance structure of FMIS, that is more conducive to farmer participation and the development of reciprocal working relationships, is better able to deal with the problem of asymmetries than the governance structure of AMIS, that is based upon relationships of dominance and dependence.

Learning that different governance structures have different abilities to deal with asymmetries, the answer to the puzzle begins to emerge. Given the prevalence of inequity in water allocation in AMIS, the further exacerbation in asymmetries brought by a decrease in labor for maintenance is not likely to show significant effects on the already high level of inequity in water allocation. Ironically, under such a situation, a drastic decrease in labor input could be a benefit to farmers in these systems. On the contrary, given that FMIS generally have a good working order in water allocation, a drastic decrease in labor for maintenance could have substantial effect on farmers' incentives to engage in organizing activities. When such a decrease is not very substantial, it reduces farmers' burden without causing too much adverse effect on the relationships among farmers. It is one factor explaining why FMIS in IE II have higher levels of performance in two out of three dimensions than those in IE I. However, when the decrease is too substantial that drastically exacerbates the asymmetries of interests and bargaining powers between headenders and tailenders, it is likely to dampen farmers' incentive to work with one another. It helps to explain why FMIS in IE III have the lowest levels of performance when compared to systems in other two IEs.

Analysis that has so far been presented in this section has focused on how governance structure conditions the effect of engineering infrastructure on irrigation performance. What if one puts the question the other way around, asking how the effect of governance structure on irrigation performance is conditioned by engineering infrastructure? In Table 6.26, the type of governance structure is arrayed by the three dimensions of performance dichotomized by their respective means in each of the three IEs. Except for IE I where AMIS do not exist and hence comparison is impossible, FMIS are shown to outperform AMIS in all three dimensions in each of the IEs. This result provides evidence to the fact that, even when the effect of engineering infrastructure is controlled for, governance structure still has a significant effect on irrigation performance.

Conclusion

In this chapter, the analysis has focused on the patterns of regularities recurring in the initial NIIS database in an effort to gain a better understanding on what and how various physical, institutional, and socio-economic attributes affect irrigation performance in various empirical experiences of irrigation governance and management in Nepal. Particularly, the effects of engineering infrastructure and of governance structure, and the way that they interact with each other to affect performance are emphasized.

Although the results of the analysis presented in this chapter are largely consistent with what has been argued in earlier chapters, there are possible rival hypotheses that might challenge what has been found in the above analysis. For example, one could argue that since most of AMIS in Nepal were constructed in the last fifty years, they are relatively "young" when compared to many FMIS that have been in operation for hundreds of years. The generally low levels of performance for AMIS, then, could be a consequence of their not having had enough time to settle down. Since this and other rival hypotheses are of great policy import, it is warranted to pay serious attention to addressing these hypotheses.

In the complete document (Lam 1994) from which Section II of this report is taken, a full chapter is dedicated to a discussion of alternative explanations and rival hypotheses concerning the relationships among physical infrastructure, socio-institutional variables and irrigation performance. In light of the counterintuitive results of the analysis based on the initial NIIS database, it is particularly important to study and understand these hypotheses. Readers interested in this comparative discussion are encouraged to refer to the more comprehensive volume.

Notes

1. The description of the variables included in the models is shown in Appendix B.

2. For the 83 systems in the initial NIIS database which information is available on the total length of canals, the size of system area measured in hectare, and the number of appropriators, the correlation between the total length of canals and the size of system area is .67, between the total length of canals and the number of appropriators is .19, and between the size of system area and the number of appropriators is .39.

3. For a detailed discussion of characteristics of different terrains in Nepal, see E. Ostrom, Benjamin and Shivakoti (1992).

4. The F-values and the associated p-values for the physical, delivery, and productivity models are F=1.17 (p=.33); F=.98 (p=.41); and F=2.06 (p=.12), respectively.

5. Systems with a negative score are those in which tailenders get more water than headenders. There are two such systems in the initial NIIS database, they are the Badachaur Irrigation System in Syangji District, and the Thuli Besi Irrigation System in Kaski District.

6. The seven institutional variables are (1) whether record of individual appropriators' attendance for routine maintenance is kept (2) whether water withdrawal of individual appropriators is recorded (3) whether water withdrawals may be forfeited for rule infraction (4) whether sanctions vary from very small to substantial (5) whether penalties are well enforced (6) what is the level of trust among appropriators and (7) what is the extent to which rules are followed. All these seven institutional variables are dichotomous. For the first five variables, a 0 was assigned for the non-existence of the particular institutional arrangement, and a 1 assigned for the existence. For the remaining two variables, a 0 was assigned for low to moderate level, and a 1 assigned for high level. The variable of agricultural productivity is the dichotomized version of the productivity dimension of performance. A 0 is assigned for systems that have a score of productivity below mean, and a 1 for systems with a score above mean.

7. Another possible reason for this pattern of relationships, as suggested in LLO, is that many systems classified in IE II were systems in Sindhu Palchok District which had gone through an intervention program by the Nepali Water and Energy Commission Secretariat (WECS) and International Irrigation Management Institute (IIMI). The intervention program had helped farmers improve physical works of their systems on the one hand, and given farmers training on how to design effective rules to govern activities involved in systems operation and maintenance on the other. The program was shown to be very successful (Shivakoti, 1992; Lam and Shivakoti, 1992), which is clearly shown in the NIIS data. However, since farmers were just beginning the process of crafting institutions, most of these systems still did not have a comprehensive set of rules at the time information about these systems was collected. Of course, one would expect that if farmers in these systems want to sustain good performance, they would need to continue the process of rule-crafting. Otherwise, the good performance brought by the intervention effort could easily dissipate.

8. The description of the variables used in the analysis in this section is shown in Appendix B.

Table 6.1 The Relationship of Governance Structure with Cropping Intensities

	FMIS (N)	AMIS (N)	F	P
Head-end Intensities	246% (97)	208% (21)	10.51	.00
Tail-end Intensities	237% (97)	182% (21)	20.33	.00

Table 6.2 Water Availability for Head End and Tail End in Different Seasons

	Water Availability in Spring		Water Availability in Monsoon		Water Availability in Winter	
	Head End		Head End		Head End	
	FMIS	AMIS	FMIS	AMIS	FMIS	AMIS
Scarce	32 33%	8 35%	0 0%	0 0%	5 6%	2 9%
Limited	32 33%	9 39%	3 3%	2 9%	47 47%	11 48%
Abundant	34 34%	6 26%	97 97%	21 91%	47 47%	10 43%
	Tail End		Tail End		Tail End	
	FMIS	AMIS	FMIS	AMIS	FMIS	AMIS
Scarce	38 40%	18 78%	0 0%	1 4%	15 15%	12 52%
Limited	35 36%	3 13%	12 12%	12 52%	46 47%	8 35%
Abundant	23 24%	2 9%	86 88%	10 44%	37 38%	3 13%

Table 6.3 <u>The Relationship of Governance Structure with Technical Efficacy of Infrastructures</u>

	FMIS (N)	AMIS (N)	F	P
Technical Efficacy of Infrastructures	3.09 (103)	2.39 (23)	20.28	.00

Table 6.4 <u>Summary of Dimensions of Performance</u>

	Mean	Std. Dev.	Min	Max	N
Physical Condition	3.52	.71	1.42	4.75	89
Delivery	3.50	.81	1.69	5.04	89
Productivity	4.15	.97	1.83	5.5	89

Table 6.5 <u>The Relationship of Governance Structure with Dimensions of Performance</u>

	N	FMIS	AMIS	F	P
Physical Condition	(89)	3.73	2.75	40.76	.00
Delivery	(89)	3.73	2.65	38.02	.00
Productivity	(89)	4.36	3.40	17.25	.00

Table 6.6 Dimensions of Performance by Governance Structure, Controlling for Natural Physical Terrain

Physical

TERRAIN	FMIS (N)	AMIS (N)	F	P
Hills	4.41 (27)	3.08 (6)	16.26	.00
Hills-River Valley	3.80 (14)	3.30 (8)	1.35	.26
Terai	4.57 (29)	3.92 (5)	2.18	.15
All Systems	4.36 (70)	3.4 (19)	17.25	.00

Delivery

TERRAIN	FMIS (N)	AMIS (N)	F	P
Hills	4.06 (27)	2.53 (6)	22.94	.00
Hills-River Valley	3.29 (14)	2.60 (8)	5.20	.03
Terai	3.64 (29)	2.87 (5)	8.92	.01
All Systems	3.73 (70)	2.65 (19)	38.02	.00

Productivity

TERRAIN	FMIS (N)	AMIS (N)	F	P
Hills	4.02 (27)	2.68 (6)	20.90	.00
Hills-River Valley	3.37 (14)	2.68 (8)	6.35	.02
Terai	3.64 (29)	2.93 (5)	11.88	.00
All Systems	3.73 (70)	2.75 (19)	40.76	.00

Table 6.7 OLS Regression Models of Dimensions of Performance

Independent Variables	Physical Condition	Delivery	Productivity
Governance	-1.0892*** (-4.76)	-1.2122*** (-4.75)	-.8653** (-2.62)
Headworks	-.5369*** (-2.78)	-.6226*** (-2.89)	-.4863* (-1.74)
Lining	.6192*** (3)	.723*** (3.14)	.1326 (.44)
Alternatives	.0423 (.28)	.1531 (.91)	.2854 (1.31)
Variations in Income	-.3144 (-1.48)	-.401* (-1.7)	-.5049* (-1.66)
Terrain	.3639* (1.96)	.4589** (2.21)	.9344*** (3.47)
Canal Length	-.00002 (-1.6)	-.00002 (-1.04)	.00003 (1.22)
System Area	.0005 (.81)	.0004 (.61)	-.001 (-1.25)
Number of Appropriators	.0002 (1.25)	.0002 (1.22)	.0004** (2.25)
Constant	3.454*** (18.05)	3.3603*** (15.74)	3.9338*** (14.21)
Adjusted R^2 =	.46	.48	.37
N =	67	67	67

Note: T-values are in parentheses.

*p<.10 (two-tailed); **p<.05 (two-tailed); ***p<.01 (two-tailed)

Table 6.8 A Categorization of Infrastructural Environments (Headworks by Lining)

Type	Systems with Temporary Headworks	System~ with Permanent Headworks
No Lining	38 48%	3 7%
Partial/Complete Lining	41 52%	40 93%
	79 100%	43 100%

Chi² = 21.11
P = .00

Table 6.9 Distribution of Systems in Infrastructural Environments

	Number of Systems
IE I Systems Without Lining & Without Permanent Headworks	38 30%
IE II Systems With At Least Partial Lining & Without Permanent Headworks	41 33%
IE III Systems With Permanent Headworks	46 37%
	125 100%

Table 6.10 Dimensions of Performance by Infrastructural Environments

	Physical Condition	Delivery	Productivity
IE I Systems Without Lining & Without Permanent Headworks	3.65 (26)	3.63 (26)	4.60 (26)
IE II Systems With At Least Partial Lining & Without Permanent Headworks	3.81 (32)	3.87 (32)	4.31 (32)
IE III Systems With Permanent Headworks	3.12 (30)	3.04 (30)	3.58 (30)
	P=.00	P=.00	P=.00

Table 6.11 Labor Days by Infrastructural Environments

	Total Labor Days	Labor Days Per Household	Labor Days Per Hectare
IE I Systems Without Lining & Without Permanent Headworks	1447.28 [2735.49] (25)	8.48 [11.25] (25)	10.61 [15.39] (25)
IE II Systems With At Least Partial Lining & Without Permanent Headworks	965.79 [1981.44] (29)	5.33 [7.83] (28)	10.46 [13.83] (29)
IE III Systems With Permanent Headworks	675.71 [1209.76] (28)	2.01 [2.50] (27)	4.16 [6.10] (28)
	F=0.96 P=.39	F=4.32 P=.02	F=2.45 P=.09

Note: Standard deviations are in brackets

Table 6.12 Distribution of Systems on the Score of Difference in Water Availability to Headenders and to Tailenders

Score of Difference in Water Availability to Headenders and to Tailenders	Number of Systems
-2	2
-1	0
0	68
1	19
2	18
3	6
4	3
5	2
Total	118

Table 6.13 The Relationship of Difference in Water Availability and Infrastructural Environments (Systems for which the performance data are available)

Difference in Water Availability between Head End and Tail End	IE I Systems Without Lining & Without Permanent Headworks	IE II Systems With Partial Lining & Without Permanent Headworks	IE III Systems With Permanent Headworks
No	15 58%	22 69%	11 37%
Yes	11 42%	10 31%	19 63%
	26 100%	32 100%	30 100%

$Chi^2 = 6.58$
P = .04

Table 6.14 The Relationship of Difference in Water Availability and Irrigation Performance

	Difference in Water Availability Does Not Exist (49)	Difference in Water Availability Exists (40)	F	P
Physical Condition	3.68	3.31	6.49	.01
Delivery	3.74	3.21	10.27	.00
Productivity	4.4	3.84	7.8	.01

Table 6.15 The Relationship of Entrepreneurial Activities and Governance Structure

Whether Appropriators Have Engaged in Entrepreneurial Activities in Trying to Achieve Coordinated Strategies in Irrigation Governance and Management	FMIS	AMIS
No	16 20%	8 36%
Yes	65 80%	14 64%
	81 100%	22 100%

$Chi^2 = 2.67$
P = .10

Table 6.16 Distribution of Systems on the Index of Institutional Development

Index of Institutional Development	Number of Systems
0	2
1	2
2	12
3	11
4	20
5	13
6	21
Total	81

Table 6.17 The Relationship of Institutional Development and Governance Structure

Index of Institutional Development	FMIS	AMIS
Scored Less Than 4	17 25%	10 71%
Scored At Least 4	50 75%	4 29%
	67 100%	14 100%

$Chi^2 = 11.05$
P = .00

Table 6.18 The Relationship of Rule-Following and Governance Structure

Level of Rule-Following Among Appropriators	FMIS	AMIS
Low/Moderate	49 49%	17 81%
High	52 51%	4 19%
	101 100%	21 100%

$Chi^2 = 7.37$
P = .01

Table 6.19 The Relationship of the Degree of Rule-Breaking and Governance Structure

When Rules are Violated, The Level of the Violation Is	FMIS	AMIS
Low	83 87%	11 52%
Medium/High	12 13%	10 48%
	95 100%	21 100%

$Chi^2 = 13.70$
P = .00

Table 6.20 The Relationship of Appropriators' Knowledge on the Resource and Governance Structure

Appropriators Have Intimate Knowledge on The Resource	FMIS	AMIS
No	29 29%	15 65%
Yes	72 71%	8 35%
	101 100%	23 100%

$Chi^2 = 10.90$
P = .00

Table 6.21 The Relationship of Mutual Trust and Governance Structure

Level of Mutual Trust Among Appropriators	FMIS	AMIS
Low	41 41%	14 64%
High	60 59%	8 36%
	101 100%	22 100%

$Chi^2 = 3.88$
P = .05

Table 6.22 Relationships of Patterns of Interaction and Irrigation Performance

Whether Appropriators Have Engaged in Entrepreneurial Activities in Trying to Achieve Coordinated Strategies in Irrigation Governance and Management

	No (N=20)	Yes (N=62)	F	P
Physical Condition	3.35	3.61	1.89	.17
Delivery	3.29	3.6	2.20	.14
Productivity	3.81	4.33	4.22	.04

Scores of Index of Institutional Development

	Less Than 4 (N=24)	At Least 4 (N=45)	F	P
Physical Condition	3.13	3.72	11.38	.00
Delivery	3	3.73	14.6	.00
Productivity	3.69	4.6	14.99	.00

Level of Rule-Following Among Appropriators

	Low/Medium (N=44)	High (N=44)	F	P
Physical Condition	3.36	3.68	4.54	.04
Delivery	3.31	3.69	4.89	.03
Productivity	3.87	4.46	8.65	.00

Degree of Rule-Breaking

	Low (N=70)	Medium/High (N=18)	F	P
Physical Condition	3.6	3.22	4.08	.05
Delivery	3.58	3.19	3.27	.07
Productivity	4.2	4.02	.45	.5

Table 6.22 (continued)

Appropriators Have Intimate Knowledge on the Resource and Governance Structure

	No (N=28)	Yes (N=61)	F	P
Physical Condition	3.33	3.6	2.87	.09
Delivery	3.23	3.63	4.84	.03
Productivity	3.85	4.29	4.07	.05

Level of Mutual Trust Among Appropriators

	Low (N=37)	High (N=50)	F	P
Physical Condition	3.25	3.73	10.04	.00
Delivery	3.18	3.75	11.71	.00
Productivity	3.78	4.46	11.77	.00

Table 6.23 Dimensions of Performance by Infrastructural Environments Controlling for Governance

	FMIS			AMIS		
	Physical Condition	Delivery	Productivity	Physical Condition	Delivery	Productivity
IE I Systems Without Lining & Without Permanent Headworks	3.65 (26)	3.63 (26)	4.60 (26)	. (0)	. (0)	. (0)
IE II Systems With At Least Partial Lining & Without Permanent Headworks	4.01 (27)	4.11 (27)	4.43 (27)	2.72 (5)	2.56 (5)	3.66 (5)
IE III Systems With Permanent Headworks	3.43 (16)	3.35 (16)	3.83 (16)	2.75 (14)	2.68 (14)	3.30 (14)
	P=.00	P=.00	P=.01	P=.90	P=.69	P=.56

Table 6.24 Labor Days by Infrastructural Environments and Governance Structure

	FMIS			AMIS		
	Total Labor Days	Labor Days Per Household	Labor Days Per Hectare	Total Labor Days	Labor Days Per Household	Labor Days Per Hectare
IE I Systems Without Lining & Without Permanent Headworks	1447.28 [2735.49] (25)	8.48 [11.25] (25)	10.61 [15.39] (25)	. [0] (0)	. [0] (0)	. [0] (0)
IE II Systems With At Least Partial Lining & Without Permanent Headworks	546.17 [1243.62] (24)	4.53 [6.79] (23)	10.36 [14.77] (24)	2980 [3530.16] (5)	8.99 [11.83] (5)	10.89 [9.21] (5)
IE III Systems With Permanent Headworks	452 [606.59] (15)	2.31 [2.24] (15)	5.33 [7.16] (15)	933.85 [1651.94] (13)	1.63 [2.84] (12)	2.81 [4.50] (13)
	F=1.86 P=.16	F=2.88 P=.06	F=0.82 P=.45	F=2.93 P=.11	F=4.41 P=.05	F=6.47 P=.02

Note: Standard deviations are in brackets

Table 6.25A Relationship of Difference in Water Availability and Infrastructural Environments for FMIS (Systems for which performance data is available)

Difference in Water Availability between Head End and Tail End	IE I Systems Without Lining & Without Permanent Headworks	IE II Systems With Partial Lining & Without Permanent Headworks	IE III Systems With Permanent Headworks
No	15 58%	21 78%	8 50%
Yes	11 42%	6 22%	8 50%
	26 100%	27 100%	16 100%

$Chi^2 = 4.02$
P = .13

Table 6.25B Relationship of Difference in Water Availability and Infrastructural Environments for AMIS (Systems for which performance data is available)

Difference in Water Availability between Head End and Tail End	IE I Systems Without Lining & Without Permanent Headworks	IE II Systems With At Least Partial Lining & Without Permanent Headworks	IE III Systems With Permanent Headworks
No	0 0%	1 20%	3 21%
Yes	0 0%	4 80%	11 79%
	0 100%	5 100%	14 100%

$Chi^2 = 0.00$
P = .95

Table 6.26 Dimensions of Performance by Governance Structure and Infrastructural Environments

	Physical Condition		Delivery		Productivity	
	FMIS (N)	AMIS (N)	FMIS (N)	AMIS (N)	FMIS (N)	AMIS (N)
IE I Systems Without Lining & Without Permanent Headworks	3.65 (26)	. (0)	3.63 (26)	. (0)	4.60 (26)	. (0)
	P=.		P=.		P=.	
IE II Systems With At Least Partial Lining & Without Permanent Headworks	4.01 (27)	2.72 (5)	4.11 (27)	2.56 (5)	4.43 (27)	3.66 (5)
	P=.00		P=.00		P=.10	
IE III Systems With Permanent Headworks	3.43 (16)	2.76 (14)	3.35 (16)	2.68 (14)	3.83 (16)	3.30 (14)
	P=.00		P=.00		P=.07	

Chapter 7: LESSONS FROM THE EXPERIENCE OF IRRIGATION GOVERNANCE IN NEPAL: INSTITUTIONS, COLLECTIVE ACTION, AND PUBLIC POLICY

This study sought to answer the question of how institutional arrangements affect the performance of irrigation systems in Nepal by focusing on two issues. First, how different kinds of governance structure (agency-managed versus farmer-managed) affect individuals' incentives and capabilities to cope with collective action problems involved in system operation and maintenance (O&M). Second, how diverse combinations of institutions and engineering infrastructures affect irrigation governance, management, and performance.

Drawing upon a theory of institutions developed in a rational-choice tradition, conditions under which individuals are likely to contribute their efforts to collective action, and the relationships of institutions to these conditions are laid out. Based upon this theoretical discussion, the incentive structures faced by irrigation officials as well as by farmers in irrigation systems in Nepal were examined. Evidence from 127 irrigation systems was studied with statistical and qualitative analysis to substantiate some of the arguments developed in this study and to clarify theoretical understanding of relevant empirical phenomena.

This concluding chapter discusses the findings of this study with respect to their implications for public policy analysis generally, and irrigation policy in Nepal specifically. After that, it discusses briefly some of the limitations of this study and suggest possible directions for future research.

Implications on Public Policy and Irrigation Policy

Irrigation Governance and Management as a Collective Effort of Problem-Solving

This study will have accomplished one of its major goals if it has highlighted the fact that the governance and management of irrigation, like that of many other resources and activities in the public sector, pertains to how: (1) ways of life are constituted at the local level where livelihood is closely linked to the resource, and (2) resources are brought together in complementary ways to realize productive potentials. Farmers who appropriate water from an irrigation system are not simply system users, but an essential component in the management of the system. They can also be a critical component in the governance of a system. The ways that farmers relate to one another and to the system, as ways of life, significantly affect the short-term performance as well as long-term viability of a system. Hence, public policy is not simply government actions but collective efforts of individuals to mobilize and organize their cognitive facilities and actions to cope with problematics involved in interdependent situations that characterize public affairs. In this sense, government officials, policy researchers, and individuals involved in problematic situations are all policy analysts who inquire and act upon ideas in an effort to work with one another to cope with collective problems (Wildavsky, 1987; V. Ostrom, 1991b). Policy actions, then, involve crafting and using institutional arrangements to further the problem-solving potentials of individuals.

In recent years in Nepal, especially after the beginning of the democratization process in 1990, many government officials and irrigation specialists in the country have come to recognize the importance of the role of farmers in irrigation governance and management. Various efforts have been made by the Department of Irrigation (DOI) and international donor agencies to organize local farmers and to enhance their involvement in irrigation governance and management. "Institutional development" has become a standard component in the process of constructing new systems or rehabilitating existing systems that are facing difficulties. Unfortunately, local irrigation institutions are often seen by irrigation officials and irrigation specialists merely as arrangements through which farmers' contributions are obtained. The governing function of these institutions has been given little attention. As a consequence, enhancing farmers' participation is frequently interpreted as an exercise of tutelage by irrigation officials to tell farmers what to do and how to fit their effort in the O&M plan laid down by the officials. As discussed in earlier chapters, these efforts to organize farmers have generated few successes.

Effective irrigation governance and management will have a greater chance to be attained if it is recognized that farmers are intelligent human beings who have not only the capabilities of reasoning and of making choices of what to do but also the potentials of working with one another in an effort to resolve problems that they collectively face. As the outcomes of irrigation governance and management are closely related to the working order of farmers in the system, the quest for an improvement in irrigation performance is at the same time the quest for enhancing farmers' capability of organizing themselves so as to realize their problem-solving potentials. Policy actions in irrigation governance and management should pertain to providing an institutional environment in which farmers are given positive incentives to craft effective rules, and to develop productive working relationships, in operating and maintaining the system.

As public policy is concerned with making changes in the pattern of relationships among purposive individuals, policy researchers and government officials frequently find themselves possessing only limited leverage in making these changes. On the one hand, the common understanding shared by a community of individuals that provides the foundations for interaction among them can hardly be manipulated and controlled by government officials and policy researchers. On the other hand, the behavior of purposive human beings in a complex situation is often difficult to predict. While government officials and policy researchers may be able to identify various summary variables which are parameters that an individual might take into his or her calculus when he or she is making choices of actions, the linkages between summary variables and situational variables are often configurational and complex. When put in different contexts, the same situational variable, say a particular rule, is likely to have different effects on a summary variable such as the perceived payoffs of adhering to the rule. The ever-changing world further adds to the complexity involved in the linkages. Moreover, the way that a particular situational variable is translated into a summary variable is very often determined by individuals' modes of thinking as well as their perceptions of the empirical world. A rule that produces positive incentives to individuals in one system might produce perverse incentives to those in another.

The fact that policy researchers and public officials have only limited leverage to change the behavior of, and the pattern of relationships between, individuals might appear to give a grim picture of the usefulness of policy analysis and actions. Yet it is just a fact of life with which fallible human beings must cope. A recognition of the characteristics and limits of what government officials and policy researchers can do, or can do better, is itself essential to effective policy analysis and actions. With such a recognition in mind, government officials and policy researchers would be more sensitive to the context of a particular irrigation system when they recommend particular policy actions to the system, more able to appreciate the complexity of social phenomena, and more conscious of the possibility of counterintentional and counterintuitive consequences of policy actions. Further, such a recognition could prompt policy researchers and government officials to realize that successful policy actions require that individuals, or in this case farmers, function as effective problem-solvers themselves in dealing with recurring problems in various exigencies.

Engineering Infrastructure and Irrigation Governance

One of the strong findings of this study is that, contrary to what many irrigation specialists expect, sophisticated engineering infrastructure does not necessarily bring about better irrigation performance. In fact, for the 127 irrigation systems in the initial NIIS database, systems with permanent headworks tend to have lower levels of performance than those with temporary headworks; and the difference in performance is both statistically and substantively significant. Most of the systems with permanent headworks are established and managed, or have been assisted, by government or international agencies. In other words, the construction of permanent headworks and other engineering infrastructures has been a major policy tool by the DOI and international donor agencies to improve irrigation performance. That permanent headworks have failed to bring about the expected improvement in irrigation performance casts serious doubts on the viability of a policy tool that emphasizes technological fixes that are not well crafted to meet local physical and social circumstances.

One of the reasons for such a counterintuitive pattern, of course, is that many of the engineering infrastructures in Nepal are not as well-constructed as they are designed on paper. Rugged topography, changing river courses, low levels of incentives for officials to monitor the quality of construction works, and the prevalence of the practice of "commission" payment all contribute to low-quality construction. Yet a more important reason for the counterintuitive pattern is the possible adverse impacts that permanent headworks can inflict upon the patterns of relationships between farmers in the systems. As analysis in this study showed, the existence of permanent headworks significantly reduces the amount of labor needed for the O&M of the systems. Such a significant reduction in labor demand frequently makes the labor contribution by farmers at the tail end become less important to farmers at the head end. When headenders perceive that they do not need the help from their neighbors at the tail end, they can afford ignoring the demands and well-being of tailenders. A high level of tail-end deprivation, a low level of cooperation, and low levels of performance are likely results. Several recent studies on how engineering infrastructures affect irrigation O&M all come to this same theoretical conclusion (E. Ostrom and Gardner, 1993; E. Ostrom, 1994; Lee, 1994). This analysis presents empirical evidence that, among irrigation systems in Nepal, the negative effect of permanent headworks is especially strong among FMIS. For AMIS, on the other hand, the existence of permanent headworks does not have a significant impact on irrigation performance, but the performance levels are already generally low.

The findings of this study shed light on why many attempts by the DOI or international donor agencies to help develop irrigation by constructing sophisticated engineering infrastructure have received limited success, or in some cases, brought about negative outcomes. Although modern engineering infrastructure can potentially enhance the water delivery capability of a system, the extent to which the potential can be realized depends upon how it fits in the context of the system. In particular, whether effective institutions exist that provide social capital in terms of managerial capability and productive working relationships supporting the O&M of the infrastructure is of major importance.

Thus, the construction of physical capital and the development of social capital are intricately related, and should not be considered as two domains in isolation of one another. In many irrigation construction projects in Nepal funded by international donor agencies, while the task of construction of physical structure is undertaken by irrigation officials, the task of institutional development is conducted by a team of "social scientists." The existence of these two teams who usually have a minimum level of coordination has frequently put farmers in a difficult situation. For example, it is not uncommon that farmers who are assigned by the "social scientists" to a particular irrigation group find themselves getting water from an outlet under the jurisdiction of another irrigation group. The lack of attention to the interplay between institutional arrangements and infrastructure renders many irrigation development efforts futile.

Thus, the construction of physical capital and the development of social capital are two complementary processes, and should be considered simultaneously in the planning of irrigation development. Attention should be paid to the questions of how institutions should be developed and designed to support the O&M of engineering infrastructure, and of how the social capital that has already existed in the local community can be better utilized. Engineering infrastructure could be designed in the way that it complements local institutions and water rights to the extent possible. Furthermore, given that the process of institutional development is often difficult, an analyst should not presume that the establishment of institutional arrangements necessarily comes *after* the construction of physical infrastructure. Instead of asking what kinds of institutions are needed to cope with a new engineering infrastructure, the analyst should make a critical assessment on the local situation *before* an engineering infrastructure is constructed. Such an assessment, then, can serve as a reference with which a more manageable engineering infrastructure can be constructed. For example, in systems where farmers have not been able to organize themselves effectively, or where officials have difficulty mobilizing necessary resources for maintenance works, the analysts should consider constructing a technologically less-sophisticated infrastructure instead of a more-sophisticated one.

Irrigation and Governance Structure

Perhaps one of the most precious lessons that can be learned from the Nepali government's experience of irrigation development in the last several decades is that cooperation among individual farmers is not automatic, even though potentially the cooperation might bring benefits to all of them. In numerous instances, sophisticated engineering infrastructure begins to deteriorate soon after construction due to farmers' collective *inaction* in operating and maintaining their systems. Government officials and irrigation specialists have usually diagnosed the collective *inaction* as a syndrome of farmers' selfishness. Such a diagnosis has often led to recommendations of either imposing more government control on irrigation management, or a bigger role for officials in exercising tutelage over farmers' organizing activities. Yet as discussion in earlier chapters indicates, higher degrees of government control and the tutelage of officials have only exacerbated problems involved in irrigation governance and management. If neither government control nor the tutelage by officials is a way out, what can be done?

Individual farmers are likely to contribute their efforts to the O&M of their irrigation systems when: (1) they perceive that they are able to reap the long-term benefits of engaging in collective action, (2) they are aware of their interdependence and also the viability of working with one another for mutual benefits, (3) a set of rules is in place that counteracts perverse incentives and provides positive incentives for cooperative activities, (4) the set of rules is credible, commonly understood, well-enforced, and agreed upon, and (5) the set of rules is able to sustain its own long-term viability. When a set of rules is in place that has characteristics pertaining to these conditions, individuals are able to establish stable and positive mutual expectations with one another. Such expectations are the basis upon which cooperation among individuals can develop.

The difference in performance of farmer-managed irrigation systems (FMIS) and agency-managed irrigation systems (AMIS) in Nepal can be understood with reference to the extent to which their respective governance structures are conducive to the development of these conditions for cooperation. The governance structures of FMIS tend to emphasize problem-solving, reciprocity, and active rule-crafting. Such a governance structure not only enables farmers to develop more appropriate rules to coordinate their activities but also allows social capital in terms of social accountability and human artisanship to evolve and to cumulate. Analysis in this study showed that FMIS are more likely to be associated with productive working relationships in terms of a high degree of mutual trust, active participation in the crafting and monitoring of rules, and a high level of rule conformance. These productive patterns of relationships are the basis upon which high levels of irrigation performance are attained.

The governance structure of AMIS, on the contrary, is based upon, and at the same time reinforcing, a dominance-dependence relationship between irrigation officials and farmers. Such a relationship creates a perverse situation in which neither irrigation officials nor farmers are given positive incentives to contribute their efforts. On the one hand, farmers are discouraged, or in some instances disallowed, from taking initiatives in dealing with problems that are closely related to their daily lives. On the other hand, irrigation officials are asked to bear the burden of governing and managing the system that they have little expertise, resources, and incentives to handle. Given that farmers are not given incentives to engage in the governance and management of their systems, the viability of the systems is largely hinged upon the performance of irrigation officials. Since irrigation governance and management is a co-production process in which the effort of one party cannot completely substitute for that of the other, such a design is basically flawed. Obviously, even the most well-intentioned and able officials cannot know the details of the physical structure of the canals as well as the farmers do. Nor, can they always know what kinds of rules are suitable to farmers in particular time and place exigencies. Also, it is impossible for the officials to monitor and enforce the rules all the time. When irrigation officials are facing little incentives to see to it that the systems are well-managed, low levels of performance are a likely result.

Evidence from 127 irrigation systems in Nepal indicates that the governance structure of irrigation systems is an important variable affecting irrigation performance, controlling for other factors. This finding is evidence that challenges the belief of many government officials and policy researchers that institutions are, at best, a secondary concern in irrigation management. It also corroborates what has been observed by many irrigation specialists that FMIS are more likely to be associated with high levels of performance than AMIS. The message from the analysis is clear: institutions not only matter, but matter a great deal. Interestingly, some variables which have been treated as major determinants of the likelihood of success of collective action, such group size and the availability of alternative sources of irrigation water, did not show a statistically significant effect on irrigation performance when controlling for the effect of the governance structure. It is consistent with a major argument of this study that whether a collective action, or in this case the governance and management of irrigation, will succeed depends largely upon whether individuals are able to organize themselves to *cope* with the environment of their problematic situation. Individuals' capability of organizing themselves, in turn, is mainly determined by the design and the effectiveness of the governance structure.

A casual look at the findings of the comparison between AMIS and FMIS presented in this study might lead one to draw a conclusion that a FMIS necessarily performs better than an AMIS. Yet caution is warranted before reaching such a conclusion. Although the evidence suggests that productive patterns of relationships are more likely to be associated with FMIS than with AMIS, which helps explain the generally higher levels of performance of the former than the latter, not all FMIS have achieved productive patterns of relationships and not all AMIS are low performers. As shown in the case materials presented in this study, a substantial diversity of institutional arrangements and performance is found among both FMIS and AMIS. By laying out the conditions for cooperation among individuals, a logic has been provided that relates the design of institutional arrangements to possible outcomes of human interaction. These conditions, however, say nothing about which particular rules are needed in a specific setting in order to attain these conditions. In other words, while these conditions pertain to basic parameters (summary variables) in the calculus of individuals when they are making choices, they do not specify how particular institutional arrangements (situational variables) might relate to these parameters. Since rules are usually configurational, the way that a particular rule affects these conditions often depends on the way that the rule is related to other rules-in-use, to the larger social-physical setting of a particular system, and to the common understanding shared by a community of individuals. No recipe exists for the best configuration of institutional arrangements that fit all situations. Thus, while the governance structure of FMIS might be more conducive to the development of an effective working order, the actual patterns of behavior in particular systems depend upon how rules are put together and related to other contextual factors in the systems. A comparison between FMIS and AMIS with reference to how they pertain to the conditions provides a way to understand the general discrepancy in performance between these two groups of systems; it, however, does not imply that a FMIS necessarily has higher levels of performance than an AMIS.

A recognition of the fact that there are diverse ways of putting institutional arrangements together to attain cooperative patterns of relationships is of both theoretical and empirical import. It challenges the simplified notion that the major question of irrigation governance and management is whether farmers or an irrigation agency should govern and manage. Various institutional arrangements could potentially be used to relate the efforts of farmers and of irrigation officials in a complementary manner. Instead of presuming that simply having farmers involved in the governance and management process can automatically bring about good performance, analysts should pay attention to the arrangements leading to the effectiveness of many FMIS and learn from diverse experiences in different systems on how various institutional arrangements can be put together to make the operation of the systems more effective.

Irrigation Governance and Management as a Continuous Process

As irrigation is a series of complex socio-technical processes, the governance and management of irrigation systems often involves a high degree of uncertainty. Uncertainties can come from many sources; capricious weather, rugged topography, the large size of infrastructure, and the normally large number of appropriators could all give rise to unexpected events from time to time. During the monsoon season, for example, canals could be broken by floods so that maintenance efforts are urgently needed. The flow of water in canals could change suddenly so that timely adjustments in water distribution schedules are required. Farmers might get into arguments concerning the allocation of water so that arbitration and conflict resolution are called for. To deal with these problems effectively often requires that individuals in the system be continuously involved and engaged in system governance and management.

That irrigation governance and management is ongoing implies that rules-in-use regulating the activities and relationships among individuals should be flexible and responsive enough to cope with ever-changing situations. Effective crafting of institutions is not a one-shot process. Individuals have to be able to engage in a continuing trial-and-error process in an effort to come up with appropriate institutional arrangements for specific time and place contingencies. Two implications follow. First, efforts in helping farmers develop institutions should be directed towards enhancing farmers' capability and willingness to relate to, and to work with, one another, rather than installing rules or organizations *for* farmers. Institutional arrangements, no matter how well designed at the beginning, could become ineffective as the situation changes. What is essential is that farmers in the system are able to engage in rule-crafting activities skillfully to make corresponding adjustments in institutional arrangements. The productive artisan is not one who has been given a good blueprint or two, but one who can be a master artisan. Second, assistance efforts should avoid creating a dependence mentality among farmers. As farmers' ways of life are closely linked to the performance of their system, their continuing initiatives and concern are essential to effective governance and management of the system. Once farmers think that external assistance or irrigation officials can solve the problems in irrigation for them once and for all, the resulting neglect on the part of farmers could bring about disastrous consequences.

Linking Irrigation Governance to Broader Institutional Setting

The governance and management of irrigation systems cannot be fully understood in isolation of the broader institutional setting in which these systems operate. In particular, the structure of the linkage between irrigation systems at a local level and an irrigation agency as a representative of the central government at a macro level is an important variable affecting the operation as well as the performance of the systems.

Micro-Macro Linkages. The structure of actors at the macro level, such as the DOI and donor agencies, and their actions constitute major components of the broader institutional setting in which local institutions operate. These components can affect the governing process of irrigation systems at the local level in two major ways. First, they create opportunities and constraints to which farmers make choices to respond. Some of these most important choices include whether it is advantageous for farmers to organize themselves at the local level and, if it is, what is the more appropriate way to do so. For instance, if the DOI is able to do a good job in managing the main system (the operation of the dam and the main canal), and that the good job is perceived by farmers as viable in the long-run, farmers would likely see the possibility of capturing the benefits made available by the officials' good job by organizing themselves at the sublateral level. Also, assistance offered by international donor agencies that goes with conditions that farmers should first organize themselves to fully utilize the assistance and need to repay the assistance to a certain extent can provide positive incentives for farmers to engage in self-organizing activities. Of course, the contrary could happen, and it often does.

Second, the structure of major actors and their actions in the broader institutional setting can affect the range of possible institutional arrangements that an irrigation system can adopt. For instance, the DOI has frequently imposed a particular blueprint of organization structure on local institutions in an effort to get farmers organized. One problem of such a practice, of course, is that these externally imposed structures may not suit the local situation. A more serious problem, however, is that the existence of these "formal" organizations could deal a serious blow to existing local institutions developed by farmers. When the legitimacy of local institutions is challenged by the new structures, farmers' faith in local institutions can erode rapidly. Issues related to institutional development at the local level will be discussed in detail in a later section.

As the governance and management of irrigation systems at the local level is nested within the larger institutional setting, any effort to improve the performance of irrigation systems is not likely to produce positive outcomes unless complementary effort is made to get the structure of the broader institutional setting "right." In particular, the structure of the DOI and the linkages relating the DOI to farmers are of special policy import.

An analysis of the incentive structures facing irrigation officials in Nepal appears to portray a discouraging picture for almost every actor concerned. For policymakers in the government, the incentive structures facing irrigation officials provide few realistic avenues for motivating officials. The levels of salary for irrigation officials in Nepal are indeed very low. Given budgetary restraints, raising the salary levels of irrigation officials as a means of motivation is practically impossible. In fact, little leverage exists that would soothe the officials' frustration that hard work rarely pays off. For irrigation officials, their jobs not only provide low payoffs but also are very restraining. As the upper echelons of the DOI monopolize the decision-making power and the purse strings, irrigation officials who are responsible for O&M in the field are often unable to take any initiative to deal with day-to-day problems. As a consequence, officials often find themselves asked by farmers and their superiors to accomplish tasks that they have neither the resources nor the discretion to accomplish.

For farmers, they often find themselves powerless in dealing with irrigation officials, and are basically subject to the mercy of the officials. Given the dominance-dependence relationship between irrigation officials and farmers, farmers just cannot expect that officials would treat them seriously. Making meaningful changes in the linkage between the DOI and local farmers requires that the strengths and weaknesses, as well as the malleability, of each actor be properly understood. While an accurate assessment of the strengths and weaknesses enables analysts to get a better idea on how the resources and efforts of different actors can be arranged so that they complement to one another, a better understanding of the malleability allows the analysts to make realistic and practicable recommendations. In the following sections, three directions of reforms are described and discussed concerning the structure of DOI and the way that the department is linked to local irrigation governance that have often been suggested by policy researchers and irrigation specialists. The viability of these recommendations will be examined with reference to what have been found in this study.

Reforming the Structure of the DOI as a Reform Strategy. It has often been suggested that a better system of reward and punishment in the DOI can create an incentive structure that brings about more effective and responsive irrigation officials. Presumably, if officials perceived that doing a good job would pay off and shirking would bring about severe punishment, they would likely align their behavior with that incentive structure, and be more effective and responsive. While this suggested direction of reforms might seem logically sound, it is practically non-viable. First of all, little incentive and leverage exists for the upper echelons of the DOI to see to it that irrigation officials in the field contribute the best efforts to their jobs. For high-ranking irrigation officials, exercising reward and control over subordinates is costly in terms of time and effort involved. More important, doing a good job in motivating subordinates does not bring any benefits to high-ranking officials and it could put them in conflict with their subordinates. Second, too much control and centralization is itself a major reason causing the department's ineffectiveness. More control would only exacerbate the problem. In fact, contrary to what people might expect, the DOI, despite its overtone of hierarchical control in its administrative procedures, has seldom attempted to exercise reward and control as a means to obtain good performance from irrigation officials. Senior irrigation officials all expressed serious doubt about the viability and the usefulness of making changes in the internal structure of the department as a way of improving the performance of irrigation officials.

Decentralization as a Reform Strategy. The second oft-suggested direction of reforms is to increase the degree of decentralization in the DOI. Since the late 1980s, a District Irrigation Office (DIO) has been set up in each of the administrative districts in Nepal to handle the O&M of small-sized irrigation systems in the district. For large-scale irrigation projects, project offices have been set up to deal with the projects' O&M activities. The underlying logic of the decentralization effort is straightforward. If officials in the field were given higher levels of discretion, they would presumably be able to take initiatives in undertaking necessary actions to deal with problems that they might encounter and be in a better position to keep in touch with local farmers. Potentially, these changes would bring about better performance on the part of officials, as well as better linkage between officials and farmers.

Despite all these organizational changes, irrigation officials at the local level still possess only limited discretion. Budgets assigned to the District Irrigation Offices are often very small. Approval from Kathmandu is often needed for decisions at the local level. In fact, according to informants, as a result of the strong resistance of high-ranking DOI officials to the decentralization efforts by the central government, the department is one of the government agencies that has the slowest pace of decentralization. Two related reasons might possibly help explain the slow pace. First, irrigation maintenance or rehabilitation projects often involve construction budgets which could be a source of "commissions." For many senior officials, giving up the control of these projects could mean giving up opportunities for lucrative "side-incomes." Second, most of the assistance money to irrigation development from donor agencies is channeled into the country through the headquarters of the DOI. This practice further enhances the trend of centralization in the department.

As long as decentralization is narrowly perceived as a delegation of power by headquarters to irrigation officials in the field, it is not likely to bring about positive changes in the governance and management of irrigation systems. One major reason is that no matter how much power is delegated to the field offices, the superior-subordinate relationship between officials at the headquarters and those in the field will still be the same. Understanding that the advancement of their careers depends on their superiors, irrigation officials in the field have every incentive to avoid offending their superiors by asking for approval from them before making major decisions. So, although formally the structure of power between officials at the headquarters and those in the field has been changed, the patterns of relationships between them remain. Moreover, with little changes made in the payoff structures faced by irrigation officials, officials in the field would still find doing as little as possible the safest strategy for their career development. Further, that officials in the field are given greater discretion does not mean that they would necessarily use the discretion to serve the farmers; on the contrary, the discretion could possibly be abused for the personal benefits of officials. Like many other bureaucratic organizations, structural reforms of the DOI face the dilemma that while tightening control stultifies, loosening it would likely give rise to widespread corruption.

Vertical decentralization of power and responsibilities within the DOI will have a greater chance to work if it is complemented by the development of horizontal linkages between officials inside the DOI and farmers outside the bureaucracy. Effective horizontal linkages could be developed in such a way that farmers are authorized to function as citizen-consumers to relate themselves to irrigation officials functioning as public managers. Such a working order, however, would need to be supported and sustained by a whole set of socio-political institutions as well as the habits of hearts and minds of individuals that pertains to the covenantal type of interaction. Given that the Nepali polity has been built and functioning upon a hierarchical image for a long period of time, a recommendation putting such a working order in place as a solution would be unrealistic. Of course, it is encouraging to witness that a process of democratization is in progress in the country. Although a rapid change in the socio-institutional setting of the country is practically impossible, small changes can be made to establish a certain degree of reciprocity and accountability between irrigation officials and farmers at the local level.

Irrigation officials perceive that they can get away with low-quality goods (construction and repair works) and services (mainly water distribution) they provide to farmers in agency-managed or agency-assisted systems largely because they see themselves the sole suppliers of these goods and services. This relationship between officials as suppliers, and farmers as receivers, is highly asymmetric. On the one hand, since irrigation officials see that they are giving goods and services to farmers, they often do not see why the farmers have a right to complain about the quality of the goods and services that they supply. After all, they would think, these goods and services are *free* to farmers! On the other hand, as long as farmers have few or even no alternative access to these goods and services other than the DOI, they cannot do much to make their voices heard by the officials.

Such asymmetric relationships between officials and farmers would be somewhat ameliorated if farmers have a voice concerning whether, what, and how the officials are to provide. Farmers' claim of the right of a say will be better supported if farmers are paying for at least part of the goods and services that officials supply. Water fees can play a significant role. Institutional arrangements could be designed in the way that water fees were collected and kept by farmers for their collective use in regard to O&M activities. The liberty of deciding how to mobilize and spend the collected funds would give farmers a certain level of "purchasing power." This purchasing power would give farmers greater ability to undertake activities that they see appropriate for O&M and also increase their bargaining power vis-a-vis irrigation officials.

With farmers paying part of the goods and services that officials are providing, officials would no longer be the ones who deliver "free" goods and services to farmers; instead, they are partners in a transaction with farmers which is on a more equitable basis. Under such a situation, farmers would have incentives to get their money's worth. Officials would likely treat farmers in a more positive manner. One may be concerned, however, that farmers would be unwilling to pay the water fees, as they currently are. Yet earlier research suggests that as long as farmers see that the fees they pay will pay off, they are willing to pay (Hilton, 1991; Wade, 1988). Discussion in earlier chapters also suggests that farmers are likely to pool their resources together for collective endeavors if they perceive that their investments will pay off and not fall prey to others.

Other than water fees, another possible way to enable farmers to acquire a certain level of "purchasing power" is that donor agencies channel aid funding directly to local farmers who need the help, instead of through the DOI.

For farmers' purchasing power to bring about positive outcomes, multiple suppliers of irrigation goods and services should exist that create a certain level of competition among the suppliers. Presently, in agency-managed or agency-assisted systems, the DOI normally hires *dhalpas* (water guards) for minor maintenance tasks and day-to-day operation, and contracts out larger-scale maintenance and repair works to private contractors. Since DOI officials have the control of what kinds of repair works are to be done and which contractors will be given the contracts, they are in a position that they can ignore the demands and needs of farmers on the one hand, and extract favors from contractors on the other. To remedy such a problematic relationship, changes could be made that allow farmers to contract out their maintenance and repair works directly to private contractors. While farmers could still choose to have the DOI arrange for their maintenance and repair works, they would now have alternatives. By allowing competition among suppliers, farmers would be given not only more options and opportunities but also a means to put pressure on irrigation officials to improve their performance. Note that as long as farmers are able and allowed to acquire a certain level of "purchasing power," these changes could be relatively easily put in place without dramatic structural changes. Instead of making their bids to irrigation officials, private contractors would make their bids to farmers directly.

Division of Work as a Reform Strategy. The third oft-suggested direction of reforms is to reduce the role of the DOI in O&M activities by turning over agency-managed systems to farmers. The basic justification for such a direction of reforms is straightforward: if farmers have been able to do a better job in O&M than officials, it would be better to let farmers do what they are good at. Although farmers might have great potentials of organizing themselves in handling various collective actions in irrigation governance and management, it would be unrealistic to expect that farmers can effectively carry out all relevant activities all by themselves. The O&M of large-sized dams in large-scale irrigation systems, for example, is a technically sophisticated activity for which farmers have no training. Thus, the major policy question here is *not* how to get rid of irrigation officials from O&M activities, but how to develop a better division of work between irrigation officials and farmers.

Two issues pertain to the likelihood of success in developing productive allocations of work between irrigation officials and farmers. First, the strengths and weaknesses of local institutions and the DOI should be identified. Generally, with its engineering orientation, the DOI should concentrate on tasks that require technological know-how and resources that farmers are not able to provide themselves. Maintenance of the main canal and modern headworks in large-scale systems is one such task. Farmers who possess indigenous knowledge about their systems, on the other hand, should be responsible for the O&M of canals at the sublateral level.

Given that irrigation officials usually do not have accurate information about the socio-institutional aspects of irrigation systems, they should avoid being directly involved in the allocation of irrigation water to farmers. Presently in many agency-managed or agency-assisted systems, water allocation is undertaken by the *dhalpas* hired by the DOI. Formally, these *dhalpas* adjust water gates to allow water flow into different canal branches in accordance to a schedule fixed by irrigation officials or overseers. Presumably, such a schedule is made on the basis of an assessment of the physical characteristics of the system as well as of the needs of farmer households. Given the complexity and the ever-changing nature of the physical environment, however, it is doubtful that such a schedule can take into consideration all of the relevant physical factors. Even if the schedule could actually reflect the physical characteristics, the fact that it gives little attention to the issues of water rights often renders the schedule ineffective (Ambler, 1990, 1994). In fact, in most AMIS, the *dhalpas* often adjust water gates in an *ad hoc* basis, usually upon the requests of the farmers who are most able to make their voices heard. Obviously, "might is right" is often the *de facto* principle for water allocation. Note that since irrigation officials are the ones who have the power to decide the schedule, farmers are not allowed to develop a water allocation order to meet their needs. When the official schedule does not fit the local situation, "might is right" seems to be the only alternative for farmers.

The kinds of resources that can be effectively mobilized by the DOI and by local institutions are also different. While the former is more able to mobilize material as well as monetary resources, the latter is better able to mobilize labor resource. Presently, farmers in many FMIS who do not receive any assistance from the DOI have to use primitive materials to build irrigation infrastructures such as headworks, outlets, and water-control structure. Although farmers in many instances have shown mastery of irrigation engineering, these primitive irrigation infrastructures are often prone to natural damage. In AMIS or systems receiving technical assistance from the DOI, on the other hand, maintenance and repair works are usually undertaken by private contractors. Since irrigation officials generally have little or no incentive to monitor whether the repair works are well-undertaken or not, most of the repairs are of low quality. The low-quality and delay of maintenance and repair works is always a major source of discontent for farmers. It is ironic that, regarding the implementation of maintenance works, even irrigation officials do not have much leverage to monitor the contractors. Recall that contractors have to pay a commission to irrigation officials to get a contract, and money for the commission comes out of the budget for the contract. Thus, the officials themselves are part of the reason for the low-quality works. Officials do not find themselves in a position to monitor the works of contractors.

Problems in both AMIS and FMIS can be somewhat ameliorated, if not resolved, by relating the resource mobilization effort of the DOI to that of local institutions in a complementary manner. The DOI could concentrate itself on providing farmers with necessary materials for maintenance and repair works, and farmers could contribute their labor effort. Then, on the one hand, the O&M tasks in FMIS would be made somewhat easier for farmers to carry out. On the other hand, maintenance and repair tasks in AMIS that have been conducted by contractors could be carried out by farmers themselves. Letting farmers undertake O&M tasks themselves in AMIS not only avoids the problems involved in monitoring the contractors but also facilitates farmers' involvement in the O&M of their systems.

Second, the division of work should be clearly specified and be commonly known by both farmers and irrigation officials. An unclear specification of division of work can easily cause confusion. When individuals are uncertain about what they are allowed or obliged to do, collective *inaction* is often a result. In many AMIS, for example, while irrigation officials assigned to the systems see their O&M responsibilities confined to the main system level, farmers in these systems often expect the officials to undertake O&M activities for the whole system. As a result of the misunderstanding, the maintenance of canals below the lateral level frequently becomes nobody's responsibility. Problems involved here are not simply that individuals do not know what they are supposed to do but that they might have incentives to take advantage of the unclear specification for shirking. Thus, a clear hand-over point where the officials' jurisdiction ends and the farmers' jurisdiction begins is essential to successful management of O&M in irrigation systems (Wade, 1987). It not only allows individuals to establish mutual expectations about the rights and responsibilities of one another but also provides a clear-cut "checklist" with which individuals can monitor the contribution of one another. With a more "transparent" division of labor, a certain degree of mutual accountability can be fostered. Such accountability is of utmost importance when farmers or officials contemplate whether to cooperate with one another. In particular, when farmers are aware that they cannot totally rely upon officials to operate and maintain their systems, they are less likely to develop a dependence mentality.

Developing Local Institutions

Two major lessons that can be learned from the various experiences of irrigation governance and management in Nepal are: (1) local institutions are of major importance to effective irrigation governance and management and (2) institutions are not simply formal rules on paper but rules-in-use understood and followed by a community of individuals that are used to relate the activities of individuals to one another. These two lessons seem to offer somewhat contradictory policy implications. While the former points to the importance of taking policy actions to enhance and facilitate the development of local institutions as a means to improve irrigation performance, the latter highlights the possible limits of what policy actions can do in facilitating the development of local institutions. Such a concern is very real, for experiences of facilitating the development of local institutions in Nepal and elsewhere have largely been disappointing. A serious policy question arises: can policy actions be taken to facilitate the development of local institutions?

My answer to the question is a cautious "yes." The major part of my caution lies in the recognition of the fact that institutions are by their very nature "ideas in action." Rules are prescriptive linguistic entities crafted by human artisanship, based upon human ideas and visions, and acted upon by individuals in an effort to structure their ways of life. Ideas are invisible and amorphous, they exist only in human minds. For fallible human beings who have only limited cognitive capability and are unable to read the mind of one another, using ideas to relate themselves to one another in an effort to engage in collective action is always a challenge of major proportions. No guarantee exists that ideas underlying institutions would necessarily be viable, nor that individuals would necessarily choose to act upon ideas and be bounded by them. The fact that institutions are "ideas in action" not only signifies the potential fragility of institutions but has important implications on undertaking policy actions to facilitate the development of local institutions (V. Ostrom, 1994).

Ideas pertain to institutional arrangements in two related ways. First, ideas underlie the way that individuals put together a large array of rules-in-use to constitute an institutional setting in which they find themselves. The meanings of particular rules can only be construed with reference to ideas grounded upon the common understandings of a community. For instance, a rule that requires farmers to affix their thumbprints on a constitutional document might not mean anything to outsiders who do not have ideas on the meanings of the action shared by the community of farmers. Institutions matter only if they are understood. What it implies is that institutions cannot be simply imposed on a community of farmers. Policy actions that aim at facilitating the development of local institutions would have a greater chance to succeed if they start with the institutions or common understandings that already exist in a local community. Instead of aiming at changing or building local institutions from scratch, institutional development should proceed with reference to the *status quo* institutional setting. It is important to recognize that institutional development is more a trial-and-error process of making incremental modifications on existing institutions than a grand process of social engineering.

Ideas also provide a framework with which disparate rules are put together in a particular setting. The effect of a particular rule is determined by how the rule is linked to other rules as well as various contextual factors in a particular situation. Thus, the way that rules are put together significantly affects the overall effectiveness of the institutional arrangement. Two policy implications follow. First, the mastery of making use of ideas as a guide to put rules together is a form of human artisanship which cannot be learned and taught pedagogically. Individuals acquire the mastery of human artisanship only through practicing, and sharing their experiences with one another. Thus, opportunities of discussion and of taking initiatives in organizing activities are essential in a process of institutional development. This is attested by that fact that the method of farmer-to-farmer training, in which farmers from different irrigation systems are brought together to share their experiences of irrigation organization, has been proven a successful strategy for local institutional development in Nepal (WECS/IIMI, 1990). Second, introducing changes in rules always faces the pitfall that the changes, when in interaction with other rules in particular settings, could produce unintended consequences. An individually reasonable rule, when put in a particular setting, might produce disastrous consequences. A policy researcher has to recognize that there are both commonalities and specificities in social phenomena. While identifying the commonalities can enable the researcher to better understand the general logic underlying relevant social phenomena, these commonalities should not be seen as "the laws" that can fully explain the phenomena. Policy actions in facilitating local institutional development are more likely to succeed if knowledge about general commonalities be combined with ideas on how rules can be put together to fit the context of a particular situation. Effective communication between policy researchers and farmers, as partners who possess unique knowledge respectively, is an important component in policy actions.

The second way that ideas relate to institutional arrangements is by underlying the conceptualization of how a collective endeavor can be organized, and by laying out the principles with which institutional arrangements are constituted. In other words, ideas provide institutional arrangements with constitutional meanings of how individuals should relate to one another.

Constitutional meanings that individuals assign to institutional arrangements significantly affect the viability of the institutional arrangements as well as of the collective endeavor. The way that individuals see the nature of the game, as implied in particular institutional arrangements, affects the way they see how they should play the game. For example, when farmers perceive that their O&M efforts are only remedial to officials' shortcoming, they are likely to contribute so much as to keep the system minimally operable. Without changing the presuppositions of farmers, only changing their structure of situation alone may not suffice to bring about positive changes.

Most policy analyses have emphasized the operational level of action in which individuals are portrayed as rational choosers under a particular set of opportunities and constraints. Implicitly or explicitly, individuals are often presumed to be self-interested narrowly defined. These analyses would then focus on how to align the opportunities and constraints in the way that individuals are induced to be cooperative. Yet as pointed out by many political economists, no set of institutional arrangements is completely fool-proof from strategic or opportunistic behaviors (Miller, 1992; Williamson, 1985). Individuals always have opportunities to shirk and to cheat without being detected. In a situation where individuals will cheat whenever there are opportunities, no set of rules is likely effective. Individuals who are predisposed to engage in relentless seeking of self-interest and to fight one another will pursue opportunistic strategies no matter what kinds of institutional arrangements they find themselves. Thus, cooperation among individuals can be attained only if individuals are able to go beyond a narrow conception of self-interests, and be able to see the complementarity between self-interests and collective interests, and the viability of long-term mutually productive relationships (V. Ostrom, 1994; Miller, 1992; Uphoff, 1992). A process of institution development pertains not only to getting the incentive structure "right" but also to developing among farmers a vision of working with one another in achieving mutual betterment.

No recipe exists that would enable farmers to develop a vision of reciprocity. On the contrary, most of the social principles that underlie the structure of Nepali society put heavy emphasis on hierarchical relationships. This adds to the difficulty of developing a vision of reciprocity. Yet, three avenues exist that might help facilitate the development of the vision. First, individuals are more likely to conceive the idea of reciprocity if they are able to see the complementarity between their interests and those of others. Being able to understand the situation of one another is prerequisite to one's understanding of how the efforts and interests can be put together. Thus, giving farmers opportunities to discuss with one another and to articulate their ideas is instrumental to facilitating the development of a vision of reciprocity.

A second avenue is to encourage farmers to share their experiences and ideas with farmers in other systems. Ideas do not just happen, especially for farmers who do not have many opportunities to contact the outside world and new ideas. More importantly, farmers are very often skeptical of the practicability of new ideas. Letting farmers see that new ideas have actually worked in other systems might give the farmers a certain level of confidence to try out new ideas.

Third, farmers in many instances may be trapped with a particular vision of how they should relate to one another, and cannot see the existence of other possibilities. In a system where a working order does not exist, for example, villagers at the tail end often see villagers at the head end as the exploiters. Visions that portray fighting as inevitable is likely to dominate in farmers' minds. Such visions are often so deep-rooted that any talk of working with one another sounds like an absurdity to the farmers. Individuals who are trapped in a particular vision find it difficult to get out of it. In this instance, external assistance could play an important role to help. Assistant workers can expose farmers to new ideas and, hence, new possibilities, of dealing with one another. As Uphoff (1992) reports of the assistance experience in Gal Oya, Sri Lanka, irrigation organizers (IOs), who were college graduates trained to help farmers organize, were able to induce local farmers to perceive new ways to deal with one another, and to conceptualize anew irrigation governance and management. The success of the experience attests to the usefulness of policy actions in facilitating the development of new visions in the minds of farmers, and new meanings for ideas about working with one another.

The vision of reciprocity alone does not suffice for long-term cooperation. Rational farmers would continue to act upon a particular vision only when they see the vision as viable. It is at this juncture that local institutions can play an important role in supporting the viability of the vision of reciprocity and, hence, long-term cooperation. The design of local institutions determines the extent to which the institutions are supportive. In the process of establishing new local institutions, irrigation officials should confine their roles to giving farmers necessary advice, and avoid being directly involved in the design and operation of local institutions. When farmers perceive that a water-users committee has been set up by irrigation officials from the DOI, they are not likely to treat the committee as "their" governing body. Instead, the committee is likely to be seen as an administrative arm of the DOI to control the farmers. The perception that the water-users committee is imposed by the government often discourages farmers from becoming actively involved in activities of the committee.

Local institutions should be given a certain level of autonomy so that farmers can see that their organizing efforts actually pertain to their lives. When farmers see that how well they govern and manage particular activities can actually affect their lives, and that they cannot count on the unconditional help from irrigation officials, they are more likely to be willing to engage in various governing and managing activities. Local institutions are likely to enjoy substantive autonomy only if their rights and responsibilities are clearly defined, and their relationships with the DOI are clearly specified. Rules should be in place that stipulate the limit of the activities and power of the DOI in relation to the activities of local institutions. In other words. the autonomy of local institutions can be better safeguarded if constitutional constraints are put on the DOI. Yet irrigation officials are not likely to have incentives to put constraints on their own power and activities. Hence, assigning irrigation officials the task of establishing local institutions involves a problem of conflict of interests. Given that irrigation officials usually have important roles to play in irrigation governance, such as operating and maintaining the main system, such a problem cannot be resolved simply by taking officials totally out of the process of local institutional development. One possible way to deal with this problem is to introduce a disinterested third party to mediate a process of specifying the relationships between newly created local institutions and the DOI. In irrigation projects that are funded by donor agencies, these agencies would have a legitimate claim in playing the role of the disinterested third party, for it is a step to ensure that effective institutional institutions could be developed to support the operation of the engineering infrastructure that they invested to build.

That local institutions enjoy autonomy, however, does not imply that farmers are to be abandoned. Since local institutions are nested within the broader institutional context, the operation of local institutions can be made more effective if a facilitative institutional context is in place. Various experiences of irrigation governance and management in Nepal and elsewhere indicates that the recognition from governments at higher jurisdictional levels is important for the functioning of local institutions. Such a recognition affords local institutions access to politico-administrative instrumentalities. A water-users committee, for example, can turn to the court for resolution of disputes with other actors. Of course, it is naive to assume that the court can always satisfactorily resolve such disputes. Nevertheless, the very availability of such legal recourse constitutes a "shadow of the court" which provides a framework in which farmers could resolve the disputes themselves (Williamson, 1985; Blomquist, 1992).

Directions for Future Research

This study has identified various variables that might affect the pattern of interaction of individuals in regard to irrigation governance and management and, hence, irrigation performance, in Nepal. Particular attention has been given to how institutions affect the incentive structures faced by irrigation officials and farmers in irrigation systems. Since institutions are by their very nature "ideas *in action*," the dynamic aspects of institutions are emphasized in the theoretical discussion. Specifically, institutions and the actions of individuals are mutually-interacting, and viable institutions should have built-in mechanisms to reinforce individuals' faith, interests, and understanding pertaining to the institutions, and that the crafting of institutions is an ongoing, trial-and-error process. In spite of that, this study did not directly address the issues concerning the way that institutions evolve and develop over time. In other words, while this study has pointed out the kinds of equilibrium conditions that are likely to be associated with particular institutional arrangements, this did not address the process through which the equilibrium conditions are reached. Also, in the initial NIIS database, the unit of data collection is a time slice in which the structure of the situation that individuals face remains constant. This kind of data allows an analyst to examine the pattern of association between variables. Nevertheless, a potential pitfall exists in that the information captured in a particular time slice may reflect a state of flux rather than of equilibrium. Thus, to gain a better understanding of how institutions affect, and are affected by, human interaction, research efforts on developing a better theoretical understanding of institutional change and collecting longitudinal data within a small number of irrigation systems would be particularly helpful.

Although the initial NIIS database is one of the largest samples of irrigation systems in one country, it is a small sample for the purpose of conducting statistical analysis of the kinds of questions addressed in this study. Specifically, irrigation governance and management involves a large number of variables as well as complex interaction effects. Due to the relatively small sample size of the initial NIIS database, the effects of a relatively small number of variables could be examined at one time in most of the analyses. As a consequence, the results of these analyses are not conclusive. To cope with such a limitation, disparate pieces of information were carefully assembled about various aspects of important variables, and the information was interpreted in an effort to highlight the patterns of regularities among variables in the data. Yet, more statistically thorough and conclusive analysis would require a database with a larger number of cases. Continued effort to expand the database could open more opportunities for future analysis.

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APPENDIX A. A BRIEF OVERVIEW OF THE METHODOLOGY OF THE STUDY

Paul Benjamin and Elinor Ostrom

The number of previous field studies of irrigation systems already completed in Nepal represent a substantial investment in learning about how government and farmer-organized systems operate in practice. But even though many of these studies were undertaken by individuals in close communication with one another, it has proven hard to provide a real synthesis of what was known and unknown about irrigation systems in Nepal. In the early 1990s, members of Decentralization: Finance and Management (DFM) project[1] were invited to study various forms of decentralized governance in Nepal--particularly those related to irrigation and forestry. Because so many studies had already been undertaken, it was proposed that the important next step in an effort to understand how various systems operated and what affected their differential performance, was the creation of a database where a consistent set of indicators could be coded for a large number of systems.

We will briefly review the development of knowledge about irrigation and elucidate our assumptions about the dual value of preserving context and a comparative research effort that seeks a level of generality. Then we will go on to discuss the construction of a structured database from qualitative cases and describe the coding manual we have developed. We will continue this line of thought by briefly outlining the theoretical background of institutional analysis and the methods we have employed in research. We will discuss the combination of research methods we have used to understand irrigation institutions and our fieldwork in Nepal.

Case Studies and the Development of Knowledge about Irrigation

Studies of irrigation by social scientists, for the purposes of discussing national policy issues, patterns of particular cultures, or assessing the performance of irrigation systems, have generally drawn on a small number of case-studies of irrigation systems. There appear to be relatively few studies involving a large number of case studies. Clifford Geertz (1972), for example, compared two cultures, Moroccan and Balinese, using just two irrigation systems as his referent. In a recent book by David Freeman (1989), a total of five cases are analyzed. Prachandra Pradhan (1989) has an important study that examines twenty-one irrigation systems in Nepal. Neglecting for the moment the considerable knowledge and wisdom scholars of irrigation have developed, many conclusions about the nature of irrigation seem to be based on a small number of case studies. A corresponding lack of empirical evidence touches on governance and management issues related to irrigation. There are few studies, Wade and Seckler (1990: 15) 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." We address questions regarding the governance and management of irrigation systems through a database of information gleaned from a large number of irrigation case studies in one country. We hope, in this way, to come to an understanding about how the organization of both farmer and agency managed irrigation systems affects performance of those systems.

The case-studies come from a variety of sources: there are rapid rural appraisals, master's thesis, Ph.D. dissertations, brief reports, field-site visits by expatriate advisors, and published accounts of irrigation systems in books published by the International Irrigation Management Institute (IIMI). In all, we have used more than 100 documents describing various Nepal irrigation systems. We also added several new cases during fieldwork in Nepal. In total, we have gathered, read, visited, coded, and entered into the computer, and analyzed 127 cases. Nearly all of these systems are farmer-managed irrigation systems (FMIS); that is, they are systems that are governed and maintained by farmers themselves. Some 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 of the government systems we have coded involve a considerable amount of joint management and could be considered jointly managed irrigation systems (JMIS). There are two few of these, however, to undertake a separate analysis of them in this work.

The General and the Unique

The problem of general versus unique is something that any comparative analysis will face. It is a problem not simply of social science but of science. Ernst Nagel, for example, distinguished between the "nomothetic, which seek to abstract general laws for indefinitely repeatable events and processes . . . and the idiographic, which aim to understand the unique and the nonrecurrent" (Nagel, 1961: 547). The problem is that as data is abstracted from unique contexts to build general ideas, models, or even laws, some of context and the configurations of circumstance that produce the phenomenon of interest are lost. Unique histories, acts of synthesis and creation, peculiar evolutionary paths, adaptation to local environments, and contributions of outstanding individuals risk being reduced to data that are not so interesting in and of themselves; the value of the data is in their comparability.

On the other hand, an appeal primarily to that which is unique may doom one to a perspective that all is unique. Some scholars argue that meaning can be forged only within context and our capacities for understanding and explanation are bounded by the borders of that context. Understanding of other people would be beyond being simply problematic; it becomes impossible as we fail to establish any standard of comparative understanding among unique phenomena. A science and perhaps a history, comparative or not, would be impossible in such a situation. The trick is to find out how to do meaningful contextual work without saying that everything about a particular context is unique. The organization of irrigation contains both general characteristics across many systems. Each system, like each individual, possess unique characteristics that farmers have crafted according to the exigencies of their environment. We want to be able to understand common elements of all systems and their variable adaptations.

In order to overcome some of the problems associated with comparative studies, we have attempted to preserve as much of context as we can through a data base that contains both quantitative and qualitative data and is nested in a relational manner. We attempt to retain contextual features within a framework that allows for comparison over many case studies. We attempt to capture important physical aspects of each irrigation system case study--the total area served, the amount of water available, the number of people involved, the length of the main canal, and so on--but also information about the people who do the irrigating--their ethnic group and caste identity--and the kinds of relationships they establish with one another in the governing of the irrigation system. We have also been especially keen to learn what kinds of rules farmers develop to run their irrigation systems, particularly with regard to the exigencies of local context and circumstance.

Interdependent Choice Making

The basic problem to be described and explained in this work is the pattern of human choice and action and the results that occur in interdependent situations in irrigation in Nepal. How do people come to make decisions together about issues that concern the fulfillment of self-interest--obtaining water to irrigate for rice cultivation--through collective effort--the organization of many to bring water that they cannot obtain acting alone? Garrett Hardin's thesis regarding the tragedy of the commons was that choices would be made independently, not by individuals who coordinated their actions: "Each herder acts rationally by adding yet one more beast to his herd. . ." (Hardin, 1968: 1243). Temperance, he suggests, to ameliorate the tendency to overgraze (over-populate, etc.) "can best be accomplished through administrative law. . ." (Hardin, 1968: 1243). Coordinated choices are not considered in this view and hence, pastures are overgrazed, fisheries overfished, and water is not brought for irrigation, except, perhaps, by the intervention of the state (see Wittfogel, 1957).

Yet it occurs among farmers in Nepal who irrigate their fields with water drawn from sources that are often distant and precarious. Although "private" irrigation systems do occur, they are rarely very large and do not predominate.[2] Individuals and single households alone often cannot bring water to irrigate many or large fields. In most of the farmer-managed irrigation systems in Nepal, farmers depend on one another and solve problems associated with their joint property. In our experience, both in the literature available to us and in our fieldwork, we found farmers to be keenly aware of their dependence on one another and the need to come to agreement about governance and management of their resource. Robert Yoder captured this perception in his observation of a stirring speech given by a newly elected chairman of an irrigation system:

> We are here to discuss the operation of the canal, not politics. Within a month we will need irrigation water to sow our rice seedbeds and before then we must clean and repair the canal. If we do not accomplish the repair, none of us will have a rice crop. We must work together. We know we do not all agree about political matters, but this meeting is not about the school, the drinking water system, or any other social concern. It is about irrigation. Today we put our political views out of sight and work together to operate the irrigation system (Yoder, 1991b).

The serious nature of the work is clear in this speech. The appeal is for people to work together, not such an easy task in rural Nepal. But if they do not work together, no one will have a rice crop. Rules exist, developed by the farmers themselves, requiring attendance at meetings such as the one above, at designated work days for annual maintenance of the irrigation system, and during emergency repairs when a land-slide or other catastrophe has occurred that disrupts water supplies. An unexcused absence during a required work day will be fined in this system; eagle-eyed secretaries stand, with their *hajir kitab* (attendance books) in hand, placing check marks against names people in attendance on the appointed date. Absences are discovered quickly. No one likes being the object of a penalty, even if it is light and involves *only* the scorn of one's neighbors. Most farmers also recognize that following their rules, so long as others also follow these rules, is one way to try to avoid the much higher cost of losing a rice crop or the irrigation that makes growing rice at all feasible.

Rules in Nepali Irrigation Institutions

Both in the case-studies we have read and in the fieldwork phases of this study, we encountered rules that were fashioned according to local situations. The unusual system of water shares of the Thulo Kulo system in Chherlung, Palpa, where rights to water are separable from ownership of land, developed because of the way the system was originally financed and the continued need for extensive annual maintenance over its 6.5 kilometer long main canal that courses across steep lands that are prone to landslides. The length of a canal from the source had persuaded most people in Chherlung that water could never be brought from there. In 1928, two men invested Rs 5,000, a considerable amount of money in rural Nepal at that time, to commence construction of the canal. When water began to flow a few years later, much to the astonishment of other villagers, these two men would not share the water with their neighbors until their investment was repaid. They sold "shares" of water, measured by wooden proportional weirs called saachos, to other farmers.[3] The group of farmers, water-share holders, who came to own the system, improved it each year, providing increasing supplies of water which were then sold to other farmers desirous of irrigating their land. Individual farmers were also keen to use water efficiently in order to sell excess water to others. Chherlung Thulo Kulo developed these rules in accordance with unusual entrepreneurial abilities of the two farmers who began the canal construction and because of the need for labor to maintain the canal over its 6.5 kilometer length across land-slide prone hillsides (Martin and Yoder, 1983b).

Boundary rules were also fashioned according to local circumstance. Many farmer-managed irrigation systems in Nepal, had clear and forthright; farmers we spoke with had clear ideas of who was and who was not a legitimate irrigator in their systems. The farmers in these systems would exclude farmers who did not contribute labor or monetary assessments as required in their bidhan (charter). In the Budhi Rapti area of eastern Chitwan, a somewhat different situation prevailed. While labor contributions were monitored, there was less certainty about who was and was not an irrigator. This part of Chitwan is flat and well watered; nearly are the farmers in the area are within reach of irrigation facilities, and if a farmer between two systems was not able to obtain water from one system, he could obtain it from another.

Rules that dealt with equity of distribution and theft of water varied too. In Buda Dabar, a system in the Dang valley in western Nepal, the irrigation service area is divided up into 16 *anna*, or parts, for water rotation when demand for water is high and supplies are low. All available water is sent into one anna per rotation period, no matter whether the anna is in the head or tail region of the service area. Theft of water, if it occurs, is plainly obvious to all when water is present out of turn in a portion of the service area. Fair distribution of water is insured and the willingness of farmers to supply labor to maintain the system is sustained. The problems of equity and theft of water are handled differently by a neighboring system in Dang. In Bangaon, a representative from each household is *required* to be present, day or night, during the time of rotation to that household's plots. The irrigation system committee will fine those who are absent.

These differences in rules are crafted by people who are intimately familiar with their land, with their water resources, and with one another. The rules reflect both the exigencies of the local environment and the histories of the development of the irrigation system. They are frequently crafted with a sage understanding of both the long-term joint and individual interests that are at stake. And on many systems they are followed by most farmers most of the time. Further, on many systems they are enforced by the farmers themselves. A characteristic of rules is that they have prescriptive force, that "knowledge and acceptance of a rule leads individuals to recognize that if they break the rule, other individuals may hold them accountable" (E. Ostrom, 1986b: 6).

Other individuals may lay very tight hold, indeed! We listened in startled amazement one day while a farmer gestured with his whole body in demonstration of the most severe sanction we had ever heard of. If a farmer stole water out of turn, he told us, "we used to stake him down, all day, face up, out in the field during the month of Jeth" (the hottest month of the year). At another system fifty kilometers away, we listened to another farmer who told us, frankly but with a smile on his face, "*hamro nyamharu khatarnak chha*" (our rules are dangerous). Even though the rules are dangerous and they could be applied to one's neighbors, one's relatives, or oneself, they are enforced.

Institutional Analysis: Rules Constitutive of Irrigation Institutions in Nepal

We begin our analysis of institutions with the examination of rules. Rules are:

> potentially linguistic entities that refer to prescriptions commonly known and used by a set of participants to order repetitive, interdependent relationships. Prescriptions refer to which actions (or states of the world) are required, prohibited, or permitted. Rules are the result of implicit or explicit efforts by a set of individuals to achieve order and predictability within defined situations. . . (E. Ostrom, 1986b: 5).

Rules, made, monitored, and enforced by farmers themselves, make 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 configurational in nature.

Rules are also multi-leveled in nature. 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.

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).

These levels interrelate with one another. The constitutional choice level specifies how boundary rules, for example, are to be established. Who is an irrigator and what are his rights and duties? Using these rules, members of the irrigation committee can identify those farmers who have irrigation rights and those who do not. They can take decisions to provide or deny water to farmers based on those constitutional level rules. In the irrigation system we saw in Laxmipur in Sarlahi, we saw this denial of water taking place. According to the farmers' constitution, labor had to be contributed to maintain the system and money had to be paid to retire loan for construction of the headworks. One wealthy individual did not feel compelled to contribute money or labor and was in the habit of taking water when he needed it. The other farmers have agreed to deny this man water. The basis for their decision was their constitution, fully registered with district authorities, that empowered them to confront the wealthy but uncooperative farmer. At the operational level, then, withdrawal of water into this man's fields are not permitted and any farmer observing such withdrawal has the right to halt it.

The configurational nature of these rules means that different levels of rules will influence one another. The different levels we have described here and their relationships to one another are shown in Figure A-1.

FIGURE A-1 Linkages Among Rules and Levels of Analysis

Rules:	Constitutional	Collective Choice	Operational
Levels of Analysis	Constitutional Choice	Collective Choice	Operational Choice
Processes:	Formulation Governance Adjudication Modification	Policy-making Management Adjudication	Appropriation Provision Monitoring Enforcement

Source: E. Ostrom (1990: 53).

This framework was employed in the development of the Common-Pool Resource (CPR) coding manual and later in the development of the Nepal Irrigation Institutions and Systems (NIIS) project.

NIIS Project

The initial NIIS database is composed of data gleaned from 127 case studies of irrigation systems in Nepal. The tool we have used to gather this data, both in fieldwork and reading cases, has been the Nepal Irrigation Institutions and Systems Coding Manual based on the CPR coding manual whose origins go back to 1986. The CPR manual was developed to address research questions regarding common-pool resources. The term "common-pool resource" refers to "a natural or man-made resource system that is sufficiently large as to make it costly . . . to exclude those potential beneficiaries from obtaining benefits from its use" (E. Ostrom, 1990: 30). Characteristics of common pool resources include subtractability of resource units whereas the resource system is subject to jointness of use. The important distinction here is that of resource units from resource system; resource units--tons of fish, cumecs of water, numbers of trees in the forest, etc.--can be withdrawn by "appropriators" for their use and their use means those resource units are not available to other appropriators. The resource system, however, can be jointly provided and/or produced. Common pool resources are similar to public goods since the "relatively high costs of physically excluding joint appropriators from the resource or from improvements made in the resource are similar to the high costs of excluding potential beneficiaries from public goods" (E. Ostrom, 1990: 32). The CPR manual was used as the foundation for research on fisheries (Schlager, 1990) and irrigation (Tang, 1992) and was meant to be applicable to a wide range of common-pool resources.

The NIIS Coding Manual

The NIIS coding manual is composed of seven separate coding forms. 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. 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.

The purpose of the *Location Form* is to capture general physical and institutional characteristics of the area in which the irrigation system is located. The location not only encompasses the appropriation resource but also other crucial features of the resource environment, including governmental activities in the location, such as formal village and district political structures. With this linkage, we can aggregate information in the database about all irrigation system located within a particular governmental jurisdiction. We have now identified the rain stations proximal to each of the locations in our database so that we can merge information about the level and distribution of rainfall to the irrigation systems we have data for.

The purposes of the *Appropriation Resource Form* are to capture the major physical characteristics of the appropriation resource, delineate the boundary of the appropriation resource, and describe how the appropriation resource is related to the relevant resources for producing, distributing, and using the resource unit. For the delivery of resource units, we distinguish among four different stages: production, distribution, appropriation, and use.

The production resource in an irrigation systems is usually referred to as the headworks. A distribution resource is what irrigators call the main canal; it is those canals that exist after the production resource and before the command or service area. The appropriation resource is the area where resource units--irrigation water--are appropriated by the farmers. Conventional usage in irrigation would call this the command or service area. The use resource is the actual field where farmers use the resource. Part of our interest in this research is to find out who controls what resource and what the interrelationships are among the agencies that manage the different resources. On the Appropriation Resource Form, we code information about the type of headworks (temporary or permanent), length and number of canals, and the locus of authority for the headworks (production resource) and for main canal (distribution resource).

On the *Operational Level Form*, we code information about how individuals take direct actions or adopt strategies for future actions, depending on expected contingencies. At this level, each individual faces an action situation in a particular "time slice." A "time slice" is a period of no determinate length, but 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. On the Operational Level Form, we code, via the Yoder matrix, for the relationship of system performance to seasons and crops, information about the flow of water at the source.

The *Subgroup Form* is where we code for specific attributes of the farmers who use the irrigation system. 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 here 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 one of which has different rights of access to water, each one of those sets would be a subgroup. If a system has more than one subgroup, we code one Subgroup Form and one Operational Rules form for each subgroup.

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 kinds 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 is a matrix, the columns of which represent provision, production, distribution, appropriation, and use activities related to a particular appropriation resource.[4] The rows of the matrix represent the level at which the activities have been organized, including operational, collective choice, and constitutional choice, levels which were discussed above.

Finally, the Organizational Structure and Process Form 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 Database

We employ a database to store systematically in personal computers data that we have gathered via the NIIS coding manual. It is 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 database for ease of transportation to other research and policy centers.[5] 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 tne other tables. Interesting comparisons can be done in this way, such as, for example, comparison via cross-tabulations of all Farmer-managed Irrigation System with all Agency-managed Irrigation systems against a variable that measures performance. Relevant data can also be exported to statistical software packages for more sophisticated analysis.

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 systems to the appropriate rainfall station. One could eventually link forestry institutions and irrigation institutions to the same location form. 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 a substantial time, and retrieval requires skilled knowledge of how to combine information from various "tables" inside the database.

Coding Cases and Fieldwork

We depended in the early phases of this research 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 cases studies. The general method was to assign cases to individuals according to district[6] so that each coder could become familiar with the conditions and linguistic terms of a region. Myungsuk Lee, for example, was assigned the cases we have for Chitwan and Tanahun, two districts in central Nepal. Wai Fung Lam had 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 dissertation material and Paul Benjamin, because of his 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 CL's of 4 through 1, where "1" represented the least certainty.

The staff worked individually but the group met once a week during the coding of cases in Bloomington to discuss problems over 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, monitoring, and so on, had not been systematically asked of any irrigation systems in Nepal, with the possible exceptions of the dissertations of Yoder, Martin, Hilton, and Pradhan. In other words, until recently, irrigation was not perceived as a CPR, nor was there a strong perception that social organization was fundamentally important to the development, operation, and maintenance of an irrigation system (Coward, 1979).

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 after that. He would be able to make arrangements for fieldwork that would include hiring two or three other field-workers and Benjamin could join him in early December.

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 produced in triplicate to produce one set for Shivakoti, one set for Benjamin, and one set for a spare in Kathmandu. 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" graded systems were therefore put into the "non-priority" category. We also put systems into the "nonpriority" 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 by 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 Sindhu Palchok, 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 have 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 Sindhu Palchok. Pradhan had worked in Sindhu Palchok 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 Sindhu Palchok. 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 each, with Benjamin and Pandit forming one team, and Shivakoti and Upadhya forming the other. The five 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 then 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 and 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 coded 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 and 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.

No pretension is made that the initial NIIS database is a random sample of irrigation systems in Nepal. In fact, it is not. Yet, since the database was built upon a variety of past field efforts, the systems that are included in the initial NIIS database are very much evenly distributed across different parts of the country. There is no reason to believe that conspicuous bias in the selection of these cases exists. While the findings based upon this database cannot be generalized to all irrigation systems in Nepal, they can serve as empirical evidence upon which one substantiates and understands some of the theoretical conjectures that are of intellectual and policy import. Moreover, the database is one of the largest databases about irrigation systems in Nepal that has ever been established and analyzed; it is instrumental in establishing the feasibility of developing such kind of database for future research.

The structure of the NIIS data, although appears to reflect very much the characteristics of the population of irrigation systems in Nepal, does not provide adequate information for controlling some of the major variables that might have possible confounding effects on the findings based upon the analysis of the data. As an effort to make the findings from the initial NIIS database as conclusive as they possibly can, the NIIS team conducted another round of data collection in Nepal during the summer of 1993. Information about 23 new cases of AMIS and 4 old cases of AMIS with missing information filled out was augmented to the initial NIIS database. Analysis based on these additional cases is reported in Lam (1994), as well as systems eventually included in our analysis.

Notes

1. This is a USAID-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 Development in Burlington, Vermont.

2. In the Deutsche Gesellschaft für Technishce Zusammenarbeit (GTZ) (1991) report on irrigation in Dhading District, family owned irrigation systems account for approximately 10 percent of almost 3,000 irrigation systems counted in the whole district while nearly 90 percent were common properties.

3. "A *saacho* is a log or beam with two or more notches of equal depth but varying widths cut into the top. It is installed in a canal such that all the water flows through the notches causing the flow to be divided proportionally relative to the ratio of the widths of the notches" (Martin and Yoder, 1983b: 14).

4. 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).

5. 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.

6. There are 75 districts in Nepal.

APPENDIX B. DESCRIPTION OF THE VARIABLES USED IN THE ANALYSIS OF THIS STUDY

GOVERNANCE:

What is the type of irrigation system?

The variable is dichotomous, with 0 being "Farmer-Managed Irrigation Systems" and 1 being "Agency-Managed Irrigation Systems".

For systems about which information is available in the initial NIIS database,

FMIS	104
AMIS	23
Total	127

For systems that are used in regression analysis (after listwise deletion),

FMIS	52
AMIS	15
Total	67

HEADWORKS:

What kind of headworks does this system have?

The variable is dichotomous, with 0 being "Temporary Headworks" and 1 being "Permanent Headworks".

For systems about which information is available in the initial NIIS database,

Temporary Headworks	79
Permanent Headworks	46
Total	125

For systems that are used in regression analysis (after listwise deletion),

Temporary Headworks	45
Permanent Headworks	22
Total	67

LINING:

Are the canals in the irrigation system lined? The variable is dichotomous, with 0 being "No" and 1 being "Yes, partially or completely".

For systems about which information is available in the initial NIIS database,

No Lining	42
Partially/ Completely Lining	82
Total	124

For systems that are used in regression analysis (after listwise deletion),

No Lining	22
Partially/ Completely Lining	45
Total	67

ALTERNATIVES:

Do the members of this appropriation group have access to an alternative source of supply of water? The variable is dichotomous, with 0 being "No" and 1 being "Yes".

For systems about which information is available in the initial NIIS database,

No	70
Yes	40
Total	110

For systems that are used in regression analysis (after listwise deletion),

No	40
Yes	27
Total	67

VARIATIONS IN INCOME:

The variance of the average annual family income across families in this subgroup is:

The variable has two categories, with 0 being "Low/Medium," and 1 being "High". For systems about which information is available in the initial NIIS database,

Low/Medium	96
High	22
Total	118

For systems that are used in regression analysis (after listwise deletion),

Low/Medium	56
High	11
Total	67

TERRAIN:

The terrain of the irrigation system location is:

The variable is dichotomous, with 0 being "Non-Terai" and 1 being "Terai".

For systems about which information is available in the initial NIIS database,

Non-Terai	74
Terai	53
Total	127

For systems that are used in regression analysis (after listwise deletion),

Non-Terai	44
Terai	23
Total	67

CANAL LENGTH

What is the length of this irrigation system (meters)?

For systems about which information is available in the initial NIIS database,

	Mean	Std. Dev.	Min.	Max.	N
Canal Length	5840.58	5122.43	100	31000	85

For systems that are used in regression analysis (after listwise deletion),

	Mean	Std. Dev.	Min.	Max.	N
Canal Length	6235.87	5484.79	100	31000	67

SYSTEM AREA

How many hectares are irrigated by this entire system?

For systems about which information is available in the initial NIIS database,

	Mean	Std. Dev.	Min.	Max.	N
System Area	399.02	1233.29	6	9816	127

For systems that are used in regression analysis (after listwise deletion),

	Mean	Std. Dev.	Min.	Max.	N
System Area	128.24	185.14	7	1072	67

NUMBER OF APPROPRIATORS

Give a close estimate of the number of participants in the system:

For systems about which information is available in the initial NIIS database,

	Mean	Std. Dev.	Min.	Max.	N
Number of Appropriators	584.5	2449.74	8	25000	117

For systems that are used in regression analysis (after listwise deletion),

	Mean	Std. Dev.	Min.	Max.	N
Number of Appropriators	304.82	691.81	8	5000	67

ENTREPRENUERIAL ACTIVITIES

Has any member of this group assume leadership or entrepreneurial activity in trying to achieve coordinated strategies?

The variable is dichotomous, with 0 being "No" and 1 being "Yes".

For systems about which information is available in the initial NIIS database,

No	24
Yes	79
Total	103

For systems about which data on both this variable and the three dimensions of performance is available,

No	20
Yes	62
Total	82

FARMERS' KNOWLEDGE ON THE RESOURCE

Do the appropriators have a well-developed understanding of the characteristics of this resource? (e.g. structure, peculiarity and flow of units)

The variable is dichotomous, with 1 being "Intimate knowledge of resource" and 0 being "Less than intimate knowledge of resource".

For systems about which information is available in the initial NIIS database,

Less Than Intimate Knowledge of Resource	44
Intimate Knowledge of Resource	80
Total	124

For systems about which data on both this variable and the three dimensions of performance is available,

Less Than Intimate Knowledge of Resource	28
Intimate Knowledge of Resource	61
Total	89

INSTITUTIONAL DEVELOPMENT INDEX

This index is created by combined six variables that are concerned with whether particular rules exist or not. How this index is developed is described in the text. The description of the six variables are as follows:

(1) Information on Water Appropriation
Are records of the withdrawals or rights to specified quantities of water from this resource kept in any systematic way?

The variable is dichotomous, with 0 being "No" and 1 being "Yes".

For systems about which information is available in the initial NIIS database,

No	49
Yes	57
Total	106

For systems that are used in constructing the institutional development index (systems about which information is available for all the six variables constituting the index),

No	31
Yes	50
Total	81

(2) Information on Individual Farmers' Contributions to Maintenance
Are records of the appropriators' contributions to the maintenance of the resource kept in any systematic way?

The variable is dichotomous, with 0 being "No" and 1 being "Yes".

For systems about which information is available in the initial NIIS database,

No	26
Yes	93
Total	119

For systems that are used in constructing the institutional development index (systems about which information is available for all the six variables constituting the index),

No	12
Yes	69
Total	81

INSTITUTIONAL DEVELOPMENT INDEX (Continued)

(3) Penalty for Rule Violations
Are fines levied for failing to attend "labor" days?

The variable is dichotomous, with 0 being "No / Yes but not well enforced" and 1 being "Yes and well enforced".

For systems about which information is available in the initial NIIS database,

No / Yes but Not Well Enforced	47
Yes and Well Enforced	72
Total	119

For systems that are used in constructing the institutional development index (systems about which information is available for all the six variables constituting the index),

No / Yes but Not Well Enforced	26
Yes and Well Enforced	55
Total	81

(4) Water Withdrawal Rights
Is it possible for appropriators to lose their entry or appropriation rights for breaking rules related to the appropriation and/or maintenance of this resource?

The variable is dichotomous, with 0 being "No" and 1 being "Yes".

For systems about which information is available in the initial NIIS database,

No	49
Yes	51
Total	100

For systems that are used in constructing the institutional development index (systems about which information is available for all the six variables constituting the index),

No	35
Yes	46
Total	81

INSTITUTIONAL DEVELOPMENT INDEX (Continued)

(5) Monitoring Rule Conformance
Are appropriators of this resource readily observed by each other?

The variable is dichotomous, with 0 being "Rarely seen / May be seen" and 1 being "Easily observed".

For systems about which information is available in the initial NIIS database,

Rarely Seen / May be Seen	56
Easily Observed	66
Total	122

For systems that are used in constructing the institutional development index (systems about which information is available for all the six variables constituting the index),

Rarely Seen / May be Seen	25
Easily Observed	56
Total	81

(6) Variations in Levels of Sanctioning
Is there a gradation of social, physical, and official sanctions that varies with the severity of rule violations?

The variable is dichotomous, with 0 being "No" and 1 being "Yes".

For systems about which information is available in the initial NIIS database,

No	35
Yes	63
Total	98

For systems that are used in constructing the institutional development index (systems about which information is available for all the six variables constituting the index),

No	27
Yes	54
Total	81

RULE-FOLLOWING

Characterize the usual behavior of the members of this group with respect to local operational level rules-in-use related to appropriation process from this process in years other than extreme shortage:

The variable is dichotomous, with 1 being "Almost all members follow the rules" and 0 being "Most members follow the rule / About half of the members follow the rules / Most members do not follow the rules / Almost all members do not follow the rules".

For systems about which information is available in the initial NIIS database,

Not Almost All Members Follow Rules	66
Almost All Members Follow Rules	56
Total	122

For systems about which data on both this variable and the three dimensions of performance is available,

Not Almost All Members Follow Rules	44
Almost All Members Follow Rules	44
Total	88

DEGREE OF RULE-BREAKING

Is the level of infraction of those members of the group who are not rule followers usually:

The variable is dichotomous, with 0 being "Small" and 1 being "Medium / Large".

For systems about which information is available in the initial NIIS database,

Small	94
Medium / Large	22
Total	116

For systems about which data on both this variable and the three dimensions of performance is available,

Small	70
Medium / Large	18
Total	88

LEVEL OF MUTUAL TRUST AMONG FARMERS

How would you characterize the levels of mutual trust among appropriators?

The variable is dichotomous, with 1 being "Moderate to high levels of trust (e.g. oral promises given high credence)" and 0 being "Modest levels of trust (e.g. oral promises are used but appropriators may be uncertain about performance) / Low levels of trust (e.g. oral promises rarely used)

For systems about which information is available in the initial NIIS database,

Modest / Low Levels of Trust	55
Moderate to High Levels of Trust	68
Total	123

For systems about which data on both this variable and the three dimensions of performance is available,

Modest / Low Levels of Trust	37
Moderate to High Levels of Trust	50
Total	87