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INSTITUTIONS FOR IRRIGATION MANAGEMENT IN FARMER-MANAGED SYSTEMS:
Examples fmm the Hills of Nepal

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Summary: This paper examines farmer organizations and property rights which have evolved as institutions in Nepal that enable collective management of water for agricultural production.

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INSTITUTIONS FOR IRRIGATION MANAGEMENT IN FARMER-MANAGED SYSTEMS:
Examples from the Hills of Nepal

Edward D. Martin and Robert Yoder[1]

INTRODUCTION: IRRIGATION INSTITUTIONS

There is a growing literature which examines farmer-managed irrigation systems[2] in a number of countries and a variety of ecological environments. Studies from the Philippines (Lewis, 1971; Siy, 1982), Indonesia (Geertz, 1980), Thailand (Tan-kim-yong, 1983), Sri Lanka (Leach, 1961), and Peru (Mitchell, 1976) have described a variety of irrigation systems which are managed by farmer groups. This article describes and analyzes the institutions employed by farmers for the management of gravity irrigation systems in the hill region of western Nepal.

Water, as one of the essential resources in agricultural production, has several unique characteristics, especially in hill environments.) Individual farmers, acting alone, can seldom acquire water for irrigation. Construction and maintenance of the structures to divert, convey, and distribute water usually require investments beyond the capacity of a single farmer. Surface water cannot be easily stored, certainly not by the individual farmer, in the way that fertilizer can be. It must be used when it is available or it is lost. Fanners generally cannot transport water economically over great distances, and the locations to which it can be conveyed are limited by the topography. One implication of these characteristics is that institutions are needed for the development and operation of irrigation systems. The form and function of these institutions vary depending on the physical, social, and economic environments.

Institutions have been defined as "complexes of norms and behaviors that persist over time by serving collectively valued purposes (Uphoff, 1984)." Institutions regulate individuals' actions and consist of significant practices and relationships within a society. In some cases, institutions may be formalized in organizations like cooperative., local governments, or banks. Examples of institutions which are not organizations are land tenure systems and customary labor exchange relationships.

Institutions of both kinds contribute to production and development processes in several ways. They facilitate the aggregation of resources beyond an individual's capacity and the application of resources to the solution of problems for the benefit of many. They reduce uncertainty by the predictability of behavior that they encourage and enforce in various spheres including the distribution of benefits from collective investments.

In this paper we examine institutions that have evolved to enable the collective management of water for agricultural production. One institution is the farmer organization itself, an organization which has been vested with legitimacy by the local community? Another important institution is the convention of property rights in water.

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[illegible] was [illegible] 1981 [illegible] 1983 [illegible] the auspices of the Research Division and the Research Centre for Applied Science and Technology, [illegible]uvan University, Kathmandu, Nepal. [illegible] was [illegible]ed by the Ford F[illegible] [illegible] International, and C[illegible] [illegible] P[illegible] Intern[illegible] [illegible]gric[illegible]
The authors gratefully acknowledge the contribution of Prachandra Pradhan to the development of this paper. He visited the system frequently and the ob[illegible] concept[illegible] [illegible] on [illegible] also grateful [illegible] useful criti[illegible] [illegible] D[illegible] Merrey and Mark Svendsen. Both Authors with to express their appreciation to the editorial and production staff of IIMI.

[2] Farmer-managed irrigation systems are operated and maintained collectively by groups of farmers. Management of the whole system from source of water to the fields where it is used is the responsibility of the fanners. Irrigation systems of this type are often referred to as "community-managed" systems (Coward, 1980). The term 'her-managed" is used to avoid the ambiguities inherent in the term "community."

[3] Some of these characteristics do not apply to the case of irrigation from ground water sources, but ground water is not an important source of irrigation in hill environments.

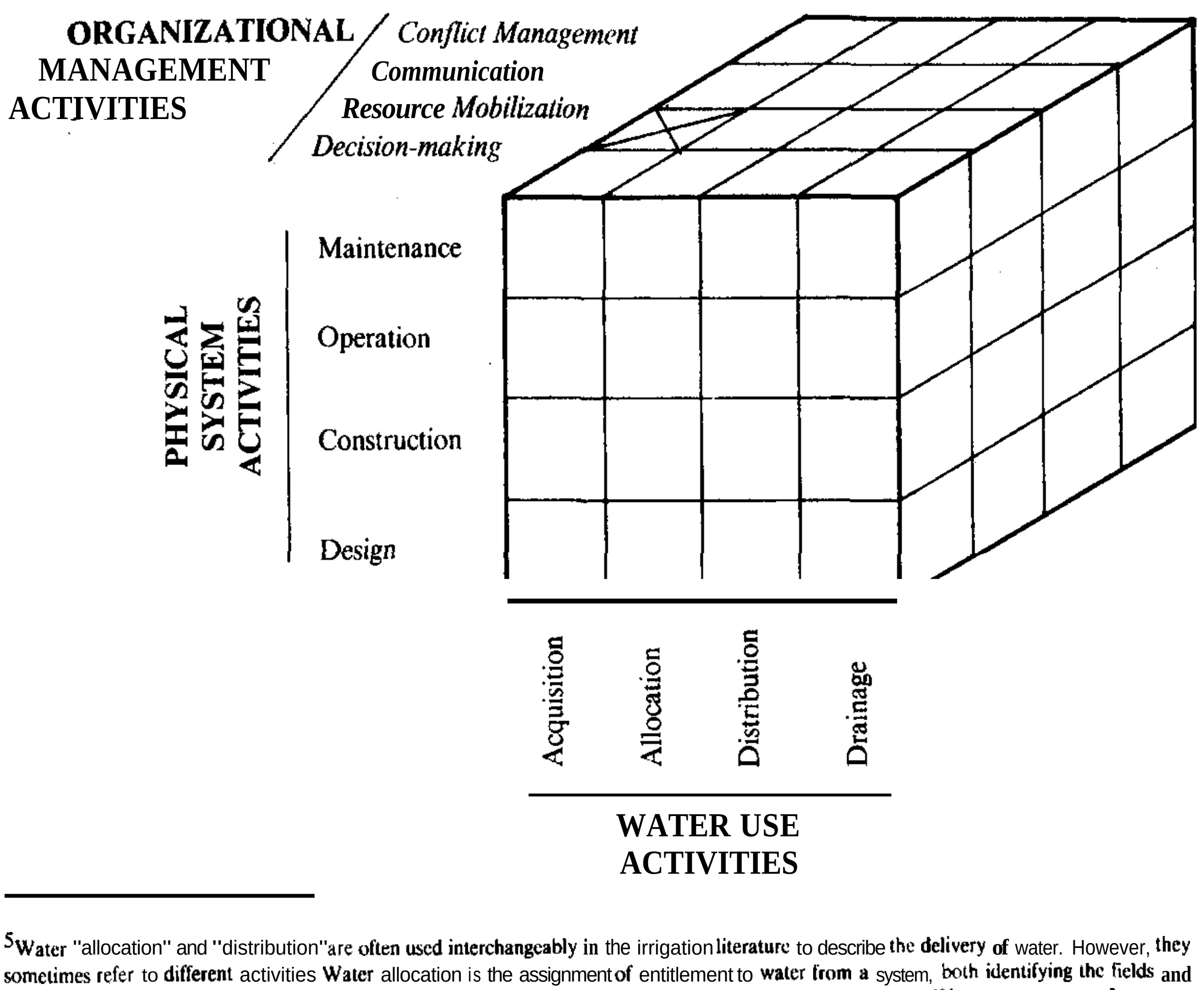
[4] The degree of formal legitimation by civil authorities varies among countries.

Property rights include both the principle by which water is allocated among farmers and the responsibilities that individuals have for maintenance of the system. Both institutions, the organization and the convention of property rights, are crucial to the effective management of irrigation systems.

Irrigation Management Activities

Farmer-managed irrigation systems are found in diverse environments and employ a wide range of technologies to exploit different types of water sources for production of a variety of crops. All these irrigation systems, however, require that certain essential tasks be accomplished if the system is to function productively. One set of management activities focuses directly on the *water.* Water must be *acquired allocated, distributed,* and, if there is excess. *drained.*[5] A second set of management activities deals with the *physical structures* for controlling the water. These structures must be *operated* and *maintained.*[6] A final set of activities focuses on the *organization* which manages the water and structures and includes *decision making, resource mobilization, communication,* and *conflict management* (Uphoff, 1986). Figure 1 depicts these three sets of irrigation management activities as a three-dimensional matrix.

Figure 1. Irrigation systems activities matrix (adapted from Uphoff *et al.,* 1985).



[5] Water "allocation" and "distribution" are often used interchangeably in the irrigation literature to describe the delivery of water. However, they sometimes refer to different activities Water allocation is the assignment of entitlement to water from a system, both identifying the fields and farmers with access to water from the system and the amount and timing of the water to be delivered to each. Water distribution refers to the physical delivery of water to the fields and may or may not conform to the water allocation.

[6] The structures must also be designed and constructed. but these are not usually considered to be management activities. The design and construction of the physicl structures certainly have implications for the management of a system, however. Not all types of management practices are possible with every design, and both the design and quality of the construction may limit the effective management of a system.

There is interaction among the activities of the three sets; for example, the organization must *decide* how to *operate* the structures to *distribute* the water. Not all activities are equally important in each environment, and the farmers' irrigation management institutions will reflect the relative importance of activities in a particular location. In the context of the hills of Nepal, *resource mobilization to maintain* the system *for water acquisition* is the primary activity which influences the structure of many of the farmer irrigation organizations. In addition, the institutions of property rights in water and the principle by which water is *allocated* have important implications for **the** efficiency and equity of the fanner-managed irrigation systems studied in Nepal.

In the following discussion, we will describe and analyze two farmer-managed irrigation systems located in the western hills of Nepal which were studied for 20 months in 1982-83. The discussion will focus on the management institutions for operating the systems, i.e., 1) the organization and the way it accomplishes irrigation activities, particularly resource mobilization, and 2) the principle of water allocation.

HILL IRRIGATION IN NEPAL

Irrigation to grow flooded rice in the valleys of the hill region of Nepal has been practiced for many centuries. Groups of farmers with adjacent landholdings have worked together to construct brush and stone diversions. They have dug canals to convey water to fields that they have leveled and bunded for growing irrigated rice. The canals frequently must pass along steep slopes and through rock outcrops. Tunnels a few meters underground are used to pass vertical cliffs and rocks. Landslides along the canal and floods which destroy the diversions demand high maintenance inputs to keep the systems operating. In some systems each Farmer receiving water must contribute 20-30 days of labor each year for maintenance.

In order for a group of farmers to accomplish the various irrigation management activities, their behavior must be organized. All but one of the 25 systems investigated had explicit organizations with designated rules and roles for carrying out these activities. The degree of formality of the organizations varied considerably among the systems.? The focus of an organization and its structure are determined, in part, by the activities which arc most important. The hill environment requires long canals traversing steep, landslide-prone hillsides to bring water from streams subject to flooding during the monsoon season. As a result organizations are structured to mobilize the resources needed to maintain the intake and canal for acquiring the water.

In organizations that must mobilize a large amount of resources, written attendance records, sanctions for missing work, and audited accounts were found. The rules and minutes of meetings tended to focus on issues surrounding the mobilization of resources, e.g., how much labor and cash members must contribute. the fines for missing work, and circumstances under which one is excused from work. The main functions of the elected officers of the organizations were to organize and supervise the maintenance work on the system, keep accurate records of members' contributions, and enforce sanctions for failure to contribute as required. The formality of organizational structure was found to be, to a large degree, a function of how much labor must be mobilized to maintain the system. If little labor is required, the organization tends to be less formal and vice versa.[8]

ARGALI AND CHHERLUNG IRRIGATION SYSTEMS

The two systems to be discussed are both on river terraces (*tars*) 100-200 meters above the Kali Gandaki River at an elevation of about 650 meters. Argali is in Argali Village Panchayat and Chherlung is in Baugha Gumha Village Panchayat,[9] both located in Palpa District between Ridi Bazaar and Ranighat (see Map in Figure 2.) Argali and Chherlung are about two hours' walking distance from each other.

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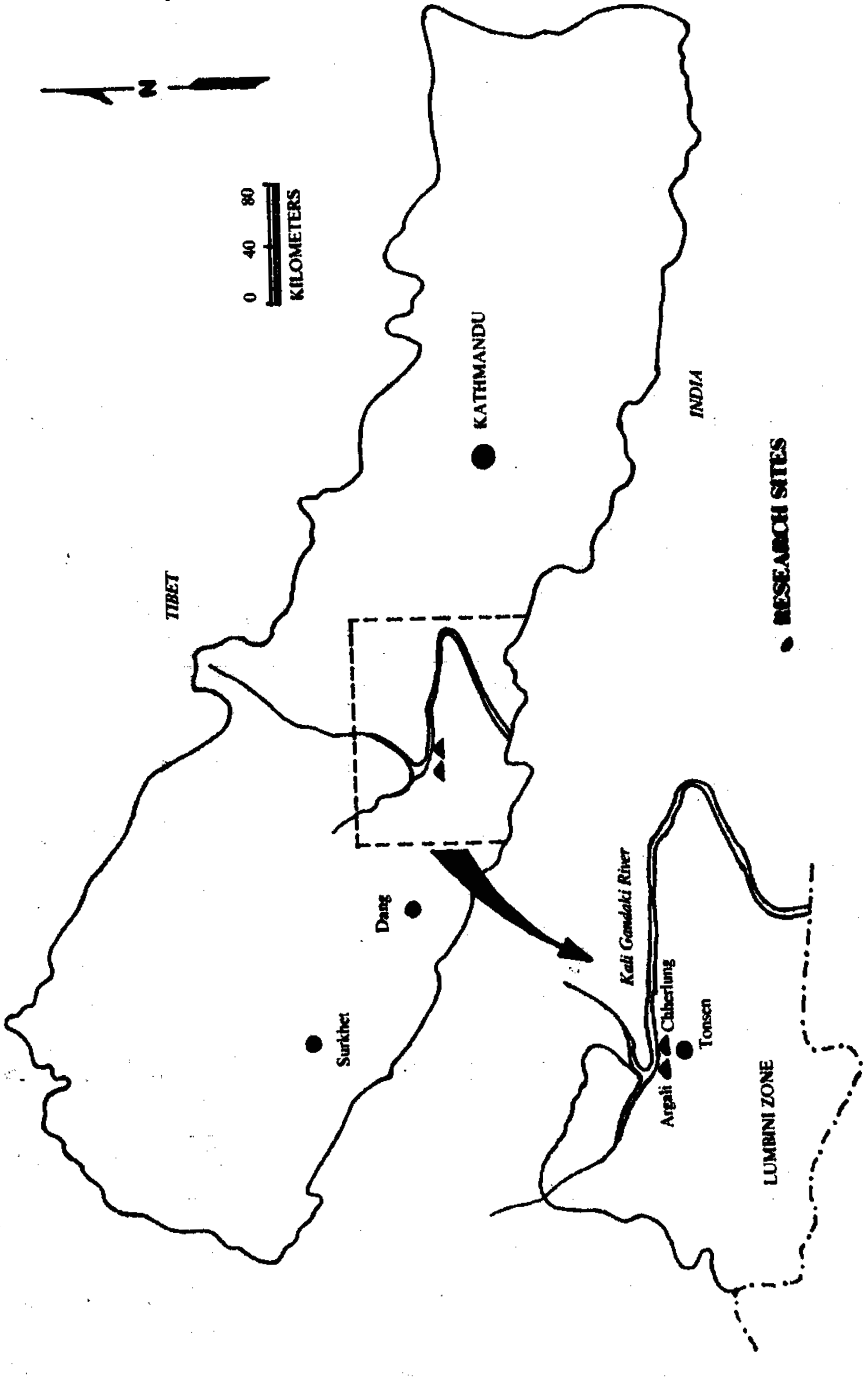
[7] Indicators of the degree of formalization of organizational structure were the number of designated roles, regular meetings, established sanctions and the extent of written records such as minutes of meetings, work attendance records, accounts, rules, and listing of members' water allocation.

[8] This conclusion is examined and supported by statistical analysis in Martin (1986).

[9] Nepal is divided into sever81 levels of political and administrative units. The village Panchayat, which consists of nine wards, is the lowest level. There are more than 3,000 village panchayats in Nepal. These aggregated into 75 district panchayats. The national panchayat is the equivalent of a national Parliament. Members of the Panchayats are elected by the adult constituency which they represent.

Figure 2. Location of Argali and Chherlung.



In Argali there are four irrigation systems, each consisting of an intake on the Kurung Khola (stream) and a canal which conveys water to a command area on the Argali river terrace. The four systems range in area irrigated during the monsoon season from about 11 to 47 hectares and in membership from 28 to 159 households. Since there is little difference in the four organizations, we will limit the discussion to the largest system, the Raj Kulo (Royal Canal).

Three systems irrigate the land in Chherlung. The smallest system serves less than 10 hectares and is supplied with water by a spring near the command area. Little labor is requ'ired to operate this system, and it has an informal organization.

The other two systems have intakes on the Brangdhi Khola. They are called the Thulo Kulo (large canal) and Tallo Kulo (lower canal) systems and irrigate 35 and 17 hectares of rice, respectively, in Chherlung. The Thulo Kulo has 105 members and the Tallo Kulo, 60 members. They employ a principle of water allocation which is distinctively different from that used in Argali. Because the Thulo and Tallo Kulo organizations and their historical development are similar, we will focus on the Thulo Kulo system and compare it with the Raj Kulo of Argali.

In both sites the soils are well-drained with high percolation rates. Measurement of the rate of water subsidence in selected rice paddies yielded estimates of the seepage and percolation (S&P) rate which increased over the season from about 10 to 80 millimeters/day in fields which were continuously saturated and from 10 to 160 millimeters/ day in fields which cracked due to drying during rotational water distribution (Yoder, 1986).[10] Consequently, water application rates for rice cultivation are extremely high. The average over the monsoon season when rice was cultivated ranged from 4 to 7 liters/second/hectare depending upon the water supply available and the water distribution method.]' While the top soil layer has a relatively high clay content, it is not deep. The depth of the puddled layer is controlled by the depth of plowing which averages only 75 millimeters. The sub-soil layer is porous, and the water table on the river terraces is far below the surface. The shallow puddled layer, nature of the subsoil, and deep water table contribute to the high percolation rate.

Farm sizes are small in both villages. The average size of irrigated landholding (*khet*)[12] per household in both systems is about 0.3 hectares. Agriculture is extremely intensive in both locations, which is made possible by effective irrigation systems. Farmers in both systems have developed the same cropping pattern on their irrigated fields. Most farmers grow three crops: monsoon rice, winter wheat, and premonsoon maize. Several farmers in Argali planted rice on some of their land in the pre-monsoon season. In Chherlung, however, the water supply is so limited in the pre-monsoon season that if rice were grown, only one-third of the area could be cultivated, leaving the remainder fallow. In order to provide equitable irrigation benefits among the members in Chherlung, water is allocated on a priority basis for maize. Since maize is a less water-intensive crop than rice, all of the hydraulic command area can grow irrigated maize. Total grain production per year from a hectare of land in each system averaged approximately 8 tons. Table 1 presents the results of crop cuts that were taken in the two systems.

Figure 3 shows the crop calendar that was observed in Argali in 1982/83. The calendar for Chherlung was virtnally identical to that of Argali. Whereas during the monsoon season all of the khet is used for growing rice, in the winter season some fanners grow potatoes, cabbage, or other vegetables in place of wheat on some of the area. In the pre-monsoon season maize is grown on most of the khet with a lentil crop, usually cowpeas, intercropped with the maize as a vegetable, fodder, or green manure.[13] A few farmers with larger holdings leave part of their khet fallow in the winter and plant a longer-season, higher-yielding maize variety before the time of wheat harvest.

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[10] The measured increases in S&P over the season are thought to be a result of the shallow depth of plowing which allows easy root penetration and cracking of the puddled layer.

[11] In contrast, systems in the lowlands of India, the Philippines. Indonesia, and Thailand usually require 1 to 1.5 liters/sec/ha.

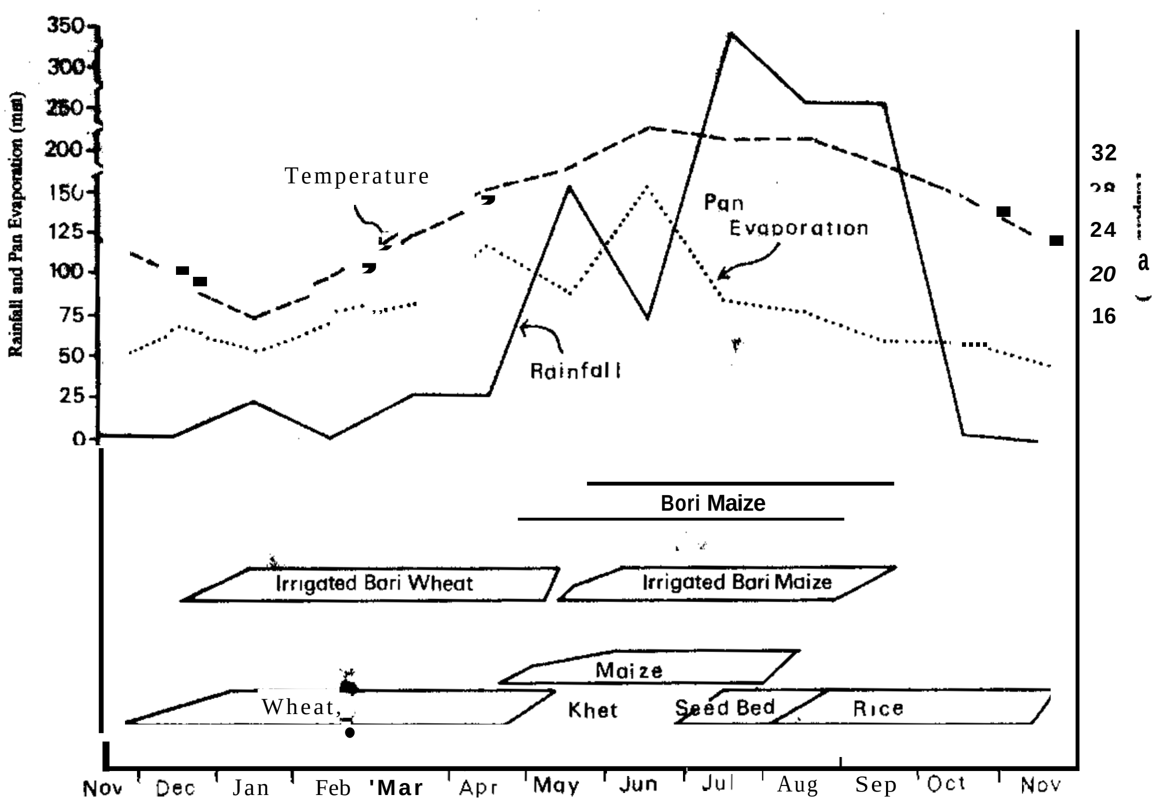
[12] *Khet* is the Nepali term far fields which have been leveled and bunded into terraces for the cultivation of flooded rice. *Bari* is Ihe term for upland fields which have not been leveled and bunded for flood irrigation.

Table 1. Grain yields estimated from sample crop cuts in 1982-83 (tons/hectare).

	Argali	Chherlung
Khet (leveled & bunded)		
Rice	3.3 (89)[a]	3.5 (121)
Wheat	2.5 (83)	2.5 (95)
Maize	1.7 (92)	2.4 (95)
Total	7.5	8.4
Irrigated *bari* (sloping upland)		
wheat	2.9 (14)	*
Maize	3.9 (14)	*
Total	6.8	

[a] Number of crop cut samples used to compute the mean yield. * No crop cuts taken.

Figure 3. The Argali 1982/83 crop calendar.



[13] As the yields reported in Table 1 indicate, maize suffers in the three crop pattern on the khet and produces less than half the yield of maize grown on irrigated bari. Khet maize was harvested before maturity so that rice, the priority mop, could be planted soon after the onset of monsoon rains. It was in the field less than 95 days on average compared to 115 days for bari maize.

In both villages traditional varieties of rice are grown in the monsoon season. However, management-responsive varieties of wheat and maize have been adopted by most of the farmers. The farmers in Argali who cultivated pre-monsoon rice planted a management-responsive variety.

Many of the farmers also have some upland fields (bari). These may or may not he irrigated during the wheat and maize seasons depending on their location relative to the canal. If the bari is irrigated, farmers usually plant winter wheat followed by a long-season maize variety which is not harvested until near the end of the monsoon in September. Most households plant potatoes and vegetables for household consumption on part of their irrigated ban during the winter wheat season. A legume is intercropped with the maize and harvested for household consumption and animal fodder. After the maize is harvested, mustard may be planted, but this is not irrigated. A long-season variety of maize is the common crop planted on unirrigated bari in both villages.

Historical Development

Oral tradition in Argali states that the Raj Kulo was initialed by Mani Makunda Sen, the first Sen rajah of Palpa. This would make it over 300 years old. It was originally constructed to irrigate land to support a temple which he had built on the bank of the Kali Gandaki River at Rid!. Part of the production from a small section of the present command area is still given to the temple. Since the original construction took place so long ago, nothing is known of how resources were mobilized and work carried out.

Much more is known about the history of the Thulo Kulo in Chherlung because construction began in 1928. Men who worked on it in their youth are still farming land which it irrigates and remember some of the details of the original construction. Two individuals, a Brahmin and a Chhetri[14], are credited with initiating and organizing the construction and contributing the bulk of the initial resources needed to dig the canal. An additional 25 households provided some support, but other families in the community doubted the feasibility of delivering water from an intake more than six kilometers away by means of a canal which had to be cut through dense jungle, hard rock, and along the face of sheer cliffs.

To build the canal a contract of Rs. 5,000 and ten *maato muri* (about 0.12 hectares) of potential khet land was given to four Agris from the village of Damuk Khanee in Gulmi District[15]. These four skilled canal builders hired laborers, including people from Chherlung, and each supervised 25-30 workers. Construction was begun in 1928 and continued for 10 months each year. The work was interrupted when people from Tansen, the District Center, arrested several workers on the charge that they were taking wood from the jungle without authorization and burning it to heat and break rocks. Tansen residents were also concerned that the canal would leak and ruin the road to Ranighat, the place where they traditionally cremated their dead. A settlement was reached when the Chherlung farmers agreed to repair any damage to the road, received permission to cut firewood, and were granted the right-of-way for the canal. Water first flowed through the Thulo Kulo to the Chherlung command area in 1932.

Farmers in Argali and in Chherlung have continued developing the irrigation potential of their respective water and land resources. In Argali they have built three more canals parallel to and below the Raj Kulo. These three, known as *Maili* (second daughter), *Saili* (third daughter), and *Khanchi* (youngest daughter) irrigate an additional 42 hectares of khet.

After construction of the Thulo Kulo in Chherlung had demonstrated the feasibility of irrigation from the Brangdhi Khola, two Magars[16] organized the construction of the Tallo Kulo parallel to the Thulo Kulo. The local

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[14]Brahmins and Chhetris are high caste Hindus.

[15]Persons who spent time working in the once flourishing mining industry of western Nepal became known as *agris.* Numerous ethnic group and castes were involved in this work. Man Bahadur Kami, one of the four who took the Chherlung contract, is credited with constructing a number of irrigation canals in Palpa and Gulmi Districts.

[16]Magars are a Tibeta-Burman ethnic group native to the hills of western Nepal

convention regarding water rights required this second canal's intake to be below that of the Thulo Kulo even though its command area was higher. Thus the two canals cross just before they reach the command area. The Same four skilled canal builders who had constructed the Thulo Kulo were given a contract to build the Tallo Kulo.

In Chherlung the contractors were retained for an additional four years to maintain and improve the Thulo Kulo. They did this during the monsoon months and worked to construct the Tallo Kulo the rest of the year. The members paid for all of the contract work and in addition contributed labor. Since that time the members have continued to mobilize labor and cash to make improvements. Gradually the canal has been enlarged to deliver a higher discharge, and the intake structure has been improved. In 1967, cement was used in the system for the first time, and since then short sections of the canal have been lined. The district panchayat made small grants to the organization in 1967, 1975, 1981, and 1983. These were used primarily to purchase cement.

It was reported that in the first years only a trickle of irrigation water could be delivered through the Thulo Kulo. Increase in water discharge over the years has allowed the area irrigated to gradually expand, and in parts of the system, farmers can now irrigate their rice by continuous flow. In the early years of the system, it was necessary to distribute water by rotation to all fields throughout the entire system.

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. Those who farmed irrigated rice land, whether owners or tenants, were members of the irrigation organization and were responsible for operating the system. 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 rather than used to improve the system.

The tenant operators became land owners after passage of the Land Reform Acts in 1957 and 1964, and 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.

Evidence of the increased water discharge of the canal lies in the report by many of the farmers in Argali that until 10-15 years ago they needed to guard the water to their fields carefully both day and night. This required that one family member sleep by the canal turnout to their field at night. Observation of the water distribution in 1982 clearly showed that in an average rainfall year the water supply was now adequate for continuous-flow water distribution to all of the fields in the Raj Kulo system for the entire season. It was no longer necessary for Raj Kulo members to guard their water carefully.

Water Allocation

Rice is the preferred staple food in Argali and Chherlung and is the crop for which irrigation has been developed. The technology and organization, i.e., the techniques. rules and conventions, developed by the fanners are primarily for rice cultivation. Membership in the irrigation organization is limited to those who have the right to water for growing rice in the monsoon season, even though other farmers have access to water from the system in other seasons for other crops. According to local tradition and Nepali law, the first farmer or group of fanners to develop a water source can claim the right, at the point of the diversion from the stream, to all of the water that they need for cultivation (Muluki Ain, 1964).

Members of both the Raj Kulo and the Thulo Kulo have a strong feeling of ownership of their irrigation systems. This is a result of their personal investment and the physical danger they faced in developing and operating the systems. Accounts of accidents claiming lives while constructing or maintaining systems form a part of the history of many irrigation organizations in western Nepal.

Farmers carefully protect their right to a limited resource. Although drainage water from the Raj Kulo is used for cultivating several additional hectares of rice, the owners of these fields are not considered members of the system. They do not need to contribute to the maintenance of the system nor can they exercise authority by demanding water or influencing the timing of water delivery. When the members in systems like the Raj Kulo were questioned about allowing those using drainage water to become members, the answer was universal that since they had not invested in the system they could not become members. Even acquiring access to the canal water for a nonconsumptive use, such as a water-powered mill, was sometimes not possible (Scheuer et al., 1980). A frequently expressed fear was that if irrigation access or other uses were allowed, rights would be established to the water. If rights were established, then in the event of a drought the crops of the original members would be stressed and they would not be able to deny water to the new users.

Additional irrigation development from the same stream can usually only take place by other farmer groups constructing their own diversion and canal downstream of the existing intake. The only exception is if the new canal does not diminish the discharge in an existing canal with an intake below it. Many communities have three or four canals conveying water from the same stream into a command area. Frequently the canals can be seen running parallel along a hillside, separated by only a few meters of elevation but serving distinct areas within the command. The construction of multiple intakes and canals is often a result of the allocation of rights of access to water by prior appropriation. This principle was enunciated in the Law on Reclamation of Wasteland in the traditional legal code of Nepal, the *Muluki Ain,* as follows, "Water shall not be available for others until the requirements of the person who constructed the irrigation channel at his own expense or with his own physical labor are first met" (Regmi, 1978:244).

Water allocation, i.e., the distribution of entitlements to water from an irrigation system, consists of two dimensions. The first dimension, discussed above, distinguishes the farmers or fields which have access to the system's water from those which do not. The second dimension is a quantitative allocation of the water in the system among the farmers or fields which have been granted access to it, i.e., the designation of the quantity and timing of water to which each farmer or field is enritled.

The Argali Raj Kulo and Chherlung Thulo Kulo organizations have clearly defined both aspects of water allocation. In Argali during the monsoon rice season, only certain designated fields are allocated water. Fields which have no water allocation, but on which irrigation is hydraulically feasible, have no claim on the water resource from the time seedbeds are established for the monsoon rice crop until the rice is harvested. The amount of water to which each field with an allocation is entitled is defined in terms of its area relative to the total irrigated area. Formerly the unit of area measurement was a *maato **muri*** (about 1/80 of a hectare), and each field's allocation is still referred to as "so many ***muri*** of water." Only those households farming land that has a water allocation for monsoon rice are members of the Raj Kulo organization.

The allocation during the winter wheat season and for maize planting is much less strictly defined and limited. Any farmer whose fields are located where they can receive water from the Raj Kulo is entitled to water in exchange for working on the system one day for each water application. The area that is irrigated during the dry season for wheat and maize is nearly double that which is irrigated during the monsoon rice season.

Access to water for growing rice in the Chherlung Thulo Kulo system and membership in the organization is limited to households that own at least a fraction of a share in the system. At the completion of the Thulo Kulo construction, the Rs. 5,000 construction contract was divided into 50 shares of Rs. 100 each. Shares in the system were distributed among the 27 contributing households according to the investment each had made and became the basis of the water allocation.

Ownership of one share entitled a member to 1/50 of the discharge in the system. Several households had contributed enough to receive more shares than they needed to irrigate their fields, while other households received less than needed. In addition, many people who had been unwilling to risk investing in the initial construction now wanted access to irrigation. This led to the initiation of buying and selling shares. The ownership of transferable shares was thus established and continues as the method of water allocation in the Chherlung Thulo Kulo.

Now there are 105 member households, and the range of share holdings is from one-eighth to four shares. On the average in 1983, a share of water irrigated one-half hectare of rice. The price of a share has increased over the years with transactions taking place in 1985 at the rate of Rs. 10,000(US$575) per share.[17] In the same year the price of

[17]This is the cost of a one-lime purchase of a share, not an annual or seasonal rental charge

prime irrigated land was **Rs.** 40-45,000 (US$2,300-2,600) per *ropani*.[18] In 1985 the cost of water for irrigating rice was about **2** percent of the cost of the best rice land in Chherlung.

The price of shares is set by the organization's managing committee and is said to somewhat reflect the total investment in the system. Even though the price of a share has increased tremendously, shares are still denominated according to the original price like the par value of stock, i.e., one share is referred to as Rs. 100 of water even though its current price is Rs. 10,000

Over the years, improvements have been made to the main canal, significantly increasing the total flow in the system.[19] Since a share is a fixed proportion of the flow and not a specific volume, increasing the discharge in the canal increases the amount of water in a share. **A** member who initially needed two shares to adequately irrigate his land may at a later time require only one share. The member is therefore allowed lo sell all or part of a share to another farmer who has no water or less than he wan6 for irrigating his land. When a sale takes place, the transaction is recorded by the secretary and the water distribution changed to meet the new allocation pattern. This involves changing the size of a notch in a **saacho**[20] if the water is transferred between secondary canals and recalculating the time intervals for rotational distribution. The Thulo Kulo farmers are adept at readjusting the water distribution to match a new allocation of shares.

On one occasion (in 1978) a group of farmers in Chherlung with land in an unirrigated area wanted to purchase shares, but no individual was prepared to sell the number of shares they wanted. The Thulo Kulo organization decided that improvements to the diversion weir and canal were necessary before enough water could he delivered to serve an expanded command area. **A** decision was made by the organization to sell ten additional shares at the rate of Rs. 2,800 (US$233) per share. thereby *increasing* the total number of shares in the system from 50 to 60. The Rs. 28,000 received by the organization from the sale was then invested in improvements in thediversion and main canal to successfully expand the irrigated area by more than 25 percent in one year.

Organization for Irrigation Management

Membership in the irrigation organizations in both Argali and Chherlung is hydraulically determined. Even though in both locations there **is** more than one canal from the same source serving a contiguous command area, each canal has a separate organization for its operation. In Argali, the membership of the Raj Kulo irrigation organization consists only of those farmers operating land that receives a water allocation from the Raj Kulo for monsoon rice. **All** farmers in Chherlung owning shares or a fraction of a share in the Thulo Kulo system are members of the organization.

Both organizations have a ***mukhiya*** (leader) and a secretary who are elected by the members. The current officers have served for a number of years but could he replaced if members were dissatisfied with their performance. The mukhiya is responsible for organizing and supervising work done on the system, and the secretary keeps the accounts, a record of members' water allocation and attendance at work, and minutes of the organization's meetings. As remuneration the number of workers these officers must suppl for maintenance work, based on their water allocation, is reduced. lfthe number of workers that they would have to provide is less than the remuneration they are due, the balance is paid to the in cash at the local daily wage rate.

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[18]One hectare is about 20 ropani. At 1985 prices (Rs. 17.4/US$), land sold for more than US$45,000/ha.

[19]Improvements in the canal have been made on an almost annual basis. This has resulted in increased discharge from a mere tricklet in 1932 when the canal irrigated only a few small plots, to a maximum discharge of 180 liters/second in 1982. The average discharge, measured in the main canal on a twice daily basis over the 1982 rice season, was 160 liters/second (Yoder, 1986).

[20]A *saacho* is a proportioning weir used to divide water from one canal into two or more smaller canals. It is described more fully on the following page.

Both organizations have a meeting of the members in mid-May. At this meeting plans are made for the major annual maintenance which begins shortly thereafter, new officers are elected if necessary, and the operating rules for the coming monsoon season are reviewed and amended as needed. In Argali the accounts are presented for review at this meeting, whereas in Chherlung this is done at a meeting after rice harvest in the fall. Other meetings may be held throughout the year if decisions about system operation need to he made.

Water Distribution

Unless an irrigation system has an abundant supply of water allowing all fields to be adequately irrigated without concern for insuring that distribution of water is consistent with the allocation, some method of rationing the water according to each farmer's allocation is required. In Argali and Chherlung this is accomplished through the use of saachos and rotational distribution. Farmers in Argali and Chherlung irrigate rice by continuous-flow distribution whenever the supply is sufficient. Water flows continuously in all channels of the system, and farmers apply water to their fields at any time they want. With the exception of the days when they weed the field and apply fertilizer, farmers prefer standing water in their fields until near the end of the season when they dry the fields for harvest.

Saachos are used to distribute water by continuous flow in accordance with the pattern of water allocation. A saacho is a weir that the farmers install in the canal with two or more rectangular openings for the water to flow through. By having the bottom of each opening at the same elevation, the flow in the canal can be divided into parts that equal the ratio of the width of each opening to the total width of all the openings. Because of its notched shape, the proportioning weir is called a saacho (key) in the Argali and Chherlung systems. Figure 4 shows a saacho dividing the flow of one of the main canals in Argali into four secondary canals?'

Figure 4. A *saacho* installed to distribute the flow from a main canal into four secondary canals according to the water allocation of each.

[21] This same type of device for proportioning water distribution is found in many of the irrigation systems studied in western Nepal In some communities they were called *pani dhara* (water spout) or *khat bunda* (wooden closure). Similar devices arc also found in other countries In Indonesia they are referred to as *penaro* (Coward. 1985), in Sri Lanka. *karahankota* (Leach. 1961). and in Thailand. *tae wat* or *mai wai* (Tan-kim-yong, 1983).

In Chherlung, saachos are used only to distribute water from the main canal into secondary canals. The group of farmers below the saacho is then responsible to apportion the water among their fields. When the discharge is adequate, the flow into each field is controlled by adjusting the size of the opening in the earth bund and by placing stones and mud in the canal to divert part of the water.

In much of Argali, saachos are used for distributing water from the main canal into secondary canals, from the secondaries into tertiary canals, and from tertiaries to the farmers' fields. They are installed to the field level when farmers are not able to satisfactorily distribute the water among themselves less formally. Installation of a saacho eliminates the conflicts that arise under informal distribution as farmers try to take more, or are thought by their neighbors to be taking more, than their share.

In both systems, when the supply is insufficient to provide continuous flow to the entire area at once, a timed rotation system of distribution is initiated. In the 1982 rice season, rotational distribution was not required in the Raj Kulo system in Argali. Halfway through the wme season in Chherlung, however, the water supply had diminished to the extent that continuous-flow distribution to **all of** the fields was no longer possible. It was possible to retain continuous flow through the saachos into all of the secondary canals, but farmers within each secondary formed rotational units and decided independently when they wanted to initiate rotational water distribution among the fields served by their secondary.

For water distribution within the secondary, the number of minutes per share was computed by dividing the total number of shares served by the secondary into the number of minutes in the rotation cycle. Each farmer would then receive water for the time period represented by the number of shares he had allocated to his field served by that secondary. A typical rotation cycle was **36** hours. By setting the length of the rotation cycle at 36 hours, the irrigation turn for each farmer alfernated from day to night. Although irrigating at night has always been an accepted practice in Chherlung, it is both more difficult (disrupting sleep) and expensive (requiring the purchase **of** batteries for a torchlight).

Water distribution in Argali during the wheat and maize seasons is less precise and formal because the water supply is sufficient to irrigate more than the command area. Water **is** applied several days before land preparation to make it suitable for plowing and planting. Wheat **is** then irrigated two or three more times during the season. Maize may be irrigated only at planting for quick germination. At the most it is given only one or two additional irrigations, depending on the rainfall. Wheat and maize. irrigation is done turn-by-turn with the farmers informally deciding upon the order. From long tradition, farmers wanting water on a particular day will meet at the main saacho at the head of the system at 10:00 a.m. to decide the order of irrigation and to do any minor repairs necessary to deliver the desired amount ***of*** water.

In Chherlung, the most demanding irrigation period each year is at maize planting time in mid-April. Most farmers are ready to plant maize at the same time, and they must irrigate to initiate germination. Discharge in the Brangdhi Khola in April is very low, requiring that the total flow of the canal be rotated from one farmer's field to the next at the system rather than secondary canal level. Therefore, full authority for the allocation of water for maize planting--both in quantity and timing--is given to the mukhiya. All requests for water must be made to him, and as nearly as possible he assigns water delivery to each farmer's field in the order in which requests are received. A field usually consists of several terraces depending on the slope and size of the field. In order to allow equity in timely planting of every farmer's maize, the mukhiya decides, on the basis of requests for water each day, what portion of each farmer's field, i.e., how many terraces, will he irrigated in his turn. In this way water is allocated by turn to farmers, and a portion of their land, depending on the terrace size, is irrigated. The farmer must then wait for another one or more turns to complete his maize planting.

For an irrigation system to function well, the distribution of water must be done according to the allocation scheme. The precise definition *of* farmers' water allocation **is** only useful if the system can actually deliver to each farmer the share of the supply to which he is entitled. Measurement and comparison between the amount of water actually distributed and the amount allocated to different parts of an irrigation system provides an evaluation of the system's performance. The portion of the supply delivered to parts of the Thulo Kulo system was measured and compared with the amount allocated to those **parts** of the systems. The same measurements were made for the Kanchi Kulo system in Argali which distributes water in the same manner **as** the Raj Kulo. **As** Table *2* shows, the actual distribution closely matched the allocation, an indication of good system performance,

Table 2. Comparison of water distribution to water allocation in selected secondaries.

System	Location of Secondary	Water Allocation (percent of total water in system)[a]	Water Distribution[b] (percent of total water in system)[a]
Thulo Kulo, Chherlung	Head	9.5	10.2
	Middle	11.4	10.5
	Tail	21.8	20.6
Kanchi Kulo, Argali	Tail	16.6	16.9

[a]Since nut all secondaries were measured, percentages do not sum to 100 percent.
[b]Discharge in the main canal and selected secondaries was measured twice daily for 97 days during the 1982 monsoon rice season. The figures refer to the percentage of the total volume of water supplied to the respective secondaries over the season.

Maintenance

A critical period for maintenance of most hill irrigation systems, including Argali and Chherlung, is prior to and during the monsoon. Major routine maintenance is done in late May and June to prepare the system for the monsoon Season when efficient water delivery for rice cultivation is most important. At this time, the diversion and canal walls are repaired to reduce leakage, silt and weeds are cleaned from the entire length of canal, and sections of the canal are lined with clay to reduce seepage. This usually takes between two and three weeks.

In Chherlung, because of the low discharge in the stream in April, similar maintenance is also carried out prior to land preparation for maize. After the 1983 maintenance for maize, it was observed that the irrigators had used clay to seal the diversion in the stream. All of the surface water in the stream was captured, and measurements showed that for the short period during maize planting, over 80 percent of the water entering the canal reached the command area 6.5 kilometers away.

A large amount of maintenance is required throughout the monsoon season. The streams fluctuate tremendously with the monsoon rains, often damaging the diversion structures made of brush, stones, and mud. The heavy rainfall causes landslides on the steep, unstable hillsides along which the canals run, interrupting the flow of water until the canal is repaired. The intake and main canal are patrolled daily so that there is early detection of damage. The Chherlung organization pays two men to do this every day during the monsoon, while in Argali the members take turns patrolling in pairs.

The men patrolling the canal will do minor maintenance work such as repairing small leaks. In Argali if there is a need for more laborers, one of them will inform the mukhiya who then organizes members to do the repairs. In Chherlung the members are divided into seven groups, and each group is responsible for maintenance on a different day of the week, If laborers are needed, they will first be drawn from that day's group. Sometimes, due to the magnitude of the disaster, an emergency will he declared, and then each member household is required to send one man to work. Work will sometimes continue at night by the light of lanterns until the water is flowing again.

During the winter wheat and maize seasons, much less maintenance is required because there is very little rainfall. The farmers who want to irrigate on a given day may have to repair the intake to divert more water or plug small leaks in the canal to increase the flow. relatively minor efforts compared to the monsoon season maintenance.

Resource Mobilization

Resource mobilization is critical to the effectiveness of an irrigation system, and horh the Raj Kulo and Thulo Kulo organizations successfully mobilize significant amounts of resources every year. Most of the labor and cash resources are contributed by the members, although small grants and some technical assistance have been given recently by the district panchayat and Department of Irrigation, Hydrology, and Meteorology (DIHM). Both organizations mobilize between 1500 and 2500 man-days of labor annually, depending on the severity of the monsoon rains and the attendant flooding and landslides. Both organizations have assessed cash contributions from members for the purchase of cement to line portions of the canals.

In both systems resources are generally mobilized in proportion to the benefits that members receive from the system, i.e., according to the water allocation. In Argali, where water is allocated in proportion to area irrigated, labor and cash are also contributed according lo area served. Members must contribute labor for ordinary maintenance work at the rate of one man for each 40 *maato muri*[22] of khet each work day. A household with only 20 maato muri is required to provide one worker every other day.

Members in Chherlung contribute labor and cash according to the number of shares they own in the system. A household with one share is required to supply one man each day of ordinary maintenance, while one with two shares must provide two workers each day. Table 3 presents the number of man-dsys of labor mobilized by the two organizations.

Table 3. Labor mobilized for system maintenance (person-days).

Year	Routine Maintenance	Emergency Maintenance	Total
Raj Kulo, Argali			
1961	1120	681	1801
1966	1251	92	1343
1967	1120	690	1810
1968	1085	371	1456
1969	1120	825	1945
1970	1453	a	a
1971	1135	161	1296
1972	1003	159	1162
1973	1032	543	1575
1974	1287	205	1497
1975	1104	358	1462
1976	1203	294	1497
1979	1264	1378	2642[b]
1980	1087	638	1725
1981	1322	985	2307
1982	1179	822	2001
1983	1271	599	1870
1984	926	449	1375
Average	1165	544	1692
Thulo Kulo, Chherlung			
1981	c	c	1811
1983	c	c	3541[d]
1984	c	c	1362
1985	c	c	1740
Average			2114

[a]Missing. [b]Construction of a road above the canal began in 1979, resulting in mole than usual damage to the canal for several years.
[c]Routine and emergency maintenance not separated in records of the organization. [d]Damage caused hy a major landslide required much more than the average amount of labor.
Source: Raj Kulo and Thulo Kulo organizations' attendance records.

In 1982, members of the Thulo Kulo organization were assessed cash contributions at the rate of Rs. 250 (US$19) per share, raking a total of Rs. 15,000 (US$1,140) from 105 member households owning a total of 60 shares.[23] Rs. 34,800 (US$2,636) was raised by assessing the members at the rate of Rs. 580 (US$44) per share in 1983. Most of this was spent to build a masonry wall several meters high to support a section of lined canal following a severe landslide.

The one exception to the rule of proportionality in resource mobilization is when an emergency is declared. Each member household must then supply one man, irrespective of its water allocation. At the annual meeting in May 1983 in Argali, some members with small water allocations strongly protested that it was unfair for them to have to provide the same number of workers in an emergency as households with a much larger water allocation. After much discussion the decision was made to leave the rule unchanged but to be careful about when an emergency is called, i.e., only when there is a real emergency.

In order to mobilize the resources needed to maintain the system in effective working order, the organization must have sanctions which can be applied and enforced when members fail to contribute their share of labor and cash. Both systems levy cash fines against members who are absent from work. The fine for missing a day of ordinary maintenance is set near the local daily wage rate in Chherlung, Rs. 10 (US$.75) in 1982 and somewhat lower in Argali, Rs. 6 (US$.45). In Chherlung when a major emergency is declared, the fine rate is increased to encourage a higher rate of attendance. If a person is absent from the community when the emergency is declared or has another acceptable excuse such as illness, the fine is reduced to Rs. 6 per day, even for a major emergency.

Fines, when levied, are paid because as one farmer in Argali said, "If the fine is not paid, the organization can deny the offender water." Also, the community of members can exert social, as well as physical, pressure on members to pay fines. In Chherlung it was reported that in an early year of operation of the system, one man did not report for emergency maintenance for several days. When his fine was levied and he refused to pay, a group of members confiscated his cooking pots and threatened to sell them to pay his fine. Within a day or two, he paid the fine and recovered his cooking pots. Other members witnessed how serious the organization was about enforcing the rules and collecting fines, and payment has been 100 percent of all fines levied.

At a December 1982 meeting of the Raj Kulo organization, two members were appointed to collect the fines from the previous monsoon season and any that were outstanding from previous years. As remuneration for this work, they were entitled to keep 6 percent of the amount collected. In both organizations, the cash that is raised through fines is invested in maintenance and improvement of the system. Until it is spent, the money may be loaned to members who pay interest to the organization.

IMPLICATIONS OF THE PRINCIPLE OF WATER ALLOCATION

The principle of allocation has important implications for the efficiency of water use and the expansion of the irrigated area. Allocation of water in proportion to area irrigated provides no incentives for efficient water use nor a mechanism for expanding the area irrigated.[24] In Argali there have been significant improvements made in the canal, and the amount of water supplied to the command area has increased considerably in the past 25 years. However, there has been little increase in the area irrigated. DIHM invested approximately Rs. 400,000 (US$30,300) in the system in 1982 with no change in the irrigated area or cropping intensity. The main impact of the improvements made over the past 25 years, including those by DIHM, has been to reduce the water distribution

[22] A *maato muri* is a traditional measure of area. Forty *maato muri* equal approximately half a hectare

[23] The exchange rate at the time was Rs. 13.2= US$ 1

[24] An exception to this statement is the warabandi systems of Northwestern India. In these systems water is allocated in proportion to land area, but each farmer receives considerably less water than needed to irrigate his whole farm. Farmers, thus, have an incentive to use water efficiently and to expand their irrigated area.

... required to manage the system. Whereas the farmers once had to use a rotation system of distribution and go out to irrigate at night, sometimes sleeping in the field to guard their water, now the water flows continuously to all fields. It is recognized that there is plenty of water to irrigate additional land,[26] but the members have no incentive to allocate water to fields owned by nonmembers. To maintain their yields, they would have to work harder to manage a smaller amount of water more efficiently. i.e., change to a rotation system of distribution, and would receive nothing in return.

On the other hand, allocation by purchased shares in Chherlung provides both the individual incentives for efficient water management and a mechanism for expanding the irrigated area. As the system improved, the amount of water delivered and, consequently, the amount of water per share increased considerably. Shareholders can decide whether to keep all their shares and reduce their management input or to sell part of the additional water. Because the individual can sell part of his water, he is aware of the opportunity cost of his use of water, and there is a financial incentive to manage his water efficiently. In addition, if an individual sells part of his allocation, the amount of labor that he must contribute to maintaining the system is reduced. Since the Thulo Kulo requires a large amount of labor each year for maintenance, this provides another incentive to reduce the number of shares one owns and to use the water more efficiently.

A comparison of the seasonal relative water supply for the two systems gives an indication of the efficiency of water use. The relative water supply is estimated by dividing the total water supply by the total demand for water over the season.[27] Seepage and percolation in both systems was measured to be approximately the same, with the daily average over the rice season being approximately 35 millimeters. Computation using data collected twice daily over the rice season gives a seasonal relative water supply of approximately 1.0 in the Chherlung Thulo Kulo system and 1.3 in the Argali Raj Kulo system. In neither system was there any indication of moisture stress, but the Thulo Kulo farmers had to practice rotational distribution while Raj Kulo farmers were able to distribute water continuously. The relative water supply calculation suggests that water was managed more efficiently in Chherlung than in Argali, lending support to the hypothesis that allocation of water by the sale of shares results in more efficient management of water than allocation in proportion to area irrigated.

The sale of shares, either by individuals or from the system at large, provides a mechanism for expanding the area irrigated, Water is not tied to a specific land area but is distributed to wherever, within the area commanded, those owning shares want it. In Chherlung the system has expanded through the sale of water shares to the point where it now irrigates 85 percent of the potentially irrigable area. The chairman of the Thulo Kulo organization estimated that the area that is irrigated during the monsoon season doubled between 1967 and 1982 as a result of continual improvements to the system and subsequent sales of shares. In comparison, only 45 percent of the Raj Kulo's potentially irrigable area receives irrigation for the monsoon season rice crop.

Interestingly, the Raj Kulo organization has recognized that the sale of water shares would be an effective means of expanding the area served. Most members accept that there is surplus water in the system, and that the work the Department of Irrigation, Hydrology and Meteorology did in 1982 has made the supply more reliable, i.e., less subject to major interruptions by landslides. In 1983, it appeared that the government was going to reduce by half its contribution to the local school's budget, precipitating a financial crisis for the school. A decision was made, after much debate within the Raj Kulo organization, that the Raj Kulo organization would sell 200 muri of water (about 10 percent of the supply) and give the money to the school as a permanent endowment. Requests for the water

[25] The cost of maintenance was also reduced, hut the data in Table 3 do not show this. Construction of a road above and parallel to the Raj Kulo is largely the cause of the higher maintenance labor between 1979 and 1983. Rocks and mud excavated by the contractor during construction were dumped down the hillside into the Canal. Since the cut for ths road was made, the hillside is less stable resulting in more landslides. The Rs. 400,000 (US$ 30,300) invested by DIHM was used mainly to install hume pipe through this vulnerable area.

[26] Several farmers reported that if they owned all of Be potentially irrigable land, they would irrigate the entire area by rotational distribution, thus doubling the area of irrigated rice land. While some members did not agree that all of the potential area could be irrigated, all accepted that some additional area could be served with the present supply without any reduction in yields.

[27] The elements of supply are irrigation and rainfall while demand consists of evapotranspiration and seepage and percolation

were solicited, and 40 households applied to purchase nearly three times the amount offered for sale. The price was set at Rs. 2,000 (US$ 138) per muri; only two households were able to raise the necessary cash, indicating that the rate was probably set too high. Based on the flows in the Raj and Thulo Kulos in the monsoon of 1982, the price per unit of flow, i.e., liter per second, set in Argali was ten times higher than the rate in Chherlung at that time. Before the price or conditions of payment could be renegotiated, the government restored its contributioq to the schools budget to the original amount, and members of the Raj Kulo organization lost interest in the sale of water.

The allocation principle also has equity implications. In Argali the only way that a person can irrigate rice is for the household to have inherited khet land with a water allocation or to buy some irrigated land. It is, thus, nearly impossible for the poor and low caste people to acquire access to irrigation for the important monsoon rice season. In the past, no low caste households had land with an allocation of water. One Damai[28] has been able to buy a small parcel of khet with earning from work in India. He is the only low caste person in all of Argali with land that has a water allocation for monsoon rice. Irrigated land is extremely expensive (Rs. 400,000 (US$27,500) per hectare in 1983), and the poor have little possibility of buying any.

In Chherlung 20 percent of the members of the Thulo Kulo organization are low caste households, and gaining access to irrigation is much more feasible. A person with unirrigated land in the hydraulic command area has only to purchase a fraction of a share of water in the system and through hard work gradually convert his bari to khet and realize more production on it. He does not need to buy expensive, already irrigated land to acquire access to the benefits of irrigation as he would in Argali. Most of the low caste members' fields are in the area to which irrigation was first supplied after the number of shares in the system was increased by the sale of 10 additional shares in 1978.

CONCLUSION

In this paper we have described and analyzed the institutions utilized for irrigation management in a number of farmer-managed irrigation systems in the hills of Nepal. Farmer control of the entire irrigation system and the need for farmers to rely on themselves for the operation and maintenance has resulted in the development of sophisticated institutions for management of the water resource. These institutions have enabled effective use of irrigation, making extremely intensive agricultural production possible with three crops cultivated per year in many systems.

The institutions examined included both the organization which manages the irrigation systems and the traditional convention of property rights in water. Both types of institutions are essential for the effective operation of irrigation systems. Irrigation institutions are designed to enable the accomplishment of certain activities related to 1) the water, 2) the physical structures for control of the water, and 3) the organization of farmers which manage the irrigation system. In the hill environment of Nepal, the activity of *resource mobilization* for *maintenance* of the system for *acquisition* of water was found to be the mast critical activity which influences the structure of an irrigation organization. The principle of water allocation was found to have extremely significant implications for the *efficiency* and *equity* of *utilization* of irrigation resources.

Two specific systems, the Raj Kulo of Argali and the Thulo Kulo of Chherlung, were described in detail. These two systems exhibit many of the institutional characteristics common to a number of irrigation systems which were observed in West Nepal during the 20-month period of field research in 1982-83. The structure of the fanner organization in both systems is similar. Membership is limited to those households with a right to use water during the monsoon rice season, officers are elected by the members, regular and special meetings of the members are convened, resources are mobilized according to members' water allocation, sanctions are applied for failing to provide the required amount of labor for maintenance, and written records of attendance at work, accounts, members' water allocation, and minutes of meetings are maintained by the secretary. Both systems require a large amount of labor to maintain intakes, which are often damaged by floods, and the main canal which must traverse steep, landslide-prone hillsides. Between 1,500 and 2,500 man-days of labor are mobilized annually in each system for routine and emergency maintenance.

[28] The Damai are an untouchable caste who traditionally work as tailors.

The water allocation of each member is precisely detined in both systems. The Raj Kulo organization allocates water to each member for monsoon rice in proportion to the area of irrigated land owned. To acquire water rights for the monsoon season, households must buy land which already has water allocated to it. In Chherlung, the Thulo Kulo organization allocates water by the sale of shares, and property rights in water are, thus, separate from ownership of land. Most transactions of water shares take place between individuals, but on one occasion, the organization sold shares, increasing the total number of shares in the system.

A measure of the performance of an irrigation system is a comparison of how closely the actual distribution of water matches the water allocation. Measurement of water distribution to different parts of the command area showed that in both Chherlung and Argali water distribution very closely matched the pattern of water allocation. Thus by this measure both systems can be said to have performed well. Continuous flow through saachos (proportioning weirs) and timed rotation are the two methods used to distribute the water in accordance with the allocation.

The comparison of the Raj Kulo and Thulo Kulo systems demonstrates the importance of the principle of water allocation for efficient and equitable development of irrigation resources. If water is to be utilized efficiently and irrigated area increased, there must be incentives for efficient water management and mechanisms for expanding access to the water. Water allocation by purchased shares, as practiced in Chherlung, provides the individual incentive and an organizational mechanism which enable the efficient development of resources, while allocation in proportion to area irrigated does not. In contrast to the Raj Kulo system, the Thulo Kulo system bas 1) expanded the area irrigated during the monsoon season to a greater extent, 2) achieved more efficient water utilization through more intensive management of the distribution, and 3) realized greater equity in access to the irrigation resource.

REFERENCES

Coward, E. Walter, Jr. 1980. *Irrigation and agriculture development in Asia: Perspectives from the social sciences.* Ithaca: Cornell University Press.

Coward, E. Walter. Jr. 1985. "Property, persistence. and participation: The state and traditional irrigation systems." Paper prepared for the 1985 meeting of the Society for Economic Anthropology. Airle House, Warrenton, Virginia.

Geertz, Clifford. 1980. "Organization of the Balinese Subak." In E. Walter Coward (ed.) *Irrigation and agricultural development in Asia Perspectives from the social sciences.* Ithaca: Cornell University Press.

Leach, Edmund R. 1961. *Pul Eliya a village in Ceylon: A study of land tenure and kinship.* Cambridge: University Press.

Lewis. Henry T. 1971. *Ilocano rice farmers: A comparative study of two Philippine barrios.* Honolulu: University of Hawaii Press.

Martin, Edward D. 1986. "Resource mobilization, water allocation, and farmer organization in hill irrigation systems in Nepal." Unpublished Ph.D. dissertation. Ithaca: Cornell University.

Mitchell. William P. 1976. "Irrigation farming in the Andes: Evolutionary implications." In Rhoda Halperin and James Dow (eds.). *Studies in peasant livelihood.* New York St. Martin's Press.

Muluki Ain. 1964. Of Land Cultivation. In "Laws Relating to Water Resources." HMGN Water and Energy Commission Secretariat, Kathmandu, Nepal. 1986.

Regmi, M.C. 1978. *Land tenure and taxation in Nepal Vol. I-IV,* (second edition). H.K. Kuloy (ed.). Bibliotheca Himalayica series I Vol. 26. Ratna Pustak Bhandar, Kathmandu, Nepal.

Siy, Robert Y., Jr. 1982. *Community resource management: Lessons from the Zanjera.* Quezon City: University of the Philippines Press.

Scheuer, Helmut. Reinhold Metzler, and Robert Yoder. 1980. *Small water turbine. Instruction manual for the construction of a crossflow turbine.* Eshhorn, West Germany: GATE

'Pan-kim-yong, Uraivan. 1983. "Resource mobilization in traditional irrigation systems of northern Thailand: A comparison between the lowland and the upland irrigation communities." Unpublished Ph.D. dissertation. Ithaca: Cornell University.

Uphoff, Norman. 1984. "Analyzing options for local institutional development." Special Series on Local Institutional Development. No. 1. Ithaca: Rural Development Committee, Cornell University.

Uphoff, Norman. 1986. *Improving international irrigation management with farmer participation: Getting the process right.* Boulder. Colorado: Westview Press.

Yoder, Robert D. 1986. "Performance of farmer-managed irrigation systems in the hills of Nepal." Unpublished Ph.D. dissertation. Ithaca: Cornell University.

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