FARMER AND GOVERNMENT ORGANIZED IRRIGATION SYSTEMS IN NEPAL: PRELIMINARY FINDINGS FROM ANALYSIS OF 127 SYSTEMS

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Since the 1970's, a large number of individual field studies of diverse irrigation systems have been completed in Nepal. Some of these studies were undertaken by masters or doctoral students and are based on extensive periods of time in the field. Others were written on the basis of shorter periods in the field: rapid rural appraisals, brief reports, and field-site visits by expatriate advisors. Some were published accounts of irrigation systems in books published by the International Irrigation Management Institute (IIMI). Others were published by the Irrigation Management Center of the Department of Irrigation in Nepal.

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.

In the first half of this paper we will briefly review the development of knowledge about irrigation to preserve context and a comparative research effort that seeks a level of generality. Then we will go on to discuss briefly the construction of a structured, database from qualitative cases and describe the coding manual we have developed. We then will discuss the combination of research methods we have used to understand irrigation institutions and our

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fieldwork in Nepal. In the second half of the paper we will present a comparative analysis of 127 irrigation systems located in the three major terrains of relevance for Nepal governed and managed by farmers and those managed and governed by government agencies. The comparison will include physical characteristics of the irrigation systems, institutional rules, community attributes and agricultural performance of these systems.

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 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.

NIIS Project

The 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 field work 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.

In the spring and early summer of 1991, the general CPR manual was customized especially for research on Nepali irrigation. Staff and graduate students at the Workshop aided in this endeavor but assistance was also obtained from Robert Yoder, Anthony Bottrall, Robert Hunt, and Mark Svendsen. Several variables were dropped from the original GPR manual, usually for the reason that they were specific to other kinds of resources, fishery or forestry for example. Attempts were also made to clarify and simplify the descriptions of the variables so that the manual itself would be easier to learn and use.

After the coding manual was customized, colleagues at the Workshop in Political Theory and Political Theory and Policy Analysis at Indiana University read and coded 130 case studies. But we were confronted with the problem of what to do with data that was not capable of answering some of our most basic questions. Then we began to think of the possibilities of scheduling a period of field work in Nepal to "ground-truth" the coded case materials and do original fieldwork on additional irrigation systems where feasible. A total of eighty systems were visited during field visit in December, 1991 and January, 1992 by our research team. The first tentative data set was available for initial runs during April and May of 1992 but considerable data checking continued through the summer of 1992. The data analysis is proceeding in several stages. The small number of Agency Managed Irrigation Systems (AMIS) in our sample has posed several rival hypotheses and efforts are underway to augment NIIS database during this summer especially by increasing the number of AMIS. The findings in this paper include the analysis of 127 systems.

Farmer and Government-Organized Systems Included in This Study

Now we provide an initial overview of the 127 irrigation systems for which we have obtained substantial data as discussed earlier. Since most of the irrigation systems in Nepal are still governed and managed by farmers, the Nepal Irrigation Institutions and Systems (NIIS) database, where information about these systems is stored, reflects this fact. The NIIS database has substantial information about 103 farmer-organized systems, called in Nepal, Farmer Managed Irrigation Systems (FMIS). Similar detailed information is available for only 24 systems that are either entirely governed and managed by the Department of Irrigation (DOI) or where the headworks are operated by DOI and farmers have some day-to-day responsibility for managing lower canals. All 24 of these systems are grouped together for this chapter as Agency Managed Irrigation Systems (AMIS) but are separately identified in the database and in the appendix to this chapter that lists all 127 systems. The percentages entered in the tables for this chapter for systems coded as AMIS need to be carefully interpreted. Since the number of AMIS in our entire sample is quite small, the number of such systems in each terrain is even smaller. We will usually report data related to AMIS using the actual numbers involved rather than the percentage other than when we are comparing all AMIS and all FMIS in the NIIS database. Since the NIIS database is not a random sample of irrigation systems in Nepal, we report statistical significance to help researchers who find this information useful rather than making any claim that our findings can be generalized back to all irrigation systems in Nepal.

The systems located in the three major terrains of relevance for irrigation in Nepal include: (1) Hills, (2) River Valley, and (3) Terai. We use this regional classification to array data in this paper. We have combined the limited number of River Valley systems that are located in the Terai with the other systems located in the Terai due to the similarity of systems in the Terai and the small number of systems that would be included in a territorial category if we are to classify these systems separately in this report. The distribution of the 127 systems in our database by type of governance and terrain is:

	FMIS	AMIS	Total
Hills	41	6	47
Hills-River Valleys	18	9	27
Terai	44	9	53
Total	103	24	127

The existence of a very large number of irrigation systems in Nepal where farmers have overcome problems of collective action poses intriguing theoretical puzzles. How have farmers overcome problems of collective action to construct, govern, maintain, and manage such a large number of irrigation systems? Even for the systems that have received grants or loans from donor agencies, keeping up the maintenance of these systems requires substantial and sustained collective action on the part of farmers. Given the remoteness of most of these systems, farmers cannot rely on external agents to enforce rules relating to maintenance responsibilities or allocation of water.

FMIS also tend to achieve higher crop intensities. A crop intensity of 100% means that all land in an irrigation system is put to full use for one season, or partial use over multiple seasons amounting to the same coverage. The cropping intensity achieved at the tailend of the irrigation systems in three major agricultural regions of Nepal-the Hills, the River Valleys, and the terai-are arrayed in Table 1. In all regions, the average tailend cropping intensity achieved on FMIS is greater than on AMIS. Similarly, FMIS achieve a higher average level of agricultural productivity. Of the 127 systems in the NIIS database, we have yield data for 108 systems. The 86 FMIS average 6 metric tons of cereals a year per hectare; the 22 AMIS average 5MT/ha (p=.06).

The agricultural yields and crop intensities that farmers obtain depend on whether they can be assured of water during the winter and spring seasons when water becomes progressively more scarce. A higher percentage of FMIS in Nepal are able to get adequate water to both the head and the tail of their systems across all three seasons as shown in Table 2.

Many of the farmer-organized systems in Nepal lack permanent headworks and lining while many government-organized systems have permanent headworks and are at least partially lined.

How could these relatively primitive irrigation systems organized by farmers at the same or higher levels than the systems operated by a central government? How can these systems motivate farmers to devote days of hard works to keeping these systems going when farmers in many government-system refuse to pay irrigation fees? Are there any principles at work that can help explain the higher performance? What can be learned to increase the probability of successful future interventions? As part of our effort to try to answer part of these broad questions Lam (1992) have developed a measurement model for evaluating the performance of irrigation systems. He has identified three dimensions of irrigation performance:

1.	physical:	the condition of the physical system itself (e.g., how well maintained are the irrigation canals),
2.	delivery:	the distribution of water to farmers (e.g., how adequate is the water to the head and the tail of the systems across agricultural seasons), and
3.	productivity:	the agricultural productivity of the system (e.g., what type of crop intensity and yields are achieved).

Historical Information

Most irrigation systems in Nepal are originally constructed by farmers, either by themselves or as tenants on a birta land grant. Of the 126 irrigation systems for which we have data about initial construction, 79 percent have been built locally by farmers and 21 percent by governmental or non-governmental agencies (see Table 5.1). For FMIS systems, 91 percent were originally constructed by farmers. In the Hills-River-Valleys, all FMIS are originally farmer constructed. One-fourth of the AMIS for which we have data were originally built by farmers. Four out of nine AMIS that are located in the Hills-River-Valleys and were first built by farmers, but a smaller proportion of the AMIS systems in other terrains have been constructed by farmers. When the Department of Irrigation or its predecessor agencies has "taken over" a FMIS, it usually builds permanent structures and makes substantial investments in physical capital.

Physical Attributes of Irrigation Systems and Performance

Headworks

Very few Nepali irrigation systems are linked to reservoirs, tanks, or other means of providing physical storage. Only six systems in our database are linked to any form of surface or groundwater storage. They are:

Dhanauri (Kumalgari), Dang (FMIS)
Phewa Irrigation Project, Kaski (AMIS
Arughat-Vishal Nagar Communal Irrigation System, Dhading (FMIS)
Kanjawar Irrigation Scheme, Duruwa Village, Dang (FMIS)
Begnas Irrigation Project, Kaski (JMIS)
Logain, Rupendehi (FMIS)

The intake point or headworks of irrigation systems in Nepal are either constructed each year from local materials and are, thus, temporary, or are constructed out of rocks set in concrete or in containers made of gabion wire which are then relatively permanent. The control structures of those systems constructed by government agencies are usually permanent. Those constructed by farmers are usually temporary in nature. In the NIIS data base, 72 percent of FMIS have temporary headworks whereas 78% of the AMIS have permanent headworks. Farmer-constructed Hill irrigation systems account for 85 percent of the system© with temporary headworks. In the Hills-River-Valley systems and the Terai a greater proportion of farmer-constructed systems have permanent headworks.

In exploring the relationship between the presence or absence of permanent head works on the three dimensions of performance listed above and developed by Lam (1992). Each of the dimensions is measured by a standardized factor score that depends upon multiple underlying variables. There is complete information on all three dimensions of performance in the NIIS database for 88 irrigation systems (31 of which has permanent head works). The relationships between the presence of permanent headworks and the three measures of performance is shown in Table 3.

The results indicate that those with permanent head works perform at a significantly lower level on all three dimensions of system performance. The condition of the canal is not as good, the adequacy of the water delivery to farmers is lower, and agricultural yields are lower. Part of the reason for the negative impact of permanent headworks in Nepal may be associated with the problem of aligning a permanent headworks so that it captures water efficiently as river sources shift dramatically from one year to another.

Irrigation systems in Nepal also vary in regard to whether they are fully lined, partially lined, or not lined at all. All of the AMIS systems in the NIIS database are either fully or partially lined while two out of five of the FMIS are partly or fully lined. A higher proportion of the Hills and Hills-River Valley systems are lined than the systems located in the Terai.

The relationship between the presence of permanent headworks and levels of performance is also in the opposite direction On the other hand, the labor mobilized to undertake routine maintenance is much lower on systems with permanent headworks as expected (Table 4).

External Assistance

One of the reasons for lower performance on systems with permanent headworks in Nepal may well be that many of the permanent headworks have been constructed by external agencies who have not required the farmers to pay back this investment. The grant greatly reduces the need for farmers to organize labor mobilization for the annual reconstruction of the headworks. Without effective farmer organization and/or without active agency involvement in encouraging equitable water distribution procedures, water distribution may be largely based on a "might is right" principle. In such settings it is hard to achieve higher agricultural yields. As shown in the Table 5, of the systems with permanent headworks, nearly 38% were constructed by DIHM or DOI. Eight of these systems received funding from external donors.

While most irrigation systems were initially constructed by farmers, most FMIS have received some form of external assistance at one time or another. Only

17 percent of the FMIS in the database have not received any government or donor assistance. Government assistance has been extended to 26 percent and donor assistance has been extended to 57 percent. The amount of this assistance has varied widely from small grants that enable farmers to replace a wooden aqueduct with a PCB pipe all the way to the construction or rehabilitation of an entire system. The proportion of FMIS that have received some form of external assistance is probably higher in the NIIS database than it is in the field since the initial sample for data collection was the set of written descriptions that already existed about individual systems. Many of these system descriptions are written in relationship to a donor effort to improve irrigation system performance.

Lining and Performance

We have examined how the presence of permanent headworks and lining are related to one another. As shown in the Table 8 all the systems in NIIS database that are entirely lined also have permanent headworks but those systems that are partially lined are split approximately in half between those with and without permanent headworks. Table 9 examines the relationship between the combinations of lining and permanent headworks to levels of labor mobilization and irrigation performance. Irrigation systems that have both permanent headworks and are fully lined mobilize the least amount of labor but also are at the lower end of the measure of agricultural productivity. Systems with the highest agricultural productivity are those that lack permanent headworks or even partial lining and face the highest need for labor mobilization for routine maintenance.

To better analyze how physical attributes of irrigation systems, such as headworks and lining, interact with various institutional variables which in turn affect system performance, we have simplified the classification used in Table 9 and classified systems into three groups of physical environment: Group 1-system without lining or permanent headworks; Group 2-systems with partial lining but without permanent headworks; and Group 3-systems with permanent headworks. Most of the Nepali irrigation systems in the database with permanent headworks are partially lined, but systems in Group 2 have full lining and three systems have no lining at all.

We have data about physical attributes for 125 systems. On Table 10, we have arrayed these three groupings of systems whether they are self-governed by the farmers or agency-governed. All of the Group 1 systems in the NIIS database—without permanent headworks and without lining—are farmer-governed systems.

Governance, Physical Attributes, and Performance

The way an irrigation system is governed in Nepal is also strongly related to performance. Agricultural productivity is higher on farmer-governed systems than on agency systems regardless of the presence or absence of permanent headworks (Table 12). As shown in Table 13, FMIS perform much better in terms of better physical condition, more effective water delivery, and higher levels of productivity. To further explore the effect of institutional arrangements on system performance, we examine key institutional variables that might affect farmers' capability to organize themselves for various collective actions required for effective irrigation management.

Monitoring **and Sanctioning**

There are two types of monitoring arrangements frequently used on irrigation systems. The first is whether records are kept of attendance on the days of required labor for routine maintenance. The second is whether records are kept about water allocation. The patterns that we observes in Table 14 are quite similar to that which we will see on the next two Tables. Group 1 systems-systems without lining and without permanent headworks-were more likely to have both types of monitoring rules than the other two types.

On Table 15, the variables are related to sanctioning: whether the right to withdraw water could be forfeited in some instances of rule infractions, whether sanctions varied from small to large in their effect, and whether penalties were well enforced. The rule that threatened the loss of the right to withdraw water-usually on a temporary basis-when adopted was effective in systems of two of the three types of physical environments. Group 1 were most likely to adopt this rule than other two groups. In regard to sanctions varying from very small to substantial in their effect, both Group 1 and 2 systems adopted such rules.

Trust **and** Rule Following

Table 16 shows a substantial difference between the groups into the level of trust and rule following. Group 1 systems were most likely to exhibit higher levels of trust and to follow rules at a higher rate than the systems in other groups. Further the association between levels of trust and rule following with agricultural productivity was higher in these systems than it was in other two types of irrigation systems.

Index of Institutional Development

To get a somewhat more comprehensive view of the relationship between types of rules, trust, and rule-following, on the one hand, with agricultural productivity on the other hand, an index of institutional development was constructed by assigning a 1 to the presence of or a 0 to the absence of any seven institutional variables. A system that has a score of 7 for this index would have been coded as: 1) recording attendance related to routine maintenance, 2) recording water rights, 3) potentially denying water to farmers who broke rules, 4) using graduated punishments for rule infractions, 5) enforcing penalties well, 6) having high levels of trust, and 7) having high levels of rule conformance. The distribution of systems on this index is shown in Table 17.

Table 18 examines the relationship between the index of institutional development and agricultural productivity within each of the three groups of irrigation systems discussed above. All of the Group 1 irrigation systems that scored less than 4 on the index of institutional development had below average agricultural productivity, while 89% of the Group 1 systems that scored at least 4 were above average. Consequently, above mean agricultural productivity is associated with more fully developed institutions except in those situations where recent improvements in the physical works have been undertaken and/or insufficient time has elapsed for farmers to design a more fully articulated set of rules and behavior patterns.

Is There a Trade Off Between Well Crafted Rules and Well Crafted Technology?

Much of the thinking about how to improve irrigation performance has focussed on improving engineering works and ignored the importance of institutions. One of the strong findings from this study is that when major capital investments are made in engineering works that are not well crafted for their environment, not only do the works not work, they may detract from the capability of farmers to devise rules to enhance performance. Only 6 out of 31 systems, for which data is available about both the types of headworks and performance, are able to achieve above average agricultural productivity. We do not wish to argue that constructing permanent head works is a strong determinant of below average performance even though a casual inspection of the above data might lead to an initial impression that this is the lesson to be learned. We see the lesson as being different.

Many of the permanent headworks that have been constructed in Nepal are constructed by external agency without: (1) consultation about the design of headworks with the farmers, and (2) requiring the farmers to pay irrigation fees to pay off the capital investment. This has led to several consequences. First, many of these headworks simply don't operate very well in an environment of shifting water courses and level of water in the water course. Consequently, some of the mal-designed irrigation works have simply reduced performance due to their poor design and operation. Second, very little attention has been paid to the temptations that farmers might face to ignore one another's interests, and how technology and institutions might enhance or detract from the capacity of farmers to seek better distribution pattern of their water. If such circumstances develop, tailend farmers could refuse to pay the fee unless they received adequate water.

At the other end of the spectrum are the systems that have no major technological interventions-those without permanent headworks and without any lining. These are the systems where farmers have to be extremely well-organized and disciplined if they are going to succeed-and a higher proportion of theses systems do succeed than either of the two other groups. Their success is strongly affected by the configuration of rules that they adopt.

On Table 20, we examine how the three groups of irrigation systems perform in getting water to tailend of their systems. The systems that are partially lined are more able to get predictable and adequate water to the tailends of their systems than either those with permanent headworks or those without any permanent headworks or lining.

This helps us interpret our findings concerning specific rules. Systems with partial lining did perform more effectively when they used a rule that sanctioned continued rule infractions with a temporary lose of water. Some of the other rules that are used in Group 1 systems, where there are no permanent headworks or any lining, do not appear to be as important in explaining higher performance in Group 2 systems, recognizing that many of the systems included in this group have just recently been improved with substantial inputs by farmers into the design of the improvements. Rules and technology can work together to make irrigation systems more effective when those affected have a greater say about the rules and the technology to be used.

ENDNOTES

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Table 1

Tailend Cropping Intensity by Type of Governance Arrangement and Terrain

Terrain	Farmer-Managed Irrigation Systems	Agency-Managed Irrigation Systems	p
Hills	238%	155%	.00
River Valleys	205%	182%	.31
Terai	250%	208%	.06
All Systems	237%	182%	.00

Table 2

Water Adequacy by Type of Governance Arrangement and Season

Season of Year	% of FMIS with Adequate Water at the Head	% of AMIS with Adequate Water at the Head	% of FMIS with Adequate Water at the Tail	% of AMIS with Adequate Water at the Tail
Monsoon	97	91	88	43
Winter	48	43	38	13
Spring	35	26	24	9

Table 3

The Relationship of Type of Headworks with
Dimensions of Performance

	(N)	Systems Without Permanent Headworks	Systems With Permanent Headworks	F	p
Physical Condition	(88)	3.7	3.2	13.9	.00
Delivery	(88)	3.8	3.1	15.2	.00
Productivity	(88)	4.4	3.6	14.6	.00

Table 4

The Relationship of Type of Headworks with
Labor Mobilization

Average Number of Days:	(N)	Systems Without Permanent Headworks	Systems With Permanent Headworks	F	p
Devoted to routine maintenance	(107)	1546	956	.7	.40
Per hectare devoted to routine maintenance	(107)	11.9	5.5	4.3	.04
Per household devoted to routine maintenance	(102)	6.6	3.9	2.3	.12

Table 5

External Assistance and Presence of Permanent Headworks

Who has Intervened?	Systems Without Permanent Headworks		Systems With Permanent Headworks		Total	
	(N)	%	(N)	%	(N)	%
No one	(19)	25.0	(4)	8.9	(23)	19.0
DIHM or DOI	(12)	15.8	(17)	37.8	(29)	24.0
FIWUD	(5)	6.6	(1)	2.2	(6)	5.0
MPLD	(5)	6.6	(0)	0.0	(5)	4.1
CARE/NADB	(10)	13.2	(13)	28.9	(23)	19.0
ILC	(2)	2.7	(5)	11.1	(7)	5.8
Other	(23)	30.3	(5)	11.1	(28)	23.1
Total	(76)	100.0	(45)	100.0	(121)	100.0

Table 6

Relationship of Headworks and Duration

Duration (Years)	Systems Without Permanent Headworks	Systems With Permanent Headworks	Total
1 or less	1	2	3
1 - 10	20	22	42
11 - 25	11	5	16
26 - 50	15	4	19
51 - 75	6	0	6
76 - 100	6	0	6
101 - 200	8	6	14
201 - 300	5	3	8
301 - 500	0	1	1
Total	72	43	115

Table 7

Who Constructed the System

Who Constructed?	Systems Without Permanent Headworks		Systems With Permanent Headworks	
	(N)	%	(N)	%
Farmers	71	92	27	57
Government	6	8	16	34
Non-Governmental Organizations	0	0	4	9
Total	77	100	47	100

Table 8

Relationship of Permanent Headworks and Lining

Type	(N)	Percent Systems Without Permanent Headworks		Percent Systems With Permanent Headworks		Chi^2	p
		(N)	%	(N)	%		
No lining	(40)	37	93	3	7		
Partial lining	(76)	41	54	35	46		
Entirely lined	(6)	0	0	6	100	28	.00

Table 9

Effect of Headworks and Lining on Labor Mobilization and Irrigation Performance

Type	Total Labor Days	Labor Days per Hectare	Labor Days per Household	Physical Condition	Agricultural Productivity
Fully lined systems with permanent headworks	218 [322] N = 5	1.38 [1.45] N= 5	.85 [1.03] N = 4	3.65 [.54] N = 5	3.57 [.25] N = 5
Partially lined systems with permanent headworks	936 [1606] N= 28	5.0 [7.3] N = 28	3.1 [5.6] N = 27	3.06 [.69] N = 23	3.63 [.98] N = 23
Partially lined systems without permanent headworks	848 [1757] N = 38	11.1 [16.9] N = 38	4.9 [7.0] N = 36	3.81 [.76] N = 32	4.31 [.95] N = 32
Unlined systems with permanent headworks	619 [493] N = 2	7.7 [4.4] N = 2	6.7 [1.8] N = 2	3.39 [.08] N = 2	4.09 [.68] N = 2
Unlined systems without permanent headworks	2374 [5691] N = 32	12.3 [17.0] N = 32	8.5 [10.7] N = 31	3.61 [.50] N = 25	4.57 [.91] N = 25

Note: Numbers in square brackets are Standard Deviation.

Table 10

Proportion of FMIS and AMIS with Different Physical Attributes

Group	Agency-Governed Irrigation Systems		Farmer-Governed Irrigation Systems		(N)	
Group 1: Systems Without Lining and Without Permanent Headworks	(0)	0%	(37)	100%	(37)	100%
					30%	
Group 2: Systems With Partial Lining and Without Permanent Headworks	(5)	12%	(36)	88%	(41)	100%
					33%	
Group 3: Systems With Permanent Headworks	(18)	38%	(29)	62%	(47)	100%
					37%	
(N)	(23)	18%	(102)	82%	(125)	100%
					100%	

Table 11

Relationship Between Physical Type and Dicholomized Productivity Measure

Group	Systems Lower Than Mean Agricultural Productivity		Systems Higher Than Mean Agricultural Productivity		(N)
Group 1: Systems Without Lining & Without Permanent Headworks	(9)	36%	(16)	64%	(25)
Group 2: Systems With Partial Lining & Without Permanent Headworks	(15)	47%	(17)	53%	(32)
Group 3: Systems With Permanent Headworks	(25)	78%	(6)	22%	(31)
(N)	(49)		(39)		(88)

Table 12

Relationship Between Governance Arrangement of Irrigation System, Permanent Headworks and Agricultural Productivity

System Type	Agency Systems	Farmer Systems
Systems Without Permanent Headworks	3.7	4.5
Systems With Permanent Headworks	3.3	3.9
All Systems	3.4	4.4
(N)	(19)	(69)

Combined effect of Headworks and Governance Arrangement: $F = 11.9$, $p = 0.00$
Effect of Headworks: $F = 5.84$, $p = 0.01$
Effect of Governance Arrangement: $F = 7.89$, $p = 0.01$

Table 13

Relationship of Governance Arrangement, Physical Type, and System Performance

Group	Physical Condition		Delivery		Agricultural Productivity	
	FMIS	AMIS	FMIS	AMIS	FMIS	AMIS
Group 1: Systems Without Lining & Without Permanent Headworks	3.61 [.50] N = 25	. . N = 0	3.60 [.61] N = 25	. . N = 0	4.57 [.91] N = 25	. . N = 0
	p = .		p = .		p = .	
	FMIS	AMIS	FMIS	AMIS	FMIS	AMIS
Group 2: Systems With Partial Lining & Without Permanent Headworks	4.01 [.61] N = 27	2.72 [.60] N = 5	4.11 [.69] N = 27	2.56 [.69] N = 5	4.23 [.74] N = 27	3.66 [1.68] N = 5
	p = .00		p = .00		p = .10	
	FMIS	AMIS	FMIS	AMIS	FMIS	AMIS
Group 3: Systems With Permanent Headworks	3.51 [.60] N = 17	2.76 [.52] N = 14	3.44 [.59] N = 17	2.68 [.51] N = 14	3.93 [.68] N = 17	3.30 [.96] N = 14
	p = .00		p = .00		p = .04	

Table 14

Relationship between Physical System, Monitoring Rules
and Agricultural Productivity

Group	Agricultural Productivity	Record Attendance for Routine Maintenance		Record Water Rights	
		No	Yes	No	Yes
Group 1:		(3)	(22)	(6)	(18)
Systems Without Lining & Without Permanent Headworks	Below Mean	(3) 100%	(6) 27%	(4) 67%	(4) 22%
	Above Mean	(0) 0%	(16) 73%	(2) 33%	(14) 78%
		p = .01		p = .05	
		No	Yes	No	Yes
Group 2:		(6)	(25)	(21)	(9)
Systems With Partial Lining & Without Permanent Headworks	Below Mean	(2) 33%	(12) 48%	(10) 45%	(3) 38%
	Above Mean	(4) 67%	(13) 52%	(12) 55%	(5) 62%
		p = .52		p = .70	
		No	Yes	No	Yes
Group 3:		(8)	(23)	(11)	(18)
Systems With Permanent Headworks	Below Mean	(5) 62%	(20) 87%	(10) 91%	(13) 72%
	Above Mean	(3) 38%	(3) 13%	(1) 9%	(5) 27%
		p = .13		p = .23	

Table 15

Relationship between Physical System, Sanctioning Rules, and Agricultural Productivity

Group	Agricultural Productivity	Water Withdrawals May be Forfeited for Rule Infraction		Sanctions Vary from Very Small to Substantial		Penalties Well Enforced	
		No	Yes	No	Yes	No	Yes
Group 1: Systems Without Lining & Without Permanent Headworks		(5)	(20)	(10)	(13)	(7)	(18)
	Below Mean	(4) 80%	(5) 25%	(5) 50%	(2) 15%	(5) 71%	(4) 22%
	Above Mean	(1) 20%	(15) 75%	(5) 50%	(11) 85%	(2) 29%	(14) 78%
		p = .02		p = .07		p = .02	
		No	Yes	No	Yes	No	Yes
Group 2: Systems With Partial Lining & Without Permanent Headworks		(20)	(9)	(10)	(12)	(17)	(14)
	Below Mean	(10) 50%	(2) 22%	(4) 40%	(4) 33%	(7) 41%	(7) 50%
	Above Mean	(10) 50%	(7) 78%	(6) 60%	(8) 67%	(10) 59%	(7) 50%
		p = .16		p = .75		p = .62	
		No	Yes	No	Yes	No	Yes
Group 3: Systems With Permanent Headworks		(13)	(14)	(16)	(12)	(12)	(17)
	Below Mean	(13) 100%	(8) 57%	(13) 81%	(9) 75%	(11) 92%	(13) 76%
	Above Mean	(0) 0%	(6) 43%	(3) 19%	(3) 25%	(1) 8%	(4) 24%
		p = .01		p = .69		p = .22	

Table 16

Relationship between Physical System, Participant Interactions and Agricultural Productivity

Group	Agricultural Productivity	Levels of Trust		Extent of Rule Following	
		Low to Moderate	High	Low to Moderate	High
Group 1:		(9)	(16)	(10)	(15)
Systems Without Lining & Without Permanent Headworks	Below Mean	(7) 78%	(2) 12%	(6) 60%	(3) 20%
	Above Mean	(2) 22%	(14) 88%	(4) 40%	(12) 80%
		p = .00		p = .04	
		Low to Moderate	High	Low to Moderate	High
Group 2:		(13)	(18)	(18)	(14)
Systems With Partial Lining & Without Permanent Headworks	Below Mean	(8) 62%	(6) 33%	(10) 59%	(5) 33%
	Above Mean	(5) 38%	(12) 67%	(8) 41%	(9) 67%
		p = .12		p = .15	
		Low to Moderate	High	Low to Moderate	High
Group 3:		(14)	(16)	(15)	(15)
Systems With Permanent Headworks	Below Mean	(12) 86%	(12) 75%	(13) 86%	(11) 73%
	Above Mean	(2) 14%	(4) 25%	(2) 13%	(4) 27%
		p = .46		p = .36	

Table 17

Distribution of Systems on the Index of Institutional Development

Index of Institutional Development	**Systems Where Information on Index of Institutional Development is Available**	**Systems Where Information on Index of Institutional Development and Productivity Data is Available**
0	3	3
1	2	2
2	11	10
3	10	10
4	9	6
5	12	9
6	19	16
7	15	13
Total	88	69

Table 18

The Relationship Between the Index of Institutional Development and Agricultural Productivity

Group	Agricultural Productivity	Index of Institutional Development			
		Scored less than 4		Scored at least 4	
Group 1: Systems Without Lining & Without Permanent Headworks	Below Mean	(5)	100%	(2)	11%
	Above Mean	(0)	0%	(16)	89%
		p = .00			
		Scored less than 4		Scored at least 4	
Group 2: Systems With Partial Lining & Without Permanent Headworks	Below Mean	(5)	50%	(3)	25%
	Above Mean	(5)	50%	(9)	75%
		p = .23			
		Scored less than 4		Scored at least 4	
Group 3: Systems With Permanent Headworks	Below Mean	(8)	89%	(10)	71%
	Above Mean	(1)	11%	(4)	29%
		p = .32			

Table 19

Score of the Index of Institutional Development

Group	Agricultural Productivity	Irrigation System	Index of Institutional Development
Group 1: Systems Without Lining & Without Permanent Headworks	Below Mean	Tedhi/Gurgi	-
		Thambesi	-
		Hudiko Mulko Kulo	0
		Char Say Phant	2
		Chunatal	2
		Chaurasi	3
		Khairghari	3
		Char Hazar	6
		Gairagaon	7
	Above Mean	Auraha	4
		Laxmipur	4
		Kusuma-Gathauli	5
		Kanchi Kulo	5
		Tulsi	6
		Kathar	6
		Janakpur	6
		Pangduri	6
		Badgaon	6
		Chainpur (Bhutiya) Kulo	6
		Jeevanpur	7
		Kapiya	7
		Mudabar	7
		Rapti Pratapur (was Lothar)	7
		Chherlung Thulo Kulo	7
		Kharkgutte (Upper)	7

Key: - = Missing, * = Systems in Sindhu Palchok

(Table continued on following page)

Table 19, continued

Group	Agricultural Productivity	Irrigation System	Index of Institutional Development
Group 2: Systems With Partial Lining & Without Permanent Headworks	Below Mean	Mana Besi Phant	-
		Dovan Swar Ko Kulo (Dobhan Swar Kulo)*	-
		Torbang	-
		Magar Kulo*	-
		Chhahare Khola Ko Kulo*	-
		Masina Sat Tale	-
		Naya Dhara Khola Ko Kulo*	-
		Goberdiha	1
		Bhalutar	2
		Chhepetar Ko Kulo	3
		Sajhatar	3
		Soti Bagar Ko Kulo*	3
		Sisabas Parsauni	5
		Barhakol	6
		Satra Say Phant	6
	Above Mean	Besi Kulo*	-
		Subedar Ko Kulo*	-
		Dhap Kulo*	-
		Ghatta Muhan Ko Kulo (Tarali Ko Kulo)*	0
		Baghmara Ko Kulo (Baghmara Kulo)*	2
		Majha Ko Kulo (b) (Majha Kulo)*	2
		Tallo Chapleti Kulo*	3
		Siran Ko Kulo (a) (Siran Kulo)*	3
		Chap Bot Ko Kulo (Beltari Fant Ko Kulo)*	4
		Rapti Nawalpur Farm	4
		Gadkhar	5
		Yampa Phant	5
		Thuli Besi	5
		Argali Raj Kulo	6
		Bhang Bari (was Kota Tar)	7
		Pithuwa	7
		Majha Ko Kulo (d)*	7

Key: - = Missing, * = Systems in Sindhu Palchok
(Table continued on following page)

Table 19, continued

Group	Agricultural Productivity	Irrigation System	Index of Institutional Development
Group 3: Systems With Permanent Headworks	Below Mean	Bhairawa Lumbini Ground Water Project	-
		Parwanipur	-
		Dhanauri (Kumalgari)	-
		Seti	-
		Labdu-Dhikure-Sera	-
		Phewa	-
		Bhorletar	-
		Hande Tar	0
		Lahachowk	1
		Hyangja	2
		Sange Patyani	2
		Ramghatar	2
		Champi Kulo (Dimalko Kulo)	2
		Lamage Phant	3
		Kodku	3
		Belgari	4
		Ghachchowk	5
		Supaila Community	5
		Rangdi Khola	6
		Sèrabagua Bandh-Tharpu, G.B.C. Chhang	6
		Bhanu Bhairah	6
		Bhitoria	6
		Malebagar	6
		Chiregad	7
		Bulbule	7
	Above Mean	Begnas	-
		Panch Kanya	2
		Thulo Chaur	4
		Naya Simalghari Sathi-Bighe	5
		Surtan	6
		Logain	7

Key: - = Missing, * = Systems in Sindhu Palchok

Table 20

The Relationship between Physical System and
Adequacy and Predictability of Water to the Tailend of a System

Group	(N)	Water at Tailend is Unpredictable		Water at Tailend is Predictable and:			
				Inadequate		Adequate	
Group 1: Systems Without Lining & Without Permanent Headworks	(37)	(9)	24%	(17)	46%	(11)	30%
Group 2: Systems With Partial Lining & Without Permanent Headworks	(40)	(4)	10%	(15)	38%	(21)	52%
Group 3: Systems With Permanent Headworks	(44)	(11)	25%	(26)	59%	(7)	16%

$Chi^2 = 13.8$, $p = .008$