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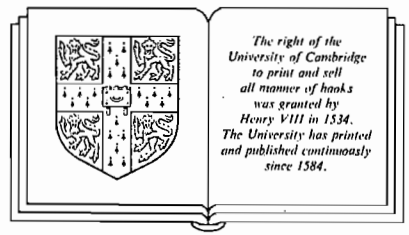
GOVERNING THE COMMONS

The evolution of institutions for collective action

ELINOR OSTROM
Indiana University



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To Vincent
For his love and contestation

Each of the villages also devised its own monitoring and sanctioning systems. Given that the mountain usually was closed, except for specified periods, anyone caught in the communally owned territories at other times obviously was not following the rules. Most of the villages hired "detectives" who daily patrolled the commons on horseback in groups of two looking for unauthorized users. In some villages, this position was considered "one of the most prestigious and responsible available to a young man" (McKean 1986, p. 561). In other villages, all eligible males rotated into these positions on a regular basis. One village that did not use formal detectives relied on a form of "citizen's arrest," and anyone was authorized to report violations.

The written codes for each village specified a series of escalating penalties for various violations of the rules to protect the commons, depending on the past behavior of the offender. An occasional infraction would be handled by the detective in a quiet and simple manner. "It was considered perfectly appropriate for the detective to demand cash and saké from violators and to use that as their own entertainment cache" (McKean 1986, p. 561). In addition to the fines paid to the detectives, violators were deprived of their contraband harvest, their equipment, and their horses. The village retained the illegal harvest. The rule-breaker had to pay a fine to the village to retrieve equipment and horses. Fines were graduated from very low levels to extremely high levels to reflect the seriousness of the offense and the willingness of the culprit to make adequate and rapid amends. The most serious sanctions that could be and occasionally were imposed involved complete ostracism or ultimately banishment from the village.

Although the level of rule compliance was very high, violations certainly occurred. McKean reports several types of infractions. Impatience with waiting for mountain-opening day was one reason. In the period just before the official opening of the commons for harvesting a particular plant, the detectives expected – and found – a higher level of infractions and were able to keep themselves well supplied with saké.

A second reason for rule violation sometimes was genuine disagreement about the management decisions of a village headman. McKean illustrates this type of infraction in the following way:

> One former detective in Hirano, now a respected village elder, described how he had been patrolling a closed commons one day and came upon not one or two intruders but thirty, including some of the heads of leading households. It was not yet mountain-opening day, but they had entered the commons en masse to cut a particular type of pole used to build trellises to support garden vegetables raised on private plots. If they could not cut the poles soon enough, their entire vegetable crop might be lost, and they believed that the village headman had erred in setting opening day later than these crops required. (McKean 1986, p. 565)

In that instance, fines were imposed, but they involved making a donation to the village school, rather than the usual payment of saké. In her conclusion, McKean stresses that the long-term success of these locally designed rule systems indicates "that it is not necessary for regulation of the commons to be imposed coercively from the outside" (McKean 1986, p. 571).

HUERTA IRRIGATION INSTITUTIONS

On May 29, 1435, about 50 years before the residents of Törbel signed their formal articles of association, 84 irrigators served by the Benacher and Faitanar canals in Valencia gathered at the monastery of St. Francis to draw up and approve formal regulations. Those regulations specified who had rights to water from these canals, how the water would be shared in good years as well as bad, how responsibilities for maintenance would be shared, what officials they would elect and how, and what fines would be levied against anyone who broke one of their rules. The canals themselves, like many others in the region, had been constructed in even earlier times. Many rules concerning the distribution of irrigation water were already well established in customary practices. Valencia had been recaptured from the Muslims in 1238 – two centuries before that meeting of the Benacher and Faitanar irrigators. Some of the rules carried into medieval and modern practice were developed *prior* to that reconquest.[10] Thus, for at least 550 years, and probably for close to 1,000 years, farmers have continued to meet with others sharing the same canals for the purpose of specifying and revising the rules that they use, selecting officials, and determining fines and assessments.

Given the limited quantity of rainfall throughout this semiarid region and the extreme variation in rainfall from year to year, its highly developed agriculture would not have been possible without irrigation works bringing water to the farmers' fields. Water was never abundant in this region, not even after major canals were constructed. Given the high stakes, conflict over water has always been just beneath the surface of everyday life, erupting from time to time in fights between the irrigators themselves, between irrigators and their own officials, and between groups of irrigators living in the lower reaches of the water systems and their upstream neighbors. Despite this high potential for conflict – and its actual realization from time to time – the institutions devised many centuries ago for govern-

ing the use of water from these rivers have proved adequate for resolving conflicts, allocating water predictably, and ensuring stability in a region not normally associated with high levels of stability. Maass and Anderson (1986) have devoted much effort to studying the institutions used in the

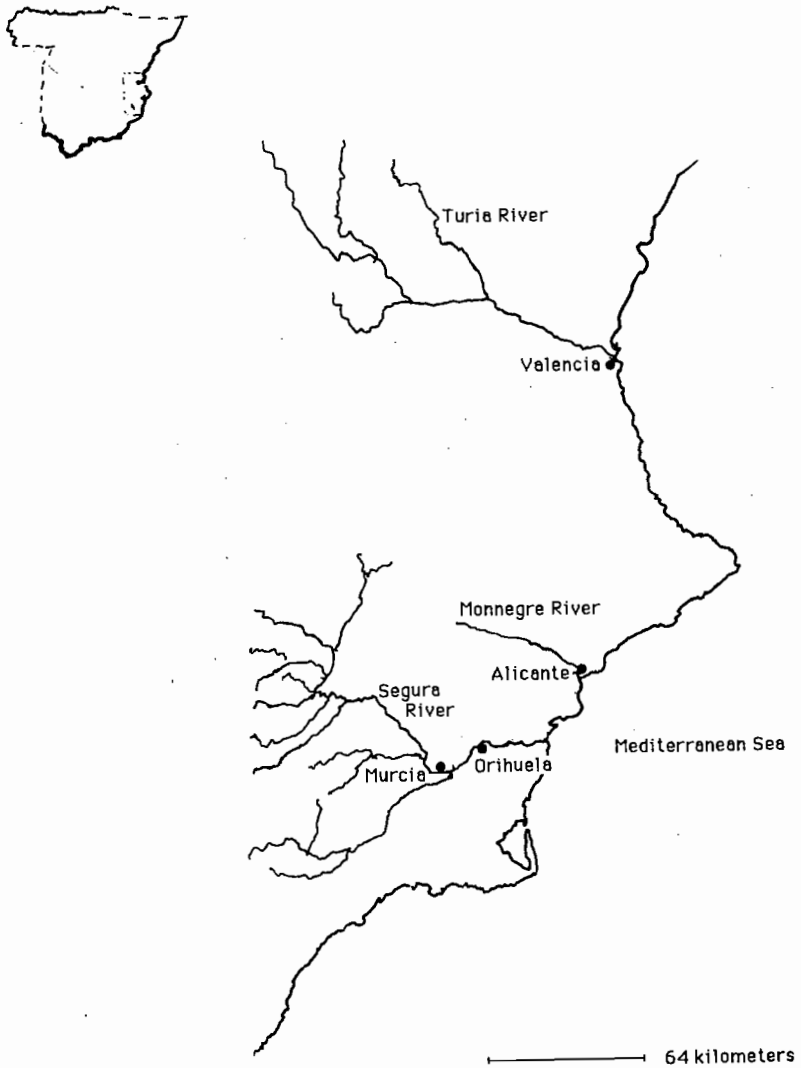

Figure 3.1. Location of Spanish *huertas*.

huertas (well-demarked irrigation areas surrounding or near towns) of Valencia, Murcia, Orihuela, and Alicante, and Glick (1970) has provided us with an authoritative study of the *huerta* of Valencia during the Middle Ages.

Valencia

Near the city of Valencia, the waters of the Turia River are divided into eight major canals serving the 16,000-hectare *huerta*. The farms in Valencia have always been small, but they have become extremely fragmented during the past century. Over 80% of the farms are less than 1 hectare, and few exceed 5 hectares (Maass and Anderson 1986, p. 11). Most winters are frost-free, and the summers are hot and sunny. Farmers are able to harvest two or three crops each year and concentrate largely on potatoes, onions, and a wide diversity of vegetable crops. Each farmer is free to select the cropping patterns he prefers.

Given the low rainfall in Valencia itself, the extensive agriculture of this region would not have been possible without effective use of the Turia River. The variation in the flow of the Turia River has historically been quite high. Years of low water flow have been followed by years of extensive flooding. Until the turn of this century, no dams had been constructed on the Turia River serving the Valencian *huerta*. It was not until 1951, when the Generalisimo Dam was completed, with 228 million cubic meters of storage, that substantial upstream storage was provided to regulate the extreme fluctuations in the river's flow. Some groundwater has been developed in the region to supplement the river's supply, but this has never been a major factor in the supply of irrigation water.

In Valencia, the right to water inheres in the land itself. Land that was watered before the time of the reconquest is specified as irrigated land (*regadiu*), and the remaining lands in these *huertas* are dry lands (*seca*).[11] Some land is entitled to water only in times of abundance (*extremales*). The basic allocation principle in Valencia is that each piece of *regadiu* land is entitled to a quantity of canal water proportionate to its size.

In Valencia, the irrigators from seven of the major canals are organized into autonomous irrigation communities whose syndic,[12] or chief executive, participates in two weekly tribunals. The Tribunal de las Aguas is a water court that has for centuries met on Thursday mornings outside the Apostles' Door of the Cathedral of Valencia. The many Islamic features of its traditions have led scholars to argue that the court evolved during the period of Islamic rule.[13] Its proceedings are carried on without lawyers, but with many onlookers. A presiding officer questions those who are involved in a dispute and others who may be able to provide additional information,

and the members of the court, excluding the syndic whose canal is involved, make an immediate decision regarding the facts of the case in light of the specific rules of the particular canal. Fines and damages are assessed consistent with the rules of the particular canal. The final decisions of the court are recorded, but not the proceedings. After the court session, the syndics may also convene a second tribunal, which serves as a coordinating committee encompassing all seven of the canals to determine when to institute operating procedures related to seasonal low waters or to discuss other intercanal problems.

The farmers (*hereters*) who own lands eligible to receive water from each of these seven canals meet every second or third year to elect the syndic and several other officials for their canal. Besides his role in the two tribunals, the syndic is the executive officer of the individual irrigation unit. His responsibilities include the basic enforcement of the regulations of his own unit. He has the power to make authoritative physical allocations of water when disputes arise in the day-to-day administration of the waterworks, to levy fines, and to determine the order and timing of water deliveries during times of severe shortages (subject to weekly review by the Tribunal de las Aguas). The syndic must own and farm land served by the canal. The syndic usually has a small staff of ditch-riders and guards whom he appoints to help him carry out these assignments.[14]

In medieval times, the *hereters* also elected two or more inspectors (*veedors*) who were representatives of the community of irrigators and were to consult with the syndic about the daily operation of the canal and assist in rendering physical judgments when conflicts between farmers or between a syndic and a farmer erupted. In modern times, the *hereters* elect an executive committee (*junta de gobierno*) to consult with the syndic until the next biannual meeting. The executive committee is composed of delegates from all of the canal's major service areas. Decisions about when to shut down the canals for annual maintenance and how the maintenance work will be organized are made by the members of this committee of irrigators.

The basic rules for allocating water are dependent on the decisions made by the officials of the irrigation community concerning three environmental conditions: abundance, seasonal low water, and extraordinary drought. In years of declared abundance – a relatively infrequent event – farmers are allowed to take as much water as they need whenever water is present in the canal serving their land.

The most frequent condition under which the canals operate is that of seasonal low water. When the low-water condition is in effect, water is distributed to specific farmers through a complex, rule-driven hydraulic

system. Each distributory canal is positioned in a rotation scheme in relation to the other distributory canals.[15] Each farm on a distributory canal receives water in a set rotation order, starting from the head of the canal and culminating in the tail end of the canal:

> On days when water is running in a lateral . . . those farmers who want to irrigate will take it in turn (*por turno*), generally in order from the head to the tail of the channel. Once a farmer opens his headgate, he takes all the water he needs, without any restriction of time; and he defines his own needs, principally in terms of the water requirements of the crops he has chosen to plant. The only limitation is that he may not waste water. If a farmer fails to open his headgate when the water arrives there, he misses his turn and must wait for the water to return to the farm on the next rotation. When a lateral operates in rotation and all users who want water at a given time cannot be served before the rotation passes to another lateral, distribution will begin, when water returns, at the point where it previously terminated. (Maass and Anderson 1986, p. 28)

The basic elements of the *turno* system are that (1) the order in which irrigators receive water is fixed, and (2) each farmer can decide how much water to take as long as water is not wasted. Consequently, no irrigator can tell exactly when his turn will come, because that depends on the volume of water in the canal and the quantity needed by those ahead of him. On the other hand, each irrigator knows that he can take as much water as he needs when his turn eventually comes.

In periods of extraordinary drought, these procedures are modified so that farms whose crops are in the most need of water are given priority over farms whose crops require less water. At the beginning of a drought period, the farmers themselves are expected to apply water only to those crops in most need to shorten their turns in order to allow other farmers in need to obtain the scarce water. As a drought period continues, the syndic and his representatives take more and more responsibility for determining how long each farmer may have water, in light of the condition of the farmer's crops and the needs of others. In recent years, procedures to be used in extraordinary drought have been needed less frequently than in earlier times, because of the increased regulatory capacity of the Generalisimo Dam. Even so, an established procedure is in place for switching rule regimes when environmental conditions change.

The level of monitoring that is used in the *huertas* is very high. In this environment of water scarcity and risk, many temptations occur to take water out of turn, or in some way obtain illegal water. As the time approaches for a farmer to take his turn at the water, he will tend his fields near to the canal so that he can be prepared to open his own gate when the water arrives; if not prepared, he misses his turn entirely and must wait for

the next round. While waiting, it is relatively easy to watch what those ahead of him are doing and watch the ditch-riders, whom he is paying. The ditch-riders patrol the canals regularly and are watched over by the syndic, who can lose respect, and his job, if the allocation of water is not handled fairly and according to the farmers' rules. Challenges to the actions of a syndic, a ditch-rider, or another irrigator can be aired weekly before the Tribunal de las Aguas, with many of the other farmers watching the confrontation with interest. The reciprocal monitoring relationships in Valencia are shown in Figure 3.2. Given that everyone is watching everyone else, there is considerable potential for violence among irrigators and between irrigators and their agents. In medieval times, the norms related to honor probably exacerbated the potential for conflict, and *hereters* "were willing to fight in an instant if they felt that their water supply was jeopardized in any way" (Glick 1970, p. 70). The actual violence never approached the potential.

The survival of the books in which fines were recorded for the years 1443 and 1486 for the nearly similarly structured *huerta* of Castellón, some of the detail of which has been reproduced by Glick, provides a picture of the types of infractions discovered, the high level of monitoring undertaken, and the low level of actual fines during an earlier era.[16] In 1443 there were 441 fines assessed; in 1486 there were 499 fines (Glick 1970, p. 54). The similarity in the distributions of offenses and the numbers of fines for these two periods more than 40 years apart testifies to the stability of the system. Guards assessed fines at a rate of more than one per day.[17]About two-thirds of the actions were initiated by the guards, and the remaining third by farmers. Forty-two percent concerned infractions that clearly were motivated by the temptation to obtain water not legally available to the farmer (taking forbidden water, stealing water, installing or undoing canal checks illegally, taking water by force, irrigating without

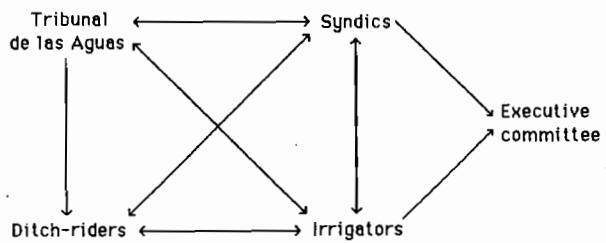

Figure 3.2. Patterns of monitoring and accountability among key actors in the Valencia *huerta*.

right). The remainder of the infractions related to actions that caused harm to others (flooding a road or a fallow field, wasting water) and were also forbidden by the community. Farmers were held publicly accountable for the errors they committed that caused harm to others. Two-thirds of those fined in a year were "one-time offenders" and were not mentioned again in the fine book. Of those who were repeaters, 41% were involved in two actions, 25% in three, 15% in four, 8% in five, and 12% in more than five (Glick 1970, p. 59).

Sufficient data exist to estimate the rate of conformance to the rules for Castellón. There were approximately 1,000 hearths in Castellón in the fifteenth century (T. F. Glick, personal communication). If the rotation system took about two weeks, each of the roughly 1,000 irrigators would have had about 25 opportunities during the year to take water illegally. Thus, approximately 25,000 opportunities for theft occurred, as contrasted to 200 recorded instances of illegal taking of water. That would give a recorded infraction rate of 0.008. One must assume that the guards did not detect all infractions. One could double, triple, or even quadruple the recorded rate, however, and still have a remarkable conformance rate.[18]

Although the conformance rate was high, about one-third of the *hereters* would have had one encounter with a guard at some time during a full year.[19] Consequently, information about the extensive monitoring was regularly conveyed to irrigators. We do not have as detailed a picture of the enforcement patterns in modern times, but both the number of ditch-riders employed and the necessity of holding a weekly court session lead one to suspect that high enforcement levels have been required to dampen the ever present temptation to steal water, as well as the potential for inter-farmer conflict and violence. The stability of this system has been achieved in spite of personal temptations to cheat and engage in violent behavior.

The books of fines also reveal that even though the syndic received two-thirds of the fine (the other third going to the accuser) and the authorized levels for fines were set high, the actual fines assessed "were very low (a few pennies at the most) and also variable, depending on the gravity of the offense, on general economic conditions, and probably on the individual's ability to pay" (Glick 1970, p. 56). Glick comments that this introduced some flexibility into the relatively rigid rotation systems. From time to time, the cost to a farmer of waiting for his next legal turn to receive water, as contrasted to stealing water available in the canal, would be extraordinarily high. Because the fines actually assessed were kept relatively low, the guards did not deeply antagonize the farmers, who generally adhered to the rules. A farmer would suffer some humiliation if detected cheating, but the monetary fine for cooperative farmers would be quite

low. Assessing harsh punishment to someone who usually follows the rules, but in one instance errs in the face of a desperate situation, can engender considerable antagonism and resentment (Oliver 1980).

Only rarely did farmers engage in ongoing harassment of one another. Glick notes one "particularly fractious individual" who made 5 accusations of theft and was himself similarly accused 13 times during 1486; 10 of the 18 incidents were conflicts between members of two families. But such cases are extremely rare in the archival data, and the absence of chronic conflict between farmers is considered by Glick to be "a tribute to both the efficiency of the distribution system and the vigilance of the guards" (Glick 1970, p. 64).[20]

Murcia and Orihuela

The Segura River runs from west to east as it approaches the Mediterranean, flowing first through the *huerta* of Murcia and then through the *huerta* of Orihuela. Of the 13,300 farms included within the service area of the *huerta* of Murcia, 83% are less than a single hectare. Of the 4,888 farms in the *huerta* of Orihuela, 64% are less than a single hectare, and 86% are less than 5 hectares. As in Valencia, water rights in Murcia and Orihuela are tied to the land. *Regadiu* and *seca* lands were designated long ago and have remained stable for centuries. The quantity of rainfall in the *huertas* of Murcia and Orihuela is, on the average, considerably less than in Valencia, and it occurs with greater variation. The terrain in Murcia and Orihuela is more varied than the terrain in Valencia, and local procedures involve much more emphasis on the problem of watering highlands and lowlands from the same canal.

Each farmer is assigned a *tanda*, a fixed time period during which he may withdraw water. Thus, each farmer knows exactly when and for how long he may obtain water, but he does not know exactly how much water may be available at that time. The *tanda* procedure has some advantages over the *turno* procedure used in Valencia. Each farmer can plan his activities with a greater degree of certainty as to when he will be able to irrigate. Each farmer is more motivated to economize on the use of water within his own fields because he must make the decision how to allocate a limited time-slice of water to his own fields. On the other hand, the *tanda* procedure is itself quite rigid, particularly as farms are bought and sold, divided or combined.

The officials of the irrigation community, in consultation with city officials, are responsible for declaring when there is insufficient water to continue the regular *tanda* procedure. When extraordinary low-water con-

ditions are in effect, the officials of each community post a new schedule for each rotation of the season – approximately every two weeks – indicating which crops will be given precedence and the schedule and special rules to be followed for the next rotation period.

There are about 30 irrigation communities in Murcia, 10 in Orihuela, and several more that take from canals just below Orihuela. In both *huertas*, the communities employ guards, who most frequently come from the canal sections where they are employed and are nominated by the farmers of that section.

> The guards patrol the canal and report any violations of the ordinances they observe; act as witnesses where one farmer charges another with a violation or themselves bring charges against farmers; and assist in the distribution of water, frequently opening and closing the principal canal checks and the turnout gate of the principal laterals. (Maass and Anderson 1986, p. 80)

The irrigation communities within both *huertas* have formed *huerta*-wide organizations. The syndics of the canal communities of Murcia meet yearly in a general assembly and elect members to an executive commission, in addition to approving an annual budget and taxes. The syndics of the canals in Orihuela meet in a general assembly of its *huerta*-wide organization every three years to elect a water magistrate, his lieutenant, and a solicitor. The water magistrate presides at all assemblies within Orihuela. The *huerta*-wide agency performs activities similar to those undertaken in Murcia. The city of Orihuela is hardly involved in irrigation activities within its limits.

Both *huertas* have established water courts in which farmers can bring charges against each other or in which officials can charge a farmer with an offense. Murcia's water court – which has the felicitous name of the Council of Good Men (Consejo de Hombres Buenos) – is composed of five canal syndics and two inspectors. Because Murcia has 30 organized communities, the names of all syndics and inspectors for all systems are placed in two bowls at the beginning of each year, and each month a new court is selected by lottery so that each canal will be represented in an equitable fashion. The Murcian court meets every Thursday morning in the City Hall and is presided over by the mayor of Murcia (or his deputy), who votes only in case of a tie. Not only is the day of meeting similar to that in Valencia, but the general procedures are the same: "oral, public, summary, and cheap" (Maass and Anderson 1986, p. 82).

The water court in Orihuela has only a single judge, and its procedures differ substantially from those in Murcia and Valencia. Those who wish to bring charges against others do so to an officer of the court. The person accused is then summoned to appear before the magistrate within a few

days. A sentence is imposed immediately if the person accused confesses to the charge. Otherwise, the magistrate tries to get those involved to come to an agreement that he can accept.

Alicante

Whereas the Segura and Turia rivers drain large watersheds, including mountain ranges where winter precipitation is stored in the form of snow and released later, the Monnegre River serving Alicante rises near the sea and drains only a small area. The even greater shortage of water in this *huerta*, as contrasted to Valencia and Murcia-Orihuela, which themselves do not have an abundant supply of water, has affected the strategies that the irrigators in Alicante have adopted. The basic water right in Alicante is closer to that of Murcia than to that of Valencia. All water rights are to a fixed time period. Originally, these time allocations were tied to land ownership. Shortly after Alicante was recovered from the Muslims, rights to withdraw water for fixed time periods were separated from ownership of land, and a market in these rights existed apart from the market for land. Alicante farmers took the initiative to construct the Tibi Dam in 1594, which at times has led to greater involvement of national and regional authorities in the management of irrigation in Alicante than in Valencia or Murcia-Orihuela. Local irrigators have sought out still other sources of water, and that has involved them in extensive contractual arrangements with large-scale private water companies.

The 3,700 hectares of *huerta* land are divided among 2,400 farms, 63% of which are less than 1 hectare, and 93% of which are less than 5 hectares (Maass and Anderson 1986, p. 101). Alicante farmers have adopted a mixed strategy of growing cereals and vegetables between rows of fruit and nut trees. Prior to the construction of the Tibi Dam, many owners of land sold their water rights to others or regularly rented their rights. Consequently, a fixed quantity of water rights existed prior to construction of the dam, and those rights were traded independently of land transactions. Tibi Dam made available twice as much usable irrigation water as the unregulated river had provided. The rights to the "new water" created by the Tibi Dam were assigned to owners of *huerta* land whose assessments paid for the dam.[21] The rights to the other half of the water supply – the "old water" – were held by those who had already acquired rights prior to construction of the dam. A new proviso was added to these rights that they could be sold or rented only to those who owned land eligible to receive new water. Consequently, the water rights could not be sold to individuals whose land lay outside the *huerta*. Although the rights to new water were

originally attached to the land, those rights were soon "rented" from time to time by farmers who did not need all of their water for a particular rotation.

Prior to a full rotation of water through the irrigation community's canals, a notice is posted by the syndicate providing information about the dates of the next rotation and the times during which "scrip" will be issued. Holders of both new and old water rights obtain scrip equivalent to their recorded water rights in denominations from one hour down to one-third of a minute. All scrip for Tibi water is fully exchangeable. Farmers who hold new-water rights, and thus land within the *huerta*, rarely have sufficient scrip to obtain enough water to irrigate their crops. They can purchase scrip in three ways: at an informal market among holders of rights conducted on Sunday morning before a formal auction is held; at the formal auction; and on market days, when farmers are congregating for trade.

In the formal auction, the irrigation community sells the approximately 90 hours of water that it owns – water rights assigned to it by the irrigators in 1926 to provide a regular income for the syndicate's operations.[22] The syndicate also sells any surplus scrip that was not claimed by right-holders during the previous allotted time period. The minimum quantity of water offered in the formal auction is a full hour, but the purchased scrip is fully divisible and negotiable. Considerable information is made available by the irrigation community to enable farmers to make intelligent choices.

> The ditch riders are present . . . and can tell a farmer when the water is likely to reach his property. The organization posts on a bulletin board outside the tavern a current report of water storage in the reservoir; a full account of all water delivered in the previous rotation, including the names of irrigators and the amounts of water delivered to each; and a full accounting of all water sold at auction in the previous rotation, including the names of all successful bidders, the number of hours each purchased, and the prices paid.
>
> (Maass and Anderson 1986, p. 116)

A farmer who wants to irrigate his land during a particular rotation tells his ditch-rider – who opens and closes all of the relevant control structures – how much time he wishes to use. The ditch-rider, in turn, informs the farmer approximately when the water will be available. The farmer is supposed to pay the ditch-rider when water is delivered, but the practice is to allow a farmer up to three days after a rotation has been completed. At that time, the ditch-rider's report of all water delivered and equivalent scrip must be turned in. Thus, farmers purchase scrip not only for future deliveries but also to cover fully what they have used during the current rotation. The price of water is consequently higher toward the end of a

rotation than at the beginning of one.[23] The price of water also varies in relation to the amount of water available. In years of abundant rainfall, farmers need less irrigation water, and the price of Tibi water falls. In times of extreme drought, there may not be any water to distribute, and the auction will not occur until water is available. In periods of seasonal low water, the price of water may become very high and can be a source of considerable conflict between holders of old rights versus holders of new rights. Alicante farmers may also purchase water from several other sources.[24]

The organization of the irrigation community in Alicante differs significantly from that for the *huertas* discussed earlier. First, there is only one irrigation community for the entire *huerta*. Second, to vote in the general assembly of the community, a farmer must own 1.8 hectares of land; to vote for the executive commission, 1.2 hectares of land; and to be eligible to serve on the commission, 3.6 hectares of land (Maass and Anderson 1986, p. 117). Whereas a farmer must own a minimum of land to participate, the votes of farmers owning more land are not weighted to reflect differences in the amounts of land owned. The executive commission is composed of 12 representatives (*sindicos*) who serve four years each (half rotating every second year). One member from this body is selected as the director.

The general assembly meets annually to approve the budget and taxes and to decide matters brought before it by the executive commission. Special meetings can be called when problems arise requiring action between the annual meetings. Both the executive commission and the assembly have been extremely active in Alicante in the repeated efforts to find new water and to attempt to develop better contractual arrangements with the private firms using the community's canal to sell water in the *huerta*. The regular expenses of the community are assessed against the holders of all water rights. Three rotations each year are designated as those during which regular taxes will be collected, and a right-holder must pay the assessment at the time of applying for scrip. Extraordinary expenses, which at times have been quite high, are also assessed in the same manner, except that the payment is due at a different set of rotations during the year.

The commission employs an executive secretary, as well as all those who operate the control structures and deliver the water directly to the farmer. The ditch-riders open and close all farm headgates in Alicante. The farmers do this themselves in Valencia and Murcia-Orihuela. The ditch-riders of Alicante, however, exercise less discretion in determining who shall receive water and when. One employee is given the responsibility of accounting for

the water that has left the regulating basins until it reaches a ditch-rider, who is again accountable for all of the water that is assigned to him.

National authorities have exerted more control over irrigation matters in Alicante than in the other *huertas*. A large structure, such as Tibi Dam, can be seized and used as a source of revenue and power by a rent-seeking ruler. Although Philip II did not attempt to exercise control over the Tibi Dam when it was built, the dam was transferred to royal ownership for a century in 1739. When control of the dam and responsibility for distributing its water were returned to Alicante in 1840, farmers did not win the right to select syndicate officers for another 25 years. The Spanish Civil War also interrupted the control that farmers exercised over the irrigation syndicate. It was not until 1950 that farmers again selected their own officials.

It should be noted that the degree of freedom to devise and change their own institutions, successfully asserted by the irrigators of eastern Spain, was not typical of the Castilian part of Spain, whose far more centralized institutions were the major influences on the evolution of Spanish national institutions.[25] By the end of the thirteenth century, the *cortes* of the kingdom of Aragon (roughly comprising Valencia, Aragon, and Catalonia) had "already secured the power to legislate and even to limit the king's power to issue legislation under certain conditions" (Veliz 1980, p. 34). The *cortes* in Castile, at the same time in history, was seldom summoned. By the time the centralized monarchy based on the Castilian model came to dominate Spain and Latin America, the autonomy of the *huertas* was well established. The continuing willingness of the irrigators in these regions to stand up for their rights attests that they had greater autonomy than did those in other parts of Spain. One can only wonder if the course of history in Latin America might have differed substantially if the Spanish monarchy established by Ferdinand and Isabella had been modeled on Aragon and not on Castile.[26]

Maass and Anderson have conducted an interesting evaluation of the comparative efficiencies of the Spanish *huertas* and several systems operating in the western part of the United States. Without including the costs of water or the administrative costs associated with governing and managing the canals, they find that the system that has evolved in Alicante enables farmers to be most efficient in using other input factors. The system devised in Valencia is the least efficient of the Spanish systems, with the Murcia-Orihuela systems coming in between. All of the systems generate positive benefits for the farmers they serve, and all have shown an amazing capacity to survive. In 1887, the Murcian historian Diaz Cassou concluded that "the democratic and representative character of the agricultural commune of Murcia had shown a remarkable stability, for a succession of very different

national political epochs had offered no serious obstacles to its continued function" (Maass and Anderson 1986, p. 83). A century later, Cassou's reflection remains valid.

ZANJERA IRRIGATION COMMUNITIES IN THE PHILIPPINES

The earliest recorded reference to the existing irrigation societies in the Ilocanos area of Ilocos Norte in the Philippines derives from Spanish priests writing in 1630 (H. Lewis 1980, p. 153). No serious effort has been made to determine if similar organizations were in existence before the Spanish colonial period, but it would not be unreasonable to assume that the modern *zanjeras* are derived from a mixture of traditions, including that of the Spanish. The most striking similarity between the *huerta* and *zanjera* systems is in the central role given to small-scale communities of irrigators who determine their own rules, choose their own officials, guard their own systems, and maintain their own canals. The internal organization of each *zanjera* has been tailored to its own history, and thus the specific rules in use vary substantially (Keesing 1962). In 1979 there were 686 communal irrigation systems in Ilocos Norte (Siy 1982, p. 25).[27]

Zanjeras have been established both by landowning farmers wanting to construct common irrigation works and by individuals organizing themselves so as to acquire land. The technologies used in *zanjera* systems are relatively crude and labor-intensive. The large number of operating systems and the amount of labor put into these by farmers – tenants as well as landowners – have meant that technological knowledge of how to construct dams and other works has been widely shared. With this knowledge, it has been possible for enterprising tenant farmers to band together to construct an irrigation system on previously nonirrigated land in return for the right to the produce from a defined portion of the newly irrigated land.

This type of contract – called a *biang ti daga* or a "sharing of the land" – allows the landowner to retain ownership. Use rights are extended to the *zanjera* dependent on continued maintenance of the irrigation system. At the time of forming an association, each original participant in the *zanjera* is issued one membership share or *atar*. The total number of *atars* is set at that point.[28] The share gives each member one vote and the right to farm a proportionate share of the land acquired by the *zanjera*, and it defines the obligation of the member for labor and material inputs. Each *atar*-holder is obligated to contribute one day's work during each work season declared by the *zanjera*, plus a share of the material required at construction time. The system was thus developed as a mode of acquiring long-term use rights

to land and the water to irrigate it without prior accumulation of monetary assets.

Each *zanjera* is laid out differently, but all that were set up by a *biang ti daga* contract share an underlying pattern. The area is divided into three or more large sections. Each farmer is assigned a plot in each section. All members are thus in fundamentally symmetrical positions in relation to one another. Not only do they own rights to farm equal amounts of land, but they all farm some land in the most advantageous location near the head of the system, and some near the tail. In years when rainfall is not sufficient to irrigate all of the fields, a decision about sharing the burden of scarcity can be made rapidly and equitably by simply deciding not to irrigate the bottom section of land.

Several parcels are set aside for communal purposes. A few parcels, located at the tail end of the system, are assigned to officials of the association as payment for their services. This system not only provides a positive reward for services rendered but also enhances the incentives for those in leadership positions to try to get water to the tail end of the system. Other lands are retained to secure income for the *zanjera* itself. See the work of Coward (1979, 1985) for a detailed description of this system.

The members of each *zanjera* elect a *maestro* as their executive officer, a secretary, a treasurer, and a cook.[29] In the larger associations, they also select foremen and team leaders to supervise the construction activities. The *maestro* has the challenging job of motivating individuals to contribute many hours of physically exhausting labor in times of emergency, when control structures have been washed out, and for routine maintenance. Given the backbreaking efforts required during the monsoon season or during extremely hot weather, this motivational task is of substantial proportions. The *maestro* is, of course, not dependent simply on his persuasive powers. Many real inducements and sanctions are built into these systems by the rules that *zanjera* members have constructed for themselves.

To illustrate the task involved in governing these systems, we shall consider one of these systems – actually, a federation of nine *zanjeras* – in more detail, based on the work of Robert Siy (1982). The Bacarra-Vintar federation of *zanjeras* constructs and maintains a 100-meter-long brush dam that spans the Bacarra-Vintar River, located on the northwestern tip of Luzon Island approximately 500 kilometers north of Manila. The unpredictable and destructive Bacarra-Vintar River drains the northeastern parts of the provinces. During the rainy season each year, the river destroys the federation's dam, which is constructed of bamboo poles, banana leaves, sand, and rock. During some years the dam will be destroyed three or four times.

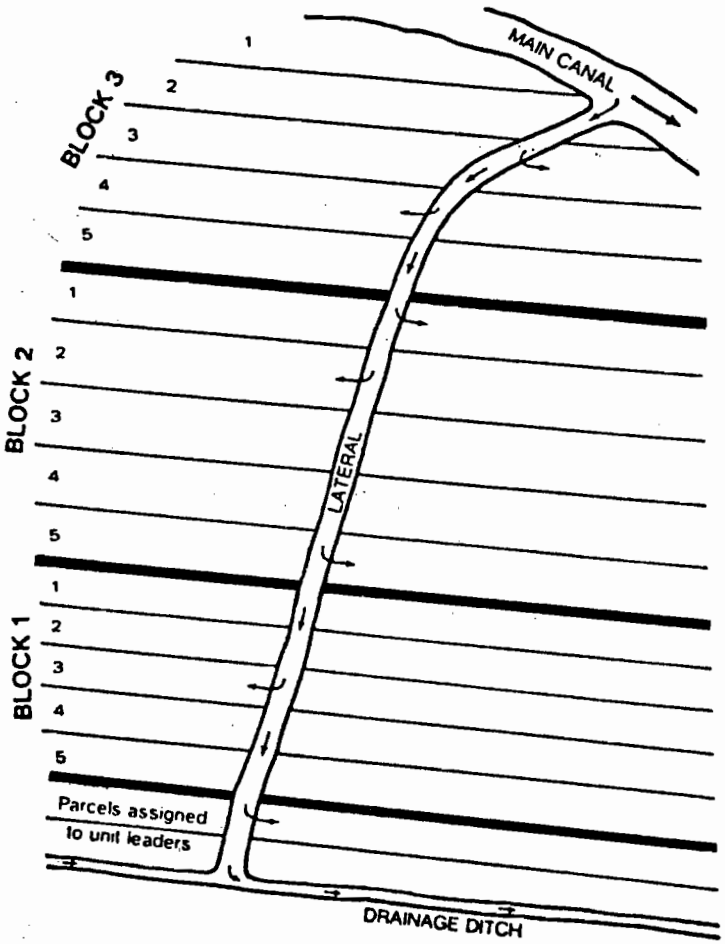

Figure 3.3. Typical layout of *zanjera* fields. (Adapted from Coward 1979.)

The histories of the nine component *zanjeras*, like that of the federation itself, have not been well preserved. What is known is that most of them were established independently and tried to construct and maintain their own diversion works from the river. The river has changed course several times in its history, and at various times some of the *zanjeras* have been cut off from their source of water by such changes. Two of the *zanjeras* were already associated during the nineteenth century and jointly constructed

one dam and canal. A formal agreement dated 1906 was written when a third *zanjera* joined their federation. Other existing systems joined slowly through the 1950s. The last two *zanjeras* entered at the time of their formation (Siy 1982, pp. 67-8).

In 1978 the federation formally incorporated as a private corporation in response to the 1976 Philippine Water Code, which defined only individuals or "juridical persons" as eligible to obtain water rights. Given the history of litigation in the area (M. Cruz, Cornista, and Dayan 1987), members of the federation wanted secure water rights in the name of the federation itself, rather than in the name of individual *zanjeras*. The heads of all the component *zanjeras* form the board of directors, with the *maestro* of the Surgui *zanjera* – one of the founding *zanjeras* – named as the president and chairman of the board. In 1980 there were 431 individuals who owned shares, or parts of shares, in at least one *zanjera*. Many members were involved in more than one of the *zanjeras*. The smallest component *zanjera* had 20 members, and the largest had 73 members (Siy 1982, p. 85). Each *zanjera* is responsible for its own financial and internal affairs and owes no financial obligations to the federation.

The board of directors determines when the dam should be rebuilt or repaired. Rebuilding takes about a week – somewhat more when the weather is unfavorable – and involves several hundred persons. Each *zanjera* is responsible for bringing construction materials and providing work teams (and the cooks and food to feed them). After spending a day preparing banana and bamboo mats, work teams in heavy boats confront the swirling waters to begin pounding in the poles that form the foundation for the dam. Then the mats are woven around the poles and reinforced with sand and rock.

Each of the five *zanjeras* with the largest numbers of *atars* provides one work team. The four smaller associations form two work teams. As the dam is laid out, it is divided, by the use of a "flexible" rod, into seven sections that are roughly proportional to the sizes of the work teams and the difficulty of the terrain. This work assignment pattern allows each group to monitor the progress of other groups and engenders some spirited competition among them. The work of maintaining the main canal is also assigned in a similar manner. Work on distributory canals is organized by each *zanjera*, which has divided itself into smaller work teams called *gunglos*, composed of 5 to 10 members.

Siy computed the total obligations (including work as well as attendance at meetings and celebrations) of *zanjera* members to their own associations and to the federation for 1980. The owner of a full *atar* share of the Santo Rosario *zanjera* was obligated to contribute 86 days during 1980 (the

largest obligation), whereas an owner of a full share in the Nibinib *zanjera* was obligated to contribute 32 days (the lowest). The average across the federation was 53 days (Siy 1982, p. 92). Given that some *atars* are held jointly by several farmers, the average number of days per working member is somewhat less – around 39 days for the year.

In terms of the contemporary schedule of 5 days per week, this amounts to two months of work supplied without direct monetary payment.[30] About 16,000 man-days were supplied by members to their own *zanjera* or federation during the year.[31] As Siy reflects, "there are definitely few rural organizations in the developing world which have been able to regularly mobilize voluntary [*sic*] labor to such extent" (Siy 1982, p. 95).[32] Given the rigorous and at times dangerous nature of the work, the level of attendance at these obligatory sessions is rather amazing.[33] On average, members were absent somewhat over 2 days out of their required 39, making the attendance rate about 94%. Fines assessed for nonattendance were fully paid in five of the *zanjeras*, and only one of the *zanjeras* had a substantial problem with the payment of fines (Siy 1982, p. 98).[34]

Over time, *zanjeras* face the problem of increased fragmentation of the original shares. A founding member with three sons, for example, may bequeath his plots to be distributed evenly among his sons, each of whom then assumes one-third of the obligations that their father had to fulfill (and having access to only one-third of the land). The individual *zanjeras* have responded to fragmentation in several ways. Some *zanjeras* appoint one person to be responsible for the fulfillment of *atar* responsibilities so that the associations do not have to monitor intra-*atar* work contributions or shirking. Some of the *zanjeras* now require prior approval before a share is sold or tenants are allowed to work *zanjera* land.

> Prospective members are "screened," and made to understand the full extent of their obligations to the zanjera before the transaction or tenancy agreement is approved. In a few cases, new members have been required to sign an agreement affirming their recognition of the zanjera's by-laws. These by-laws usually stipulate that erring members may be suspended or expelled from the zanjera, and their lands, confiscated. (Siy 1982, p. 101)

Given the great numbers of the landless population in the area, there is still fierce competition to gain access to land.

Water-allocation rules are not quite as restrictive in these systems as are work-contribution rules. In general, the supply of water to the irrigation system is more than adequate to meet the needs of the farmers, given the current cropping patterns and soil types involved. When water is abundant, water flows throughout the entire system, and anyone can irrigate at will. When water is scarce, rotation systems are established among the *zanjeras*,

and within *zanjeras* among the various distributory canals. During extremely dry periods, downstream *zanjeras* are allowed the full flow of the system for several nights in a row. After notification and agreement, the downstream *zanjera* sends its *gunglos* upstream to set up checks and close turnouts. "Other members 'stand guard' to ensure that such temporary control devices remain in place. Other groups attend to the actual delivery of water to individual parcels" (Siy 1982, p. 122). Precedence is given to parcels with the greatest need, and then a regular rotation system is established.

Several of the downstream *zanjeras* harvest only one crop per year, but two crops are possible in the higher *zanjeras*. Siy presents clear evidence that it would be possible to reallocate water among the nine *zanjeras* so as to increase the productivity of the lower *zanjera* lands without a loss in productivity by the head-end *zanjeras* (Siy 1982, pp. 122–45). On the other hand, the distribution of water is roughly proportional to the contributions of labor and materials and to *atar* shares. Thus, the three *zanjeras* that contribute most of the labor and materials (48%) receive 55% of the water, the three *zanjeras* that contribute 30% of the labor and materials receive 25% of the water, and the three *zanjeras* that contribute 22% of the labor and materials receive 20% of the water.[35]

From the perspective of technical efficiency, the system is not as efficient in its water-allocation scheme as it could be. Siy is, however, extremely careful to point out that many costs besides those of output forgone are involved in designing and running such systems:

> The costs may be in the form of the time and energy expended in deciding on an acceptable arrangement or in adjusting to an externally-imposed procedure. . . . For example, a shift in the distribution of water may necessitate a shift in the distribution of obligations among zanjeras. A zanjera that ends up receiving more water may then be required to contribute a larger proportion of labor and materials for system maintenance in order to satisfy the demands for sharing obligations in proportion to the increased benefits received. However, there is always the danger that the individual zanjera involved may not possess the immediate capability to meet such requirements, and, as such, these new demands on their resources may actually undermine the stability or solidarity of the whole organization. (Siy 1982, p. 146)

The major criterion used by irrigation engineers to evaluate the performance of an irrigation system is whether or not a system is technically efficient in the sense that water is allocated optimally to enhance crop production. The federation falls short in regard to this criterion, but it performs well in regard to mobilization of personnel for construction and maintenance activities. The members of the federation perceive the alloca-

tion of water to conform to legitimate formulas that they have themselves devised, rather than to formulas devised by external experts. As we shall see in Chapter 5, when external experts, working without the participation of the irrigators, have designed systems with the primary aim of achieving technical efficiency, they frequently have failed to achieve either the hoped-for technical efficiency or the level of organized action required to allocate water in a regular fashion or to maintain the physical system itself.

Because many members of the lower *zanjeras* also participate in other *zanjeras*, many own lands that receive adequate or more than adequate quantities of water, thus offsetting those lands that are left dry part of the year. In a survey of *zanjera* members, respondents from the lower *zanjeras* were more likely than members of upstream *zanjeras* to report a lack of water during part of the year. But when asked what major irrigation problems they faced, none "had anything to say about the way water was allocated or about the fairness of water distribution" (Siy 1982, p. 141). The problem cited by 65% of the irrigators surveyed was the hardship associated with the annual damage to their dam.

SIMILARITIES AMONG ENDURING, SELF-GOVERNING CPR INSTITUTIONS

Despite all of the differences among the CPR settings described in this chapter – and substantial differences exist – all share fundamental similarities. One similarity is that all face uncertain and complex environments. In the mountain commons, the location and timing of rainfall cannot be predicted. In the irrigation systems, erratic rainfall is again a major source of uncertainty. Whereas the construction of physical works tends to reduce the level of uncertainty, it tends to increase the level of complexity in these systems. Irrigators must have practical engineering skills as well as farming skills.

In contrast to the uncertainty caused by these environments, the populations in these locations have remained stable over long periods of time. Individuals have shared a past and expect to share a future. It is important for individuals to maintain their reputations as reliable members of the community. These individuals live side by side and farm the same plots year after year. They expect their children and their grandchildren to inherit their land. In other words, their discount rates are low. If costly investments in provision are made at one point in time, the proprietors – or their families – are likely to reap the benefits.

Extensive norms have evolved in all of these settings that narrowly define "proper" behavior. Many of these norms make it feasible for individuals to live in close interdependence on many fronts without excessive conflict. Further, a reputation for keeping promises, honest dealings, and reliability in one arena is a valuable asset. Prudent, long-term self-interest reinforces the acceptance of the norms of proper behavior. None of these situations involves participants who vary greatly in regard to ownership of assets, skills, knowledge, ethnicity, race, or other variables that could strongly divide a group of individuals (R. Johnson and Libecap 1982).

The most notable similarity of all, of course, is the sheer perseverance manifested in these resource systems and institutions. The resource systems clearly meet the criterion of sustainability. The institutions meet Shepsle's (1989b) criterion of institutional robustness, in that the rules have been devised and modified over time according to a set of collective-choice and constitutional-choice rules. These cases were specifically selected because they have endured while others have failed. Now the task is to begin to explain their sustainability and robustness, given how difficult it must have been to achieve this record in such complex, uncertain, and interdependent environments in which individuals have continuously faced substantial incentives to behave opportunistically.

The specific operational rules in these cases differ markedly from one another. Thus, they cannot be the basis for an explanation across settings. In the Japanese mountain commons, for example, appropriation rights and provision duties are assigned to established family units in a village instead of to individuals. In the Swiss mountains, appropriation rights and provision duties are inherited by individual males who own private property in the village and remain citizens of the village. In eastern Spain, a farmer's right to irrigation water is based on the parcel of land inherited, purchased, or leased, not on a relationship to a village. In the Philippines, a complex contract among long-term usufructuary right-holders determines rights and provision duties. The rules defining when, where, and how an individual's allotted resource units can be harvested or how many labor days are required also vary considerably across cases.

Although the particular rules that are used within these various settings cannot provide the basis for an explanation of the institutional robustness and sustainability across these CPRs, part of the explanation that I offer is based on the fact that the particular rules differ. The differences in the particular rules take into account specific attributes of the related physical systems, cultural views of the world, and economic and political relationships that exist in the setting. Without different rules, appropriators could not take advantage of the positive features of a local CPR or avoid potential pitfalls that might be encountered in one setting but not others.

Instead of turning to the specific rules, I turn to a set of seven design

principles that characterize all of these robust CPR institutions, plus an eighth principle used in the larger, more complex cases. These are listed in Table 3.1. By "design principle" I mean an essential element or condition that helps to account for the success of these institutions in sustaining the CPRs and gaining the compliance of generation after generation of appropriators to the rules in use. This list of design principles is still quite speculative. I am not yet willing to argue that these design principles are necessary conditions for achieving institutional robustness in CPR settings. Further theoretical and empirical work is needed before a strong assertion of necessity can be made. I am willing to speculate, however, that after

Table 3.1. *Design principles illustrated by long-enduring CPR institutions*

1. Clearly defined boundaries
   Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself.
2. Congruence between appropriation and provision rules and local conditions
   Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, material, and/or money.
3. Collective-choice arrangements
   Most individuals affected by the operational rules can participate in modifying the operational rules.
4. Monitoring
   Monitors, who actively audit CPR conditions and appropriator behavior, are accountable to the appropriators or are the appropriators.
5. Graduated sanctions
   Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, by officials accountable to these appropriators, or by both.
6. Conflict-resolution mechanisms
   Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.
7. Minimal recognition of rights to organize
   The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

For CPRs that are parts of larger systems:

8. Nested enterprises
   Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

further scholarly work is completed, it will be possible to identify a set of necessary design principles and that such a set will contain the core of what has been identified here.[36]

For these design principles to constitute a credible explanation for the persistence of these CPRs and their related institutions, I need to show that they can affect incentives in such a way that appropriators will be willing to commit themselves to conform to operational rules devised in such systems, to monitor each other's conformance, and to replicate the CPR institutions across generational boundaries. I shall discuss each of the design principles in turn.

Clearly defined boundaries

1 Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself.

Defining the boundaries of the CPR and specifying those authorized to use it can be thought of as a first step in organizing for collective action. So long as the boundaries of the resource and/or the specification of individuals who can use the resource remain uncertain, no one knows what is being managed or for whom. Without defining the boundaries of the CPR and closing it to "outsiders," local appropriators face the risk that any benefits they produce by their efforts will be reaped by others who have not contributed to those efforts. At the least, those who invest in the CPR may not receive as high a return as they expected. At the worst, the actions of others could destroy the resource itself. Thus, for any appropriators to have a minimal interest in coordinating patterns of appropriation and provision, some set of appropriators must be able to exclude others from access and appropriation rights. If there are substantial numbers of potential appropriators and the demand for the resource units is high, the destructive potential should all be allowed to freely withdraw units from the CPR could push the discount rate used by appropriators toward 100%. The higher the discount rate, the closer the situation is to that of a one-shot dilemma in which the dominant strategy of all participants is to overuse the CPR.

Since the work of Ciriacy-Wantrup and Bishop (1975), the presence of boundaries concerning who is allowed to appropriate from the CPR has been used as the single defining characteristic of "common-property" institutions as contrasted to "open-access" institutions. The impression is sometimes given that this is all that is necessary to achieve successful