district has maintained only a skeletal staff (an executive director and a secretary), rather than employing its own engineering staff. The county cannot exert full monopoly power in its supply of replenishment services, because the replenishment district has access to several other potential suppliers and could always create its own staff to undertake the replenishment activities.[42] At one point when the replenishment district was particularly unhappy with the progress of some construction work undertaken by the county, the replenishment district was able to use its bargaining power to insist that a portion of the design for one of the barriers be contracted out to a private firm.

The watermaster service of the California Department of Water Resources performs an essential service for the replenishment district and the producers by monitoring the extractions by producers. Two-thirds of the cost of this service is paid for by the producers. If these costs become too high, the producers can petition the court to assign some other agency – public or private – to be their watermaster.[43] The replenishment district and the watermaster service have entered into cooperative agreements to reduce duplication in their activities. Records of withdrawals submitted by groundwater users to the replenishment district as the basis for taxation are also made available to the watermaster. Instead of relying strictly on hierarchical relations, as within a single firm, the management system is governed by negotiation and bargaining processes among many different actors in several different arenas. Strict majority-rule procedures are rarely used in any of the decision arenas governing this system.

In addition to the public districts, private water associations remain active in each of the basins. Public officials are asked to make frequent reports to the regular meetings of the water associations. The water engineers of the private and municipal agencies who attend these meetings tend to ask tough questions and want reasoned answers. They have access to independent information about conditions and are not satisfied by stylized responses that provide little information. Many of the individuals who are elected to office in the public districts have been active in the water associations for many years. Their tenure in public office tends to be long, and normally they are active in one or another public or private role for a quarter of a century.

This brief sketch of the patterns of relationships among public enterprises illustrates how a governance system can evolve to remain largely *in* the public sector without being a central regulator. Aspects of both private and governmental activities are involved in all of these basins. Some scholars have characterized the assignment of well-defined rights to the flow of a

CPR as "privatization." Given that the water rights held by water producers are now entirely separable from land and are well defined, a market for water rights has evolved in each of these basins, and rights are actively transferred. But that is only part of the story. No one "owns" the basins themselves. The basins are managed by a *polycentric set* of limited-purpose governmental enterprises whose governance includes active participation by private water companies and voluntary producer associations. This system is neither centrally owned nor centrally regulated.

Although the solution to the problems facing these groundwater producers did not involve either a central regulator or a private-property system, it did involve creating an institutional arrangement that incorporates the full set of design principles discussed in Chapter 3. Well-defined boundaries were achieved through litigation. Viewing this set of institutions together,[44] it can be seen that congruence between appropriation and provision rules and local conditions has been achieved. Collective-choice arrangements are provided by the voluntary associations and by the special districts so that most pumpers can actively participate in the modification of rules as needed. The court-appointed watermaster has considerable monitoring powers and issues annual reports that give all participants accurate information about rule compliance and water conditions. The informal sanctions that have been utilized to encourage rule conformance have, in the main, been modest. Formal sanctions are available for use if they are needed. The continuing jurisdiction of the court and the regular meetings of the voluntary water associations provide conflict-resolution mechanisms. The legal structure of the state of California recognizes the rights of pumpers and others to organize, and the organization units are nested within larger units. Given the stability that these institutions have demonstrated thus far, and their conformance with these design principles, I believe that these CPR institutions are robust and will survive for a long time to come.

THE ANALYSIS OF INSTITUTIONAL SUPPLY

In this chapter I have described several efforts to solve second-order collective dilemmas. A pumping race is the first-order dilemma facing pumpers from a groundwater basin where legal rights to withdraw water are not limited. Each pumper has a dominant strategy to pump as much water as is privately profitable and to ignore the long-term consequences on water levels and quality. The experience in all of these groundwater basins illustrates how a pumping race can continue for many years, even though water levels fall (raising everyone's costs of lifting water) and salt water intrudes

(threatening the long-run survival of the basin itself). Overdraft conditions continued for several decades in these basins. The best explanation for the actions and outcomes during that period is that individuals caught in a pumping race will select their dominant strategy to pump as much as is privately profitable and ignore the consequence for themselves and others.

Given the initial empirical support for this prediction, it is easy to see why theorists would also predict that individuals caught in such situations would refrain from investing resources in designing, negotiating, and supplying new institutions. If pumpers will not limit their groundwater production, why should they invest in the provision of new institutions? The effort to supply institutions is described as simply a second-order dilemma that is no more solvable than the first-order dilemma. The prediction that appropriators will not expend resources to supply new institutions is, however, not supported by these case studies.

These groundwater pumpers invested heavily in the supply of institutions. They created new private associations. They paid for costly litigation to allocate water rights. They drafted legislation, had it introduced to the state legislature, and gained sufficient support from other water enterprises to get the legislation passed. They created special districts to tax all the water they withdrew from the basins, as well as the property overlying the area. They spent seemingly endless hours informing themselves about the structures of their basins, the various concerns and intentions of all parties, and future possibilities.

Incremental, sequential, and self-transforming institutional change in a facilitative political regime

The substantial investments that these groundwater pumpers made in providing new institutions occurred in an incremental and sequential process in the state of California – a home-rule state – where many statewide institutional facilities are provided to reduce the costs of local institutional supply. The investment in institutional change was not made in a single step. Rather, the process of institutional change in all basins involved many small steps that had low initial costs. Rarely was it necessary for participants to move simultaneously without knowing what others were doing. Because the process was incremental and sequential and early successes were achieved, intermediate benefits from the initial investments were realized before anyone needed to make larger investments. Each institutional change transformed the structure of incentives within which future strategic decisions would be made.

Further, because the appropriators from several neighboring basins were

all involved in similar problems, participants in one setting could learn from the experiences of those in similar settings. Sufficient overlap existed among participants across basins to ensure communication about results. Interbasin coordinating arenas were created at several junctures to enhance the ability to exchange information about agreements reached within and across basin boundaries.[45]

In each basin, a voluntary association was established to provide a forum for face-to-face discussions about joint problems and potential joint strategies. Given the uncertain legal structure, attorneys advising water companies and public utilities had consistently advised their clients to pump as much water as they could profitably use and worry about defending their water rights later. The provision of a forum for discussion transformed the structure of the situation from one in which decisions were made independently without knowing what others were doing to a situation in which individuals discussed their options with one another. Discussion by itself was not sufficient to change the pumping strategies of the participants, but discussion did lead to the initiation of litigation, which enabled the participants to reach an enforceable agreement to limit their water withdrawals.

Further, the voluntary associations provided a mechanism for obtaining information about the physical structure of the basins to be made available to all pumpers simultaneously. Prior to that investment in information, no one had a clear picture of the boundaries, demand patterns, and water levels throughout a basin. One knew only that the water levels in one's own wells were falling. No one knew the extent of saltwater intrusion or the total quantity of water withdrawn from the basin. The private associations provided a mechanism for sharing the costs and the results of expensive technical studies. By voluntarily sharing the costs of providing information – a public good – participants learned that it was possible to accomplish some joint objectives by voluntary, cooperative action. The membership dues for the associations were modest and were allocated in rough proportion to the amount of water an enterprise withdrew from a basin.[46] By spending time to attend meetings, members gained considerable information about the condition of their basins and the likelihood that others would commit themselves to follow different strategies in the future.

Whereas the voluntary associations provide a mechanism for sharing costs, the state of California provides facilities that help reduce the level of those costs. Maintaining a court system in which individuals have standing to initiate litigation in order to develop firm and transferable rights to a defined quantity of water is one such contribution. The state of California goes even further and subsidizes one-third of the cost of such litigation in

order to encourage full exploitation of water resources and settle disputes over water rights when necessary. The Department of Water Resources has provided technical assistance throughout the period, as has the U.S. Geological Survey.

The general home-rule tradition that is built into the state constitution and legislative practices in the state also helps reduce the costs of transforming existing rule systems. It is relatively easy for a group of individuals to introduce new organic legislation authorizing a new type of special district, but state legislators will rarely support such proposed legislation when there is substantial opposition to it in the state. But when individuals in one area have discussed such proposals with others who are likely to be affected, organic laws frequently are passed with close to unanimous support.

In other words, the rules for engaging in microconstitutional choice related to the control of groundwater have encouraged investments in self-organization and the supply of local institutions. A similar set of individuals facing similar problems in an entirely different type of political regime might not be able to supply themselves with transformed microinstitutions. The difference between an active effort by a central government to regulate appropriation and provision activities and an effort to provide arenas and rules for microinstitutional change is frequently blurred.

Reformulating the analysis of institutional change

Trying to understand the incremental, sequential, and self-transforming process of institutional change in these groundwater basins leads me to suggest that institutional analysts should reconsider the ways in which they conceptualize the problem of supplying institutions. Such a formulation should involve several subtle but important changes in the way analysts think about institutional rules, their origin, and their changes. An important step is to assume that all recurring situations are shaped by a set of institutional rules. Institutional rules are prescriptive statements that forbid, require, or permit some action or outcome (E. Ostrom 1986a). One of the three deontic operators – forbid, require, permit – must be contained in a statement for it to be considered a rule.[47] All three deontic operators are used in this definition of rules.[48]

Some analysts limit their conception of rules to prescriptive statements containing only required or forbidden actions and outcomes.[49] With that limited conception, some recurring situations are rule-governed, and others are not. By including all three deontic operators in a definition of a rule, it is always possible to identify the set of rules that constitute a situation.

One needs to ask only two questions concerning the actions and outcomes of relevance to this situation: (1) Is this action or outcome (or its negation) required? (2) Is this action or outcome (or its negation) forbidden? Any action or outcome (or its negation) that is not required nor forbidden is permitted. Consequently, the absence of a rule forbidding or requiring an action is logically equivalent to the presence of a rule that permits an action. Hobbes's state of nature is a situation in which no rules requiring or forbidding any actions or outcomes are present. The Hobbesian state of nature is logically equivalent to a situation in which rules exist permitting anyone to take any and all desired actions, regardless of the effects on others.

Usually it is possible to answer the two foregoing questions regarding any recurring situation that is sufficiently structured that one can analyze it. Consequently, for any such situation, one can identify a set of status quo rules related to the situation. Status quo rules continue in effect until changed. The status quo rules in a Hobbesian situation can be viewed as a set of default rules by which everything is permitted (Gardner and E. Ostrom 1990). Similarly, a CPR situation in which no one is forbidden or required to take any action is logically equivalent to a CPR situation in which everyone is permitted to take any and all actions. The rules governing such a situation are all default rules.

Once one assumes that all recurring situations are characterized by a set of status quo rules, then it is possible to broaden the concept of institutional supply to include both what can be called the "origin" of new institutions and the changing of existing institutions. The origins of institutions and changes in institutions frequently are considered to be fundamentally different.[50] In this view, origin is characterized as a situation in which individuals move from having no rules to having a set of rules. In such a view, the origin of institutions is thought of as a major, one-step transformation, whereas institutional change is viewed as involving incremental changes in existing rules.[51] Supplying new institutions is consequently viewed as nonincremental and costly, whereas changing existing institutions is viewed as incremental and not as costly.

Both origins and changes in institutions can be analyzed using the same theory when both are viewed as alterations of at least one status quo rule.[52] A change in any rule affecting the set of participants, the set of strategies available to participants, the control they have over outcomes, the information they have, or the payoffs (E. Ostrom 1986a) is an institutional change. The costs of changing the rules vary substantially from one rule to another, from one political regime to another, and from one level of analysis to another, and they also vary over time as participants and conditions

change. Whether or not it will be costly to achieve any institutional change will depend on many variables (to be discussed in Chapter 6), not simply on whether or not a new institutional arrangement is being created.

The creation of a new institutional arrangement can sometimes be quite easy and involve little cost. In the cases discussed earlier, for example, creating new voluntary associations to discuss common problems did not involve major investments by any of the participants. On the other hand, creating the Central and West Basin Water Replenishment District involved major investments in time and money. Transforming existing rules can also be very costly. Changing the water rights for overlying and appropriative water producers, for example, involved many years of costly litigation. All of these rule changes were crucial aspects of the process of institutional supply in these cases. Each built on the base of prior rules. That some rule changes could be undertaken with low transformation costs enabled the participants to gain some advantages of collective action before they were faced with more costly alternatives. All of these transformation costs are affected by the surrounding political regime. After several decades of institutional change, the resulting institutional infrastructure that had been created represented a major investment that dramatically changed the incentives and behaviors of participants and the resulting outcomes. Each institutional change became the foundation for the next change.

What is presumed to be a second-order dilemma, in which institutional change is viewed as one large step, may or may not have the structure of a dilemma when institutional change is viewed as a sequential and incremental process. The net payoffs of solving a small part of a large second- or third-order problem may be sufficiently high and distributed in such a manner that some participants will voluntarily provide initial second-order collective benefits, whereas they are unwilling to provide first-order solutions on their own. Solving some initial second-and third-order problems can help participants move toward solving first-order problems, as well as the more difficult second- and third-order problems.

With these conceptual revisions, it is possible to move toward the development of a single theory of institutional change, rather than one theory about origins and another theory about reform. Both constitutional-choice and collective-choice processes produce rules affecting the behavior of actors in linked situations (see Figure 2.2). Both constitutional-choice and collective-choice processes are themselves structured by rules. In a constitutional-choice situation, individuals decide whether or not to change a set of status quo rules that determine who is eligible and how future collective-choice decisions are to be made. Similarly, in a collective-choice situation, individuals decide whether or not to change a set of status quo

rules that determine who is eligible and how future operational choices are to be made.

The outcome of a collective-choice process frequently is conceptualized as a "policy space," leaving unspecified what is contained in that policy space. When a budget is to be determined in a collective-choice arena, the policy space can be thought of as a set of rules concerning who is required, forbidden, or allowed to spend how much money for what purpose during what time frame. When a regulation is to be determined, the policy space can be thought of as a set of rules concerning who is required, forbidden, or allowed to take what action or affect what outcomes related to a specific domain.

In both processes, individuals compare the net flows of expected benefits and costs to be produced by the set of status quo rules, as compared with an altered set of rules. To explain institutional change, it is therefore necessary to examine how those participating in the arenas in which rule changes are proposed will view and weight the net return of staying with the status quo rules versus some type of change. In Chapter 6, I shall develop these ideas further and present the rudiments of a theory of institutional change applicable to the changing of rules that structure collective-choice or operational-choice situations. Before I do that, however, it is important to examine the failure cases discussed in Chapter 5 so that these conjectures can also build on information from situations in which participants were not successful in changing their institutions.

5

Analyzing institutional failures and fragilities

The empirical cases presented so far have been success stories. Given the presumption of failure that characterizes so much of the policy literature, it is important to present examples of success. Now the time has come to examine several cases of outright failure and cases in which the institutions designed by appropriators are in a fragile condition.

Near Alanya, Turkey, where fishers were able to establish their own set of rules for regulating inshore fisheries, there are two other fishing areas whose fishers have failed to establish effective rule systems – Bodrum and the Bay of Izmir. Both suffer severe problems of overcrowding and rent dissipation. In San Bernardino County, California, groundwater pumpers are still facing overdraft conditions even after they initiated litigation and created a special district. The institutional arrangements described in Chapter 4 that helped nearby basins solve CPR problems did not work as effectively when applied to a region rather than to a basin.

In another part of the world, Sri Lankan fishers, who had devised an ingenious system for rotating access to an inshore fishery, found themselves unable to enforce an additional rule to prevent the entry of new appropriators. The rotation system continues to spread the risk involved in an uncertain environment across all participants. With too many appropriators, however, the profits obtained by local fishers have steadily declined as rents have been dissipated.[1]

In the interior of Sri Lanka, central-government authorities and donor countries have invested large sums in the reconstruction of major irrigation systems. To work successfully, these systems need the active cooperation of the farmers to schedule and manage water use so as to minimize wastage. National officials have altered the administrative structures of these systems several times without succeeding in obtaining farmer cooperation in

implementing rules to allocate water to minimize overuse. The Sri Lankan experience with the reluctance of farmers to invest time and effort to enhance the productivity of a centrally managed system has been repeated in many diverse forms throughout South and Southeast Asia. In some cases, centralized efforts to reform the structure of a system have led to worse problems. However, an experimental project to organize farmers from the ground up, without an organizational blueprint, has produced a reversal of that problem in one large Sri Lankan irrigation system.

The last case to be considered, not yet a failure, is an instance of locally developed rules to regulate access and use of an inshore fishery, but they are not recognized as legitimate or effective by national authorities. In both Nova Scotia and Newfoundland, many local villages have devised their own rules to determine who can use local fisheries and how resources are to be harvested. Recently, the Canadian national government has taken a more active role in fishery regulation along its eastern coast. The national government is attempting to develop uniform policies for the entire coast. There are, however, two quite different types of fisheries on this coast: (1) the deep-sea fisheries, which are open-access CPRs, and (2) the inshore fisheries, in which local fishers have established informal rules controlling access and use. The need for a large-scale governmental agency that can restrict access to the deep-sea fishery is well established. But the unwillingness of the national authorities to develop a nested system of rules, drawing on the experience of many generations of fishers who intimately know their own fisheries, may destroy one set of effective CPR institutions without necessarily developing effective alternatives.

TWO TURKISH INSHORE FISHERIES WITH CONTINUING CPR PROBLEMS

Bodrum is located about 400 kilometers west of Alanya on the Aegean Sea. The number of fishers appropriating from the Bodrum fishery is substantially larger than the number of fishers in Alanya. In the Bodrum fishery in 1983, there were 100 small boats with inboard power, 11 trawlers, 2 purse seiners, and 9 bottom seiners, operated by approximately 400 fishers (Berkes 1986b, p. 68). Until the 1970s, Bodrum had been the site of a successful inshore fishery. Fikret Berkes reports that in the 1970s the government of Turkey had encouraged some Bodrum fishers to construct larger trawling vessels and "had rarely enforced the three-mile limit, much to the anger of the small fishermen" (Berkes 1986b, p. 79).[2]

The early financial success of the trawlers lured others to enter the local fishery, until the revenues from the fleet as a whole were less than the costs

of fishing in the area. As Berkes indicates, Bodrum was a "textbook example of rent dissipation in a fishery" (1986b, p. 79). Although the total annual yield of fish remained approximately the same, the catch per unit of effort sharply declined. The larger vessels operating out of Bodrum could no longer make a living there and began to travel to the shrimp grounds near Mersin. A booming tourist trade lured many part-time fishers and charter fishing boats into the fishery.

A local fishing cooperative struggled unsuccessfully during the 1970s to mediate the conflicts among the small-boat fishers, the new entrants, and the trawlers. That cooperative had disappeared by 1983. Six groups of fishers with distinct interests now compete to appropriate from the same fishery:

> (1) small-scale coastal fishermen, (2) larger-scale operators including trawlers and beachseiners, (3) semiprofessionals who obtain their own fish and sell the occasional surplus, (4) large numbers of unskilled sport fishermen, (5) spear-fishermen licensed as sponge fishermen but who sell fish on the open market, and (6) charter boat operators who fish to feed their clients and occasionally sell the surplus.
> (Berkes, 1986b, p. 74)

A similar problem exists in the larger fishery of the Bay of Izmir, located farther north on the Aegean coast. In 1983, 1,800 fishers lived in the area and used 700 small boats with inboard power, 30 bottom seiners, and 27 purse seiners. The subgroup structure seen in Bodrum is similar to that in Izmir, where it is complicated by the fact that Izmir is a large urban center (a metropolitan area with a population of over 1 million) with a high demand for fresh fish. The result is an overcapitalized fishery, with too many fishers chasing too few fish.

The trawlers were not the problem in Izmir. It is difficult for trawlers to operate in such a crowded environment, and the Turkish coast guard actively patrols a major harbor. This CPR problem has been produced by a number of factors: the opportunities for quick economic gain, the large number of fishers, the internal division of the fishers into distinct subgroups with conflicting interests, and the lack of an overarching institutional mechanism in which local rules and conflict-resolution mechanisms could be designed. Two large fishing cooperatives are based at Izmir, but they represent distinct subgroups of fishers. Several other fishing cooperatives operate nearby, but also represent distinct subgroups. Each group had conflicts "with at least one other group, and in some instances, with more than one." Consequently, there were "no operational rules in place to allocate the fish, to reduce the conflicts, or to limit crowding" (Berkes 1986b, p. 75).

The general institutional setting within Turkey could be called "benign

neglect." National legislation required fishers to be licensed, but did not limit the number of licenses. Restrictions were placed on fishing during the spawning season and on the equipment that could be used. An effort had been made to segregate inshore fisheries from offshore fisheries by forbidding trawlers to fish within a three-mile offshore zone and within bays. The agency responsible for fishery rules (the Ministry of Agriculture) employed no agents to enforce those rules. The coast guard, the rural police, and the Ministry of the Interior were supposed to enforce the rules. Nonenforcement of the three-mile zone (other than in the large bays) and the financing and encouragement of new trawlers were thus sources of the failure in Bodrum.

The failure of the fishers in the Bay of Izmir and Bodrum to organize themselves to prevent rent dissipation cannot be attributed to a single cause. Internally, these were large groups that were characterized by severe heterogeneity of interests and of relevant time horizons. Given the different technologies in use, any rules that were defined to limit use would tend to benefit one subgroup over another, rather than benefit all in a similar manner. The costs of overcoming size differences and heterogeneity are substantial. In a political regime that does not provide arenas in which low-cost, enforceable agreements can be reached, it is very difficult to meet the potentially high costs of self-organization.

CALIFORNIA GROUNDWATER BASINS WITH CONTINUING CPR PROBLEMS

Although the groundwater pumpers in most of southern California have resolved their conflicts over limited water supplies and have protected their groundwater basins against continuing overdraft conditions, that experience has not been universal. The groundwater basins located in San Bernardino County, northeast of the basins described in Chapter 4, continue in overdraft condition, even though efforts have been made to allocate water rights through litigation and the creation of water districts. Why is it that individuals who have adopted strategies of institutional change that appear to be quite similar to those described in Chapter 4 have not succeeded in devising a workable set of institutional arrangements to manage their basins?

Obvious differences have to do with size and complexity. San Bernardino is the largest county in the United States, and there are nine states that are not as large as San Bernardino County. The combined areas of New Jersey, Hawaii, Connecticut, Delaware, and Rhode Island would fit into this one county (Blomquist 1989, p. 2). Approximately 83% of the county

is part of the Mojave Desert. Fifteen different groundwater basins – some interconnected and some totally independent – underlie the area. Some of these basins are fed by the Mojave River, which flows largely underground through a substantial portion of the county. Other basins are replenished only by local precipitation. The region was sparsely populated before World War II, but its population has grown dramatically in the postwar era.

Overdraft conditions were reported in some of the basins during the 1950s. During the late 1950s, the California Department of Water Resources began to plan the Feather River Project to bring water from the water-rich northern region of the state to the water-poor southern region. Areas desiring this water were encouraged to form water agencies in order to contract with the state for future deliveries of this water. The Mojave Water Agency was created, first by state law, and then by a special election in 1960, in order to levy a land tax to pay its share of the capital costs of constructing the aqueduct. After helping to pay for construction of the aqueduct, residents living in the area served by the Mojave Water Agency would eventually be able to claim 50,800 acre-feet of imported surface water per year, provided they paid for the marginal costs of a delivery system and the water itself

Some of those who had been involved in establishing the Mojave Water Agency thought of it as a water wholesaler, similar to the Metropolitan Water District of Southern California, and as an insurance strategy for a growing area that lacked a local water supply. As a wholesaler, the agency could play an important role in obtaining water for the region, but not in managing the many hydrologic subareas of this vast terrain. As an insurance strategy, the primary activity of the agency would be to collect taxes to ensure that the area would eventually be entitled to a flow of imported water. If that view had predominated, the next steps after the creation of the Mojave Water Agency would have been the development of a diversity of smaller-scale private and public enterprises to resolve water-rights issues, devise management plans within subareas, and develop a polycentric system similar to the one that emerged in Los Angeles County.

Others saw the agency as the primary water-management institution for the entire area. That group included most of the officials who were initially elected to serve on the agency's council. Within a short time of its formation, the agency hired a distinguished water-rights attorney, James Krieger, who had been involved in the West Basin and Central Basin litigations, to initiate legal action to settle water rights for the entire region. In 1966, when litigation was initiated in the Superior Court of San Bernardino County, no consensus had developed concerning several key issues:

1 Could the region best be described as one region with a single underground river, as a series of interconnected groundwater basins, or as some combination of a river system, interconnected groundwater basins, and independent groundwater basins?
2 Were all parts of the region, or only localized areas, suffering from overdraft problems?
3 Should all groundwater pumpers be treated as coequal in status, or did some pumpers have prior rights that should be given preferential treatment?
4 Should an administrative settlement be worked out by the agency staff working primarily with the larger pumpers, most of whom were located in the upper reaches of the area, or should it involve the vast number of small pumpers, most of whom were located in the lower portions of the area?
5 Should water rights be separated from land ownership in a region that had not yet been developed?

Coherent arguments could be advanced for the opposing positions on each of these issues. Krieger and the staff members of the Mojave Water Agency, however, approached the situation as if there were only one legitimate answer to each of those questions. They viewed the entire region as if it were a single underground basin with a well-documented history of overdraft conditions. They treated all groundwater pumpers as having coequal rights and attempted to reach a stipulated settlement – to separate water rights from the land as rapidly as possible – with those who had been pumping 500 acre-feet or more per year. Their view of the issues, however, was not widely shared. In 1964, for example, the California Department of Water Resources published a report that denied the existence of overdraft conditions in two of the large subbasins included within the region under adjudication. On the other hand, the Mojave Water Agency had declared in the same year that overdraft of the Mojave River basins was an "unquestionable fact" (Blomquist 1989, pp. 63, 113).

No voluntary water associations were created to facilitate discussion of these issues, and no consensus emerged over time about any of them. Conflicts emerged between the large and small water pumpers, between advocates for development and advocates for no-growth policies, between industry and agriculture, between locals and "external experts," and between appointed personnel and elected officials. The lack of fundamental agreement led to acrimonious political conflict, including several recall elections, front-page stories in the local papers that pushed aside stories on the Watergate scandal, and finally the suspension of the litigation in 1974

(Blomquist 1989, pp. 57–77). No action has since been taken to limit groundwater pumping.

During the past decade the region has undergone massive development, and overdraft conditions have now been documented by all agencies. No one has yet found an effective means for resolving the problem of water-rights allocation or even the problem of purchasing surface-water supplies. The 50,800 acre-feet of Feather River water to which the Mojave Water Agency is entitled flows by each year to be used by others in the southern California region who have organized themselves to purchase water for immediate use or to store as part of a groundwater-management plan. No one has yet found an acceptable plan for building a distribution system and a means of financing that would enable residents of this area to pay for the marginal costs of obtaining the water to which they have an entitlement.

Attempts to solve the difficult problems of this large and complex region primarily on a regional scale using one instrumentality did not enable those involved to devise effective institutional arrangements to address the diverse problems they faced. Unlike the larger-scale fisheries in Bodrum and the Bay of Izmir, individuals in the Mojave area were able to initiate major changes in institutional arrangements. The changes they made, however, did not give them effective tools for dealing simultaneously with the diversity of problems involved. Even when individuals have considerable capabilities to engage in self-governance, there is no guarantee that solutions to all problems will be achieved. Individuals who do not have similar images of the problems they face, who do not work out mechanisms to disaggregate complex problems into subparts, and who do not recognize the legitimacy of diverse interests are unlikely to solve their problems even when the institutional means to do so are available to them.[3]

A SRI LANKAN FISHERY

At the southern tip of Sri Lanka lies the fishing village of Mawelle, as described by Paul Alexander (1977, 1982). Approximately 300 Sinhalese fishers live in the village and engage in three distinct types of fishing technologies: (1) large beach seines used to catch shoals of anchovies and similar species, (2) small traditional craft that use "bible" nets and fishing lines to obtain anchovies, squid, and rockfish, and (3) deep-sea fishing for tuna off the continental shelf. Most of the fishers in Mawelle come from the Karave caste[4] and are beach-seiners. We shall focus on this aspect of the local fishery.

Beach seines (called *madella* or "big net") are half-mile-long nets that may harvest a ton of fish at one time during the prime period when many

fish are available. The peak period occurs sometime during September or October and can constitute as much as one-third of the catch for an entire year (Alexander 1982, p. 134). A beach seine lasts for about five years before it must be replaced, at a cost of about three times the average household's annual income. Beach seines can be used only on beaches with relatively hard sand. On the Mawelle beach, there is room for only two nets to be used simultaneously. If the Mawelle fishers owned only 20 to 30 nets, they could make optimal use of most of their nets;[5] however, they own 100 beach seines, and the average net was in use only seven times during 1971 – strong evidence of severe overcapitalization.

Mawelle is another classic case of rent dissipation. This case has, however, an important twist. Whereas the fishers in Bodrum and the Bay of Izmir were unable to develop any effective rules to limit entry or the use of their local fishery, the fishers in Mawelle had devised quite elaborate rules regulating access to the beach and the use of the beach seines, but they were not able to sustain an entry rule controlling the number of nets to be used. When some of the fishers tried to get officials to enforce a provision in the national legislation that limited the number of nets to be used, others were able to convince national public officials not to enforce that provision. But before we discuss this problem concerning the enforcement of entry rules, let us examine the system of appropriation rules that Mawelle fishers had devised.

The appropriation rules in operation in Mawelle involve naming all the nets and placing them into a sequence. Each net owner is aware of the sequence of nets immediately preceding and following his net. The beach is divided into two launching sites, one on the harbor side and one on the rock side (Figure 5.1). A net may first be deployed on the harbor side anytime during the day after the net preceding it has been used. As illustrated on Table 5.1, once a net has worked its way up in the sequence so as to have had a dawn run on the harbor side, the net is next eligible for the dawn run on the rock side. "Subsequently, it may be used on the rock side at any time of the day once the net immediately following it in the sequence has been used" (Alexander 1982, p. 145).

The Mawelle fishers provide a coherent explanation for why they use this complex set of authority rules, rather than a simple rotation system, to equalize the opportunity to make a big catch. Four environmental or technological considerations affect the problem of equalizing access: (1) The harbor side produces the really big catches, but the rock side is more consistently productive when there are fewer fish. (2) The first catch of the morning is most likely to be the biggest catch of the day, and prices are highest in the morning. (3) The weather affects the number of hauls that

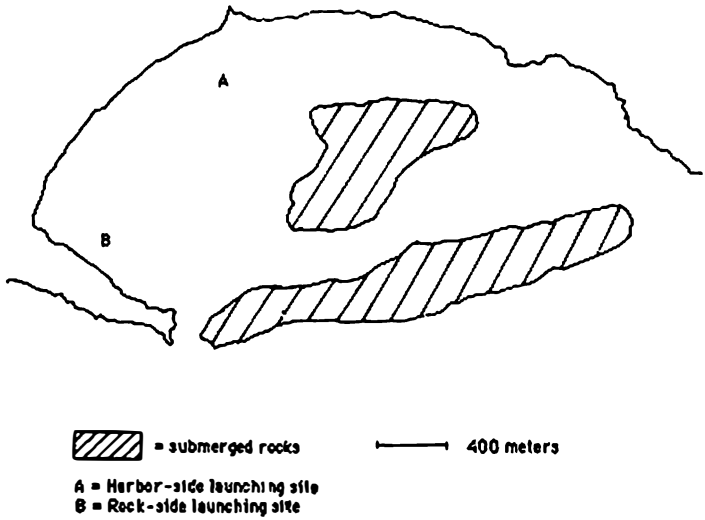


Figure 5.1. Harbor at Mawelle. (Adapted from Alexander 1982, p. 17.)

Table 5.1. *Net sequencing at Mawelle*

	Harbor side				Rock side			
Day of week	Dawn →				Dawn →			
Monday	B	C	D	E	A	Z	Y	X
Tuesday	C	D	E	F	B	A	Z	Y
Wednesday	D	E	F	G	C	B	A	Z
Thursday	E	F	G	H	D	C	B	A
Friday	F	G	H	I	E	D	C	B

Note: This is a stylized representation of how the first four nets (using letters of the alphabet to symbolize a net) would be launched daily at each site, based on Table 7.1 of Alexander (1982). In practice, the number of nets in use varies from day to day, and the same number of nets may not be launched from both sites.

can be made in a day, and any system assigning a set hour of the day would be inefficient. (4) Beach-seining involves high labor inputs to prepare a net for use and to restack it afterward, and simple rotation systems allowing all nets to be used only once per rotation would involve higher labor costs (Alexander 1982, p. 146).

Disputes about this sequencing are rare, except when the rules themselves are challenged, as described later. During the two years that Alexander spent in Mawelle, he never observed a dispute about the sequence in which nets would be beached. The absence of conflict over the authority rules in the fishery contrasts sharply with that society's high levels of violence, in Mawelle as well as similar fishing villages. During Alexander's stay, "three men were murdered and seventeen other assaults resulted in serious injuries" (Alexander 1982, p. 8).

The rotation system evolved in an era in which the number of nets varied around 20. With that number of nets, the system produced relatively equal and profitable incomes for all net owners. Because nets were so expensive and because at least eight men were needed to haul in a net, a net was divided into eight ownership shares. Until recent times, each owner did his share of the work, and they divided the value of the net's haul equally. Shares were bought and sold among village residents:

> Shares may be freely bought, sold, and used as security for various forms of mortgage. In former years they were often the most valuable item inherited, and, less frequently, were included in dowry payments. Although shares are freely transferable, in the sense that the other shareholders in the net do not have a legal veto over a prospective sale, the other shareholders do have a strong practical veto. Shareholders must work closely together and few men would buy a share in a net where the other shareholders strongly objected to the sale.
>
> (Alexander 1982, p. 143)

Until the late 1930s, fishing in Mawelle was largely for subsistence and to produce dried fish for a winter market. The returns from selling dried fish were relatively low. But demographic pressure, market opportunities, and the relationship between internal rules and external rules together changed that situation markedly.

The population of Mawelle grew by 70% between 1901 and 1931, with a disproportionate amount of the growth occurring among beach-seining families (Alexander 1982, p. 204). That disproportionate growth was due to an earlier labor shortage that had led the heads of beach-seining families to encourage their sons-in-law to live in Mawelle and invest in one of the eight shares of a family net. By 1931, the second generation of this in-migration began to marry and wanted access to the harvest. Given that access was tied to the eight-share system, sons had great motivation to

attempt to acquire a share in a new net. Alexander illustrates the logic of the situation clearly:

> If there are twenty nets, a man with one share will receive 1/160th of the annual catch. But if after his death his two sons take joint ownership of his share, they each receive only 1/320th of the catch, whereas if one joins in the construction of a new net they each receive 1/168th. (Alexander 1982, p. 204)

In 1933, legislation was enacted requiring the registration of beach-seines throughout the country. Along the southern coast, where share systems were the dominant forms of ownership, the "government limited the number of nets at any site to those in use in 1933 and codified the criteria for allocating access to the water" (Alexander 1982, p. 206). Thirty-two nets were registered in 1933. The registry reveals that almost all fishers owned a single share in one net. The legislation allowed individuals who did not inherit access rights to the fishery to purchase shares in established nets. That opened access to the fishery to persons outside the limited number of families that previously had shared access to the use of beach seines on the Mawelle beach. Opening access outside the original kinship groups would not have affected the number of nets competing for access if the provision limiting the number of nets to the number in use in 1933 had been enforced. Unfortunately, the limit on nets was not enforced, as we shall see.

During the early 1940s, the construction of a new road linking Mawelle to marketing centers, the construction of an ice factory nearby, and the marketing efforts of the Fish Sales Union greatly increased the demand for and market value of fresh fish. Prices for fish increased fourfold between 1938 and 1941 (Alexander 1982, p. 210). Then the pressure to introduce new nets really gained momentum. By 1945, 71 nets were in operation. At first, the operation of that many nets was highly profitable, even though the marginal product of each additional share was negative.[6] The average price of a share had risen substantially from 1935 to 1945 and was to continue to rise for another two decades, before dropping to a lower level again (Alexander 1982, p. 227).

New entrepreneurs began to buy shares in more than one net and to hire wage laborers to work their shares. By purchasing shares in nets well separated in the sequence, profitable returns could be made during each year. On the other hand, a poor fisher, who owned only a single share, received a profit only in those years when his net operated during the limited flush season. In earlier times, everyone had operated a net during the high-yield season. By 1971, however, that occurred, on the average, every three years. In the other two years, the income earned from a single

share was less than a subsistence-level income. Poorer owners of single shares began to sell their shares to others. A fisher who owned one share in each of five nets appropriately spaced throughout the sequence could make a modest profit each year, but he would have to make a substantial capital investment to spread his risk appropriately. Alexander computed the optimal number of shares for a person who intends to work his own shares to be 6.5 shares. In 1971, 9.5 of the fishers (58%) owned 5 shares or less.

Thus, the ownership patterns were shifting at the same time that the number of nets was greatly increasing. In the earlier system, those who owned shares had been long-term residents of the village, had belonged to the same kinship group, had owned only a single share each, and had worked that share. By 1971, many of the owners were not members of the same kinship group, owned shares in multiple nets, and hired wage laborers to work their shares. Further, the heads of several factions in the village purchased shares both for the economic return they could obtain and as a means of providing work for their loyal followers.

During that time, several efforts had been made to enforce the net-limiting provision in the 1933 legislation. After petitions had been submitted to the government agent in Hambantota in 1940, 1942, and 1945, a petition submitted in 1946 was accepted by the government agent, who agreed that the number of nets to be used in the future would be limited to the 77 nets then registered (Alexander 1982, p. 213). The 1946 petition was supported not only by the fishers who owned single shares and had actively supported the earlier efforts but also by the three largest shareholders in the village, who had earlier opposed such restrictions.

The government agent's decision substantially slowed, but did not completely stop, the construction of new nets. Entrepreneurs who offered sufficient inducements to government authorities were able to add a new net from time to time. Seven new nets were added in the next two decades, as compared with the 39 nets that had been added in the prior decade. That temporary brake on new entrants was to be completely destroyed in 1964 by the entry of a new entrepreneur – David Mahattea – into beach-seining. Finding it difficult to buy shares in current nets, Mahattea approached the local member of parliament (MP), a member of the Sri Lankan Freedom Party, and argued for permission to construct additional nets. The MP asked the district revenue officer to consider the proposal. The district revenue officer refused at first, arguing that there were too many nets. When the day came for the annual registering of nets, four members of Mahattea's faction appeared with nets borrowed from a nearby village. After considerable conflict in the village, the district revenue officer or-

dered those nets to be registered. Further nets were added when another faction leader supported a candidate from the opposition party and he won at the next election, after agreeing that additional nets could be registered in 1965. Between the two faction leaders, 24 new nets were constructed and added to the 84 nets then in operation.

At first, the other fishers were successful in excluding these new nets by devising a well-planned maneuver. The objective was to preclude the launching of the newly registered net 85. Once that net was launched, 23 more nets would follow. Fortuitously, one family owned shares in both net 1 and net 84. After net 83 was launched, that family refrained from launching net 84, and instead launched net 1. Thus, they started a new sequence, excluding one of their own nets (84) and all of the newly registered nets (85–108). That strategy was widely supported by all those who owned limited numbers of shares and by a faction leader who had not participated in the effort to bring in new nets. "As fishing was poor at the time the owners of the new nets did not protest very vigorously, but when the stratagem was repeated in the next cycle, [they] made it clear that they would resist future attempts" (Alexander 1982, p. 225).

That challenge came in 1966, when the net cycle reached net 83. Both net 1 and net 85 were launched at the same time, and fishers engaged in a brawl at sea. The boat carrying net 1 overturned. "Members of all three factions had gathered on the beach, and only the arrival of three jeep-loads of armed police, whom David [Mahattea] had warned in advance, prevented a riot" (Alexander 1982, pp. 225–6). The police stayed on for weeks to ensure that the 24 new nets were added to the sequence. The national government then issued regulations freezing the number of nets at 108. No nets were added to the official list between 1966 and 1971, when Alexander conducted his study. Alexander reports that the actual number of nets in use had dropped to 99 because of the burning of some nets in interfactional conflicts.

I have described this case in some detail because Alexander provides such an excellent record of the key steps in this process of rent dissipation. This was not a problem of ignorance. The fishers involved were aware of the consequences of adding nets. It was not a case of individuals being incapable of devising and enforcing rules well tailored to their local circumstances. The sequencing rules had been practiced successfully for many years. It does illustrate what happens in a *dynamic* local setting when appropriators do not have autonomy to make and enforce new rules.[7]

Before independence in 1948, the British had recognized the position of village headman (*vidāna arrachi*) and an official responsible for all aspects of fishing (*patabändi arrachi*). The village headmen were responsible for a

wide variety of activities in a local village, usually were appointed from among the local landowners, and frequently increased their wealth substantially as a result of holding office. They did have some real representation functions for a village. The duties of that position were abolished in 1965, and a new position was created in the civil service to handle village administrative matters. The occupants of the new offices were in an extremely weak position. They came from other locations and were subject to transfer out of an assignment if local residents with political contacts raised objections. During the year of Alexander's fieldwork in Mawelle, four men were successively appointed to that position, none staying for more than one month. The position of *patabändi arrachi* has continued in existence, but virtually the only task for the incumbent in recent times has been the annual registration of nets.

Sri Lanka has an extensive system of income-redistribution policies that bring central officials into direct contact with citizens on a frequent basis. Even though Mawelle is a relatively isolated village, villagers find themselves having to seek permission from central authorities located in Hambantota for many aspects of daily life:

> They must visit the District Revenue Office to obtain a rice ration book and the Police for a license to tap toddy. Chits to buy a variety of goods ranging from cement to extra food for a daughter's wedding are issued by the Government Agent. The Fisheries Department controls the sale of fishing gear and engine parts, while a number of consumer staples including rice, condiments, textiles and kerosene are sold through state run co-operative stores. In every case the villager is confronted by a shortage of goods, long slow-moving queues, and supercilious clerks. Yet despite the centralised control of goods and services, government agencies have few direct contacts with the village. (Alexander 1982, p. 31)

Political relationships between elected officials and local villagers revolve around patronage positions given to faction leaders in return for electoral support. Relationships inside the village are strongly affected by efforts to obtain private returns from the public treasury.

No arenas were provided by either the British or the Sri Lankan government for local discussion or local decision making at a constitutional-choice or collective-choice level. The villagers' own rotation system was codified in 1933, prior to the dramatic economic changes that would alter the incentives for all participants, and the villagers lost their right to change their own rules to adjust to the rapid change in the value of fish. National officials had promulgated a law that limited entry, but they failed to enforce it. Instead of enforcing entry rules limiting the number of nets, national officials could be convinced with promises of votes (and perhaps even bribes) to intervene and prevent the enforcement of a national rule

considered desirable by most local fishers. In any effort to close entry to a resource, some participants, or potential participants, are strongly motivated to ride free on the restrictions imposed on others. If these participants are able to make an "end-run" around local authorities, rule enforcement can be disrupted even when most appropriators strongly prefer tight enforcement.

Most of the beach-seining operations along the southern shore of Sri Lanka originally used share systems similar to the one described here. Villages that were located in closer proximity to marketing centers succumbed at an earlier date to the problem of rent dissipation. In most of those villages, a single entrepreneur bought up the shares to the local beach-seines and operated the beach-seines as a single firm. The owner hired wage laborers and captured the residual claims to profits. In villages where there were many employers of labor, such systems should have operated efficiently. Where the beach-seine operator held a monopsony position in regard to labor and the supply of labor was abundant, one would expect that the owner would keep wages as low as possible. The distributional consequences of that system frequently were undesirable. Private ownership may have been the only viable institutional arrangement along this coast, not because it was "the only way" but because the external regime was unwilling to allow local rule determination and enforcement. External intervention to prevent rule enforcement against political favorites undermines the viability of common-property arrangements.

IRRIGATION DEVELOPMENT PROJECTS IN SRI LANKA

Millions of dollars have been poured into the development of irrigation works in the dry zone of Sri Lanka. Extensive irrigation works had been developed in that area before the Christian era and had flourished until the twelfth century, when the population dependent on those systems began, for unknown reasons, to migrate to other parts of the island. In the nineteenth century, the British first began to restore the ruins of the bunds (embankments) that had created small and large reservoirs – called tanks in that part of the world – and the long, ribbonlike canal systems that stretched for great distances below the tanks. After independence, the government of Sri Lanka, assisted by foreign donor agencies, continued to invest heavily in irrigation projects.

The quantity of paddy rice produced in Sri Lanka has grown steadily in recent decades, particularly since the 1950s. The introduction of higher-yield varieties of rice has contributed to this growth,[8] but the amount of land under irrigation is the single most important factor affecting the

quantity of rice produced (Madduma Bandara 1984, pp. 298–301).[9] Although the quantity of rice produced has steadily increased, the output is substantially short of the expectations of project planners. In few of these projects has the amount of land actually irrigated approached the projections. Few systematic final evaluations of those projects have been conducted, but the detailed cost–benefit evaluation of the original Gal Oya project showed that discounted costs exceeded discounted benefits by 277 million rupees (Harriss 1984, p. 318). The area actually irrigated in another major project – Uda Walawe – was one-third of that planned when the project was funded. Much of the land that the planners presumed would produce two crops per year produced only a single crop after project water was made available.

One source of the disappointing effects on rice production is the discrepancy between project plans and project performance in terms of the amount of water that Sri Lankan farmers actually apply to their paddy lands. To understand this discrepancy, one needs to examine the relation between the quantity of water applied and the yield of paddy rice. Obtaining a high yield is dependent on receiving a substantial and reliable supply of water throughout the growing season. Farmers are strongly motivated to irrigate their fields as often as possible during the growing season. The yield for most varieties of paddy rice, in contrast to grains such as wheat, is highly sensitive to a scarcity of water and relatively insensitive to an overabundance of water (Levin 1980, pp. 52–3). Keeping fields flooded for long periods of time reduces the amount of backbreaking weeding that a farmer must do. A farmer has every reason to take almost any quantity of water that can be obtained through legal or illegal means, and very little reason to conserve water at all.

On the other hand, water is a scarce and costly factor of production. Farmers are rarely required to pay the full costs or even any costs at all for the water they receive. Further, diverting water from areas in the upper reaches of a system, when taken in excess of crop requirements, to be used in downstream areas will not reduce the yields upstream. Such a reallocation will greatly increase the rice yields in the lower reaches. Thus, if farmers are able to follow their own unconstrained preferences, they will apply far more water than is economically justified, in order to reduce their own personal labor input (even in areas where there is an abundance of labor), with the result that the total agricultural yield of the system will be substantially less than the projections made by irrigation engineers based on formulas of "optimal water-usage patterns."

A realistic estimate of actual water use in the major project areas of Sri Lanka is 12–15 feet of water applied to each hectare of paddy fields: 5–6

feet for the major (*maha*) growing season, when precipitation augments irrigation, and 7–9 feet for the minor (*yala*) growing season, when there is little or no precipitation. The most effective use of water to be recorded was in a small pilot project run by the Irrigation Department, with tight controls: a total water use between 8.4 and 10.2 feet. The 1969 project-planning document for the Mahaweli Development Programme – the largest of all the Sri Lankan projects – estimated the amount of land to be irrigated based on a presumption that 8.3 feet of water would be applied to yield two crops of paddy rice. When the project was evaluated again in 1977, planners reestimated the amount of land that could be irrigated assuming that about 7.5 feet of water would be applied over the entire project area to produce two crops of paddy rice (Harriss 1984, p. 319). Thus, the engineering plans were based on the presumption that water would be treated as a scarce good and that strict allocation rules would be enforced. Neither presumption was appropriate (Ascher and Healy 1990; Lundqvist 1986).

Bringing water use close to the figures used in project-planning documents would require a high level of organization by the farmers themselves to allocate water in the channels serving their fields according to strict self-discipline. Central-government efforts to achieve such a level of organization have not changed the fundamental incentives facing participants or their behavior. The dominant pattern of their behavior is to take as much water as their paddy fields will hold whenever they can legally or illegally obtain it and to refrain from active participation in efforts that would require them to accept any limits on their water use. The contemporary structure of incentives facing many farmers reinforces a short-term, "individualistic" strategy and discourages efforts devoted to longer-term investments in the organizational structure needed to achieve collective action. In this system, not only do the upstream irrigators seriously harm the downstream irrigators, but the general lack of reliable rules greatly increases the production and transactions costs for all irrigators.

To illustrate this problem, I shall describe the patterns of incentives and behaviors that evolved in the Kirindi Oya project, a project completed in 1920 under British colonial rule. After describing some of the vicious circles that evolved in that project, I shall then show how similar patterns of incentives have been generated in some other projects. The collective welfare of the impoverished farmers in the dry zone is dependent on their obtaining the additional food and income that would result from the design of an effective and enforceable set of rules for managing irrigation systems to increase their yields. But the farmers in that system are indeed caught in a system that is unlikely to facilitate their achieving an improved system of

rule-ordered relationships without outside help. And officials of the central government are equally trapped – given the current setting – and are also unable to break the vicious circles encompassing them and the farmers they are supposed to be serving.[10]

In 1876, the remnants of a bund located at Ellagala, on the left bank of the Kirindi Oya River, were restored, and a new settlement area was opened up. Thirty years later, a similar scheme was developed to restore a bund on the right bank of the river, using the same diversion works to fill the tank, thus opening up more land for resettlement. The construction phase was completed in 1920. Approximately 2,500 acres are served by this irrigation system. Most of the irrigators served by this system are poor tenants who are dependent on those who own large parcels of land in the area. Many of the major owners of land live elsewhere and are not dependent on local support (Fladby 1983).

The rainfall in the dry zone is 50–75 inches per year, which is a substantial amount when compared with the average for Valencia, Spain, of 10 inches and that for the Los Angeles metropolitan area of 14 inches per year. However, compared with other tropical areas, 50–75 inches is low. More important, it is highly concentrated in the October-to-December period, when dry steambeds are turned into torrential rivers. But everything will be dry a few days later (Gunasekera 1981). There is a minor rainy season in April and May. The irrigation systems restored by the British were relatively primitive structures, with few regulatory sluices or gates. Rainfall was retained behind a bund until the rainy season ended. The amount of water available in the reservoir determined the amount of land that could safely be placed under cultivation for the next growing season. For the smaller tanks, the land area covered by water just about equaled the land area that could be irrigated.

The administrative structure established by the British was designed to run a system that involved the release of water from shallow bunds in short bursts after water had been captured during one of the rainy seasons. Water would then accumulate behind the bund during the next rainy season, later to be released again. Farmers along the entire system had to be prepared to use the water during a brief period of time, or they would miss the opportunity to plant a crop for that season.[11] Under the British, the Irrigation Department named fixed dates for the release of water; the dates were supposed to be invariable each year to ensure time for two crops and for maintenance work on the bund and the channels. The notion of fixed dates was related to "a general view of British irrigation authorities that schemes should operate according to standard programmes so as to be subject to as

little influence from events and personalities as possible" (Harriss 1977, p. 367).

From 1920 to 1958, the Kirindi Oya system was managed by a dual executive structure. In principle, the responsibility for maintenance of the tank and the main canal and for allocation of water to the tank from the river was under the jurisdiction of the Irrigation Department. A subdivisional officer responsible to the director of irrigation engineering was the only person with the power to instruct an irrigation overseer to release water from the tank into the 10-mile-long main channel. Two "watchers" or "water-issue laborers" were then responsible for opening or closing the headgates, composed of simple planks, into the 11 main subchannels and for reporting on the condition of the main channels. All of these officials were paid fixed salaries by the Irrigation Department.

A different line of responsibility started at the level of the farmers' fields. There the lowest official was the *vel vidane.* In an earlier era of British colonial rule, that position was appointive and carried considerable power and prestige.[12] Because many cultivators were tenants, they did not participate in the selection of the *vel vidanes*, who were beholden primarily to the larger landowners for their positions. The *vel vidanes* were responsible for reporting on the progress made in cultivation and could enforce sanctions on cultivators who did not use water according to the rules agreed to by the landowners. They were paid a share of the yield by the cultivators. "In theory the Vel Vidanes were the instrument of swift discipline, empowered to ensure water conservation by the application of a code which laid down automatic punishments for any practices which would waste water, such as poor levelling of fields" (Harriss 1977, p. 369). However, practices varied greatly from one system to another. Some *vel vidanes* were subject "to influence by the big land controllers, so that performance of their duties was often slack and subject to bias" (Harriss 1977, p. 369). Some *vel vidanes* were known for their vigorous efforts to impose rigorous and fair discipline. Although elected locally, the *vel vidanes* were responsible to an assistant government agent (AGA) employed by the Revenue Department. Information about the status of the crops was reported upward from the *vel vidanes* to the AGA.

Water shortages occurred rather frequently. Considerable conflict was engendered between the Revenue Department, which wanted to save crops, and the Irrigation Department, which wanted a regular schedule and a set time to maintain the bund and channels. The AGAs from the Revenue Department regularly requested delays in the timing of water releases in order to prevent destruction of the first crop, which would lead to a lower

tax yield on the land. The effects of such delays were failure of the second crop in many years and a cumulative deterioration in the maintenance of the system. Further, the conflict between the two agencies could be manipulated by the larger landowners, who played on the concern of the AGAs for cultivation, rather than irrigation maintenance, and the somewhat more participatory orientation of the Revenue Department.

John Harriss reports that it was possible to make this system work when a strong AGA considered cultivation a priority. One AGA in the early 1920s was quite successful:

> He was able to resist the pressures of the powerful landowners and to exercise his power ruthlessly with regard to late cultivation, but also to manipulate the Vel Vidane system to make optimum use of available water and offer positive inducements to timely cultivation. For the system did provide for a kind of monitoring organisation throughout the tract. (Harriss 1977, p. 369)[13]

The *vel vidanes* were paid a proportion of the resulting crop, rather than a fixed income. Therefore, when coordination at the tract level was matched by predictability in water releases, there were strong motivations to enforce a discipline on the farmers that would ensure that two crops would be brought through to a successful harvest.

The British system was left substantially intact for the first decade of independence. In 1958 the system was changed by the national government in an effort to make it more democratic. The Revenue Department was removed from any responsibility for cultivation and eventually was replaced by a Department of Agrarian Services, which had no direct supervisory role in irrigation management in large projects, though it was responsible for overseeing and assisting small projects. The *vel vidanes* were replaced by the administrative secretaries (*govimandala sewakas*) of newly created Cultivation Committees. Initially, the "water meetings" held in each tract were attended by all registered cultivators, instead of just the owners of land, and elected a Cultivation Committee for a period of three years. Each Cultivation Committee met separately to set its own cultivation dates for each cultivation season of the year.[14] That arrangement greatly enhanced the flexibility of the system, but reduced the level of coordination across irrigation canals that had been possible when the Revenue Department had responsibility for cultivation matters throughout entire systems. Because most canals were unlined, water releases scheduled frequently throughout a long season, rather than at a few brief periods, would increase the amount of water lost to seepage.

The administrative secretary was responsible for enforcing compliance with the rules for water use, but he had fewer enforcement powers than

had the *vel vidanes*. The administrative secretary was paid from a fixed cash assessment levied per acre of land in each tract, whether or not the land was cultivated. Thus, the incentives of the administrative secretary were different from those of the *vel vidane*: The administrative secretary was no longer formally beholden to a small group of large landowners for his position; he had fewer powers than the *vel vidane* had had, and he was paid a set amount no matter how inefficiently water was distributed and used. On the other hand, he was dependent on satisfying farmers in his unit, to some extent, or he could not be reelected. Also, he was no longer directly accountable to external agencies for his work activity or for providing information about the condition of the crops or the condition of the irrigation works.

Large landowners frequently captured the major positions on some of the Cultivation Committees for Kirindi Oya and obtained special privileges related to water distribution through internal influence or by seeking external political intervention. In the Irrigation Department, one technical assistant became responsible for both the right side and the left side of the Kirindi Oya development. He had one maintenance overseer and two water-issue laborers assigned to him – hardly a sufficient work force to supervise 11 major outlets, many minor ones, and irrigation activities in over 2,500 acres of land (Harriss 1977, p. 371).

Effectively, the system had to operate without the services of coordinators at the tract level. The water-issue laborers were expected only to open and close gates and report damage. In any case, they could not physically limit the amount of water that any group of farmers obtained. Farmers blocked channels easily and forced water to back up into their fields. Disputes among irrigators were sometimes resolved in a violent manner. Farmers who benefited from unofficial channel blockage were not censored by their neighbors who were adversely affected (Harriss 1977, p. 374).

From 1973 to 1977, the members of the Cultivation Committee were appointed by the minister of agriculture, which meant that the local MP effectively controlled the appointment (Fladby 1983; N. T. Uphoff, personal communication). By the mid-1970s, control over water theft was "virtually nonexistent." Although 200 reports of water poaching had been submitted, none had been officially pursued. In the lower portions of the system, "about 80 acres of paddy are irrigated by means of an unofficial channel which blatantly taps the main channel, and disrupts cultivation in the last yaya (tract) irrigated. . . . This has been going on for about fifteen years" (Harriss 1977, p. 372). Those who irrigated at the tail end of this system, as in many systems, had the most unreliable supplies.[15]

Several administrative secretaries indicated when interviewed that they did not file official actions against irrigators for water poaching even though they "regularly file cases in the event of non-payment of the acreage taxes upon which they depend for their remuneration" (Harriss 1977, pp. 372–3). Irrigation rates had not been assessed since 1958. The chief engineer of the system concluded that "there is no law now" (Harriss 1977, p. 373).

The Cultivation Committees were abolished altogether in 1977, and their functions were given to appointed cultivation officers, thus replacing a system that had had at least some communal input, and bringing in an entirely centralized system. A modest change was made in 1980 to create an elected track leader (*yaya nayakaya*), but the position is quite anomalous. Although chosen and paid by the farmers, track leaders are supposed to follow the orders of the cultivation officers. As a result, no one other than the farmers themselves can allocate water or attempt to coordinate actions, at least in some villages (Fladby 1983, pp. 102, 191–5).

None of the participants in the Kirindi Oya project is motivated to do anything but follow dominant strategies. For the individual farmers, the only reasonable strategy to follow in a system in which others steal water with impunity (and use it for weed control) is to flood their own fields as much as possible, using whatever means are necessary to do so.[16] For the large landowners, keeping active political contacts with national leaders is one method of ensuring some protection for illegal practices. Politicians, for their part, interfere with irrigation procedures in order to provide "spoils" for those who support them.[17]

Because of the general personnel structure for Sri Lankan public officials – and especially irrigation engineers – few incentives exist for Irrigation Department staff to devote much time and energy to an attempt to enhance the operation and maintenance of canal systems such as the Kirindi Oya project. Recruitment is based primarily on educational qualifications and passing scores on examinations. Promotion and advancement are based almost entirely on seniority, with little crossing-over between nonprofessional and professional ranks. Irrigation engineers strongly identify with the civil-engineering profession, in which esteem derives largely from designing and constructing public works, rather than operating and maintaining them. Engineers make more money when they are assigned to construction projects than they do when assigned to operation and maintenance duties.

After a detailed analysis of this personnel system, Michael Moore concludes that it impedes efficient water management in several ways: (1) Recruitment patterns "impede effective social interaction between public

servants and cultivators," as well as "internal communication and working relationships which are especially important for water management." (2) Performance in written examinations is not associated with good work performance. (3) "There are in general few incentives for good work performance." (4) The way the bureaucracy is organized "consistently if unwittingly results in the devaluation of performance" (M. Moore 1979, p. 103). These factors lead "to poor work performance in general" and specifically to a lack of "good performance in the operation and maintenance of canal systems" (M. Moore 1979, p. 103). On top of all that, Irrigation Department officials are overworked and underpaid.

Tragically, it appears that similar problems afflict some of the other projects undertaken in Sri Lanka, as well as in other parts of Asia and the Third World.[18] Recently constructed irrigation works in Sri Lanka still are characterized by long distributory canals and few control structures. Measuring the amount of water that is allocated to different canals is extremely difficult, as is simply getting water to the tail ends of irrigation channels (M. Moore 1980, pp. 3–4). Further, the few existing control structures are easily tampered with. After reviewing recent developments, Harriss (1984, p. 322) indicates that "gates are missing, structures damaged, channels tapped by encroachers and others." When asked why they did not prevent some of the more blatant offenses, two young technical assistants replied "that they were afraid to because of the fear of being assaulted" (Harriss 1984, p. 322). Even a brave technical assistant must feel that such actions are futile, given the low probability of actually punishing an offender:

> Prosecutions have to be carried out by the police, who have usually treated water offenses as trivial, and who do not have the same incentives to tackle them as in other cases. Further, delays over court proceedings and the very light fines which have been imposed on those who have been found guilty of irrigation offenses, have made the legal sanctions ineffectual. (Harriss 1984, p. 322)

Irrigators with the appropriate connections to party officials may never be prosecuted at all.

Many settlements are heterogeneous, composed of individuals coming from different regions, castes, and kinship groupings, all of whom are initially poor and dependent on the irrigation projects for housing, initial income supplements, and provision of social services. The way in which settlers have been recruited and selected has also compounded the problem of farmer organization. The major selection criteria have been (1) being landless and (2) having a large family to enhance the labor supply (Harriss 1984, p. 325). At the same time, land allotments distributed to new settlers are supposed (by law) to be passed along intact from one generation to the

next. Although one can understand that attempt to avoid extreme fragmentation of landholdings, the result has been to exacerbate sibling rivalries within families and encourage young men to seek opportunities elsewhere. For some projects, the proportion of young men remaining to work on the family farm has fallen as low as 10% to 15% (Harriss 1984, p. 328). Paddy rice cultivation has always been a labor-intensive business. Given a shortage of family labor, the use of water for weed control to reduce the demands for labor in cultivation seems to make good economic sense for individual families, even though the subsidized water is actually more expensive than would be the marginal costs of an underemployed labor force. It makes little economic sense for a developing country with an underutilized labor supply to subsidize expensive irrigation water and have it allocated in this fashion.

The failure of the Kirindi Oya farmers to develop an effective set of rules for organizing their irrigation system is not unusual for large-scale, donor-funded irrigation systems in Third World settings. The lack of capacity to achieve self-governance appears to stem from internal factors related to the situation of the farmers and external factors related to the regime structure under which they live. Among the internal factors, I would include the following:

1 the very large number of farmers involved,
2 the fact that most farmers are poor settlers who have recently been recruited to the project and have little attachment to their land or to one another,
3 the extreme diversity of ethnic and cultural backgrounds,
4 the opportunity for wealthier farmers to control water through illegal or questionable strategies (potential leaders thus being able to take care of themselves without having to exert leadership to solve larger communal problems), and
5 the lack of physical control structures in the irrigation system itself.

These are difficult problems to overcome. They are exacerbated by the spoils politics of a central regime unwilling to enforce rules impartially, no matter whose rules they are. Those appropriators who want to avoid rule enforcement have considerable opportunity and means to obtain the help of central officials in obstructing such enforcement, thus undermining any effort to supply new local institutions.

The situation facing appropriators in such systems is one of inexorable tragedy. Or is it? Are the farmers on large Sri Lankan irrigation settlements (or similar projects elsewhere) doomed to eternal conflict and lack of cooperation? Unless there are major changes in local institutions, a firm yes

is the only answer. But then the key question is whether or not it is possible to change local institutions and thus the incentives and behaviors of the farmers. A recent experiment in the development of new organizations to enlist the cooperation of farmer-irrigators in one Sri Lankan irrigation system (International Irrigation Management Institute 1986; de Silva 1981) leads me to give a qualified affirmative answer to this second question. The situation is grim, but not hopeless.

A dramatic turnaround story has occurred on the left bank of the Gal Oya irrigation project (Perera 1986; Uphoff 1985a–c). The Gal Oya irrigation system is the largest irrigation-based settlement project in Sri Lanka. The system was completed in 1950. The system has three major divisions: the river division, the right bank, and the left bank. The left-bank division was designed to irrigate about 65,000 acres of land and is composed of "nearly 32 miles of main channels, 150 miles of major distributaries, and about 600 miles of field channels" (Perera 1986, p. 88). By the late 1970s, Norman Uphoff described the Gal Oya left bank (GOLB) as a "hydrological nightmare" (Perera 1986, p. 88). Channels had not been maintained, and their banks were broken and silted. Control structures had been destroyed, and the system was providing water to a much smaller area than originally planned. Further, lack of trust among farmers and between farmers and the officials of the Irrigation Department (ID) was endemic:

> Cooperation among farmers was minimal. Social relations among settlers, who came from different areas of the country, were often strained. . . . Relations between farmers and ID officials were marked by mistrust and recriminations. Farmers had no confidence in the competence or the trustworthiness of the ID's staff. . . . Many field-level officials . . . were notorious for their corruption and thuggery. The main obstacle to efficient water management, from the farmers' view point, was the local-level officials, who had political and bureaucratic power behind them.
>
> On the other hand, the ID officials, especially irrigation engineers, believed that farmers could not use water responsibility and carefully. Therefore, they argued that it was necessary to organize, educate, and discipline the farmers to do what the ID asked them to do. Thus farmers were considered a part of the problem while the latter constitute the solution. (Perera 1986, pp. 89–91)[19]

The entire situation was made even more difficult and tense because "most of the cultivators in the tail areas were Tamil speakers settled from nearby coastal areas while most of the upstream cultivators were resettled Sinhalese" (Uphoff 1986a, p. 202).

The original project design called for regimentation of the farmers and increased law enforcement. That approach was modified to some degree in the final proposal, which called for the organization of farmers throughout GOLB to ensure that farmers would contribute free labor to rehabilitate

and then maintain the channels that served their fields in order to increase efficient use of water. The final project assigned certain funds and responsibility to the Agrarian Research and Training Institute (ARTI) for farmer organization. ARTI was assisted by the Rural Development Committee at Cornell University.

The ARTI/Cornell team, on consideration, rejected the goal stated in the project plan to devise and test a single model of "farmer organization" for all 19,000 farmers served by GOLB within a four-year period. Instead, the ARTI-Cornell team chose to introduce "catalysts" into the situation of mutual distrust and unpredictability – institutional organizers (IOs), as they were called. The IOs could be college graduates, because Sri Lanka has one of the highest educational levels among less-developed countries (LDCs), and many college graduates there were unemployed. As college graduates, they would be able to grasp organizing principles rapidly and would have the status needed to deal effectively with ID officials. To ensure that the IOs were also able to work with the farmers, applicants were recruited who had farm backgrounds – if possible, from large settlements like Gal Oya. IOs also had to be willing to live in the remote project area.[20] The ARTI/Cornell team started development of IOs in a 5,000-acre pilot area near the head of the system, where rehabilitation was to occur first. It has been expanded to 25,000 acres, but does not yet cover the entire system.

The IOs received about six weeks of training in how to approach and motivate farmers and in technical subjects related to agriculture and irrigation. They were divided into small groups of four or five, each group responsible for the area served by one distributory canal. Each team divided its area into smaller units using field canals as the primary basis for division. Each group of IOs met weekly in order to learn from each other's experiences and bolster morale when necessary. IOs also filled in for one another in times of sickness or when one left.

An IO was expected, first, to meet each farmer sharing water from a field canal to discuss the types of agricultural and irrigation problems they faced and to complete a survey of relevant information about the area.[21] After becoming familiar with the farmers and their problems, the IO was expected to meet informally with small groups of farmers sharing the same field channel to plan self-help strategies. Instead of establishing a predefined organization, the IO tried to form a working committee to solve particular problems, such as repairing a broken control gate or desilting a field channel. Further, IOs identified problems beyond those that could be solved by the farmers working together, problems that needed to be articulated to ID officials and others. Once farmers were used to working together and had achieved benefits from group action, the IO would then

help form a local organization and select, through consensus, a farmer-representative. This representative could articulate the interests of the other farmers on his field channel at larger meetings and report back to the others what had happened in larger arenas.

The ARTI/Cornell team tried to get these bottom-up organizations in place before physical rehabilitation started, so as to provide an arena for discussions between the farmers and engineers about the plans for local rehabilitation. In discussions with ID officials, the ARTI/Cornell team used the fact that the farmers were expected to contribute considerable amounts of labor to rehabilitation and maintenance to convince the engineers that high levels of labor contribution were far more likely if the farmers were consulted during the design stages of the rehabilitation. By the time the design phase was initiated, the farmers had already begun to work together and had good ideas about how to rehabilitate their field channels. As a result, irrigation officials began to change their fundamental orientation toward the farmers.

The "field channel organization" (FCO) was the basic organizational building block for the Gal Oya project. FCOs were uniformly small, around 12 to 15 farmers. FCOs were problem-solving units that operated often without regular meeting times, agendas, or written records. A second tier of organization was built on top of the FCO at the level of the distributory channel, the "distributory channel organization" (DCO), involving 200 to 800 acres and around 100 to 300 farmers. Each farmer was thus a member of both an FCO and a DCO. Each DCO developed its own organizational arrangements, which generally involved a general assembly encompassing all farmers and committees made up of the farmer-representatives from the FCOs. Officials were selected by consensus and were nonpartisan.[22]

The third tier of organization, at the branch-canal or area level, was to follow after FCOs and DCOs had been established and linked.[23] There are four major areas in GOLB, and each eventually was represented by an "area council." All of the farmer-representatives within the area served by a branch canal were eligible to attend the general assembly of the area council. The fourth tier of organization – a project-level committee – was initiated by the farmer-representatives and the IOs. The Project Committee provides a forum in which farmers can directly participate in policy discussions. Farmers have seen real changes in the attitudes and behavior of irrigation officials toward them and in the policies adopted by the ID.[24]

Farmer behavior has changed markedly since the evolution of new institutions for collective action. In those areas where FCOs and DCOs have been established, water rotation procedures are quite generally practiced.

In a recent survey, 98% of the field representatives "felt that water rotation leads to equity in water distribution and 79 percent of the farmers felt that they would themselves be assured of adequate water under rotation" (Kasyanathan 1986; Perera 1986, p. 103). Rotations have frequently involved deliberate efforts by those located higher in the system to make water available to tail-enders. That is all the more noteworthy given that head-enders tend to be Sinhalese, and tail-enders tend to be Tamils. On one distributory channel, for example, which straddled the Sinhalese and Tamil areas, little channel maintenance had been undertaken for years. Water deliveries had been extremely unreliable, and farmers talked about previous murders over water disputes (Uphoff 1986a, p. 207). Within a few months of the creation of an FCO, Sinhalese and Tamil farmers began to work on clearing out the channels. Uphoff (1986a, pp. 207–8) described the changes:

> During my visit in January 1983, I observed fifteen Tamil and twelve Sinhalese farmers finishing the cleaning of [the channel]. The thickness of the tree root that had grown through the channel and which the farmers were chopping out by hand was mute evidence that water had not reached the tail in some twenty years. The farmers worked together for three days to get the channel cleaned, just in time for arrival of the season's first water delivery.

The result of that effort was an additional 1,000 acres brought under cultivation, benefitting 300 families who harvested two crops of rice that year (Uphoff 1986a, p. 208). Farmers have regularly participated in group projects organized by their own FCOs to clear the field channels serving their own land and even, at times, to clear distributory channels that were not cleared by officials because of lack of funding. Whereas 80% of the farmers indicated that the record for channel clearing had been poor prior to the establishment of FCOs, only 6% indicated that it was poor in 1986 (Kasyanathan 1986; Perera 1986, p. 104).

The level of conflict among farmers has also declined. "Now with the assured water supply and the availability of a forum, i.e., the FCO, to discuss and settle disputes at the [FCO] level, the frequency and the seriousness of conflicts have been greatly reduced in FCO areas" (Perera 1986, p. 104). During 1985, 77% of the farmers reported that not a single conflict occurred in their field channels over water distribution (Kasyanathan 1986; Perera 1986, p. 104). Because of the nonpartisan nature of the organizations and the bypassing of those who had been the elite, many powerful farmers in the area had originally opposed the organization of farmers at GOLB. By 1983, the opposition from such groups had disappeared, and some politicians had spoken publicly to praise the non-

partisanship of the FCOs and DCOs. Although keeping the organizations nonpartisan appeared to be difficult at the beginning, it was not unusual to find farmers from all parties holding offices in FCOs and DCOs and working well together.

The attitudes of farmers toward the officials of the Irrigation Department changed, as did the attitudes of officials toward the farmers. Officials were perceived as being far more responsive to farmers' needs, and farmers could document specific incidents in which policies had been changed in response to requests made by farmer groups. Over 70% of the GOLB officials believed that official–farmer relationships had improved and that FCOs had facilitated more communication, better understanding, and mutual trust (Kasyanathan 1986; Perera 1986, p. 103). The increased trust crossed ethnic lines. The extent of that mutual respect was demonstrated in 1981 when communal violence broke out in the district, with some roving bands of Sinhalese youths burning Tamil shops in the marketplace: The reaction of the Sinhalese farmer-representatives was to go to the homes of the Tamil Irrigation Department officials in order to protect them from violence (Uphoff 1986a, p. 206).

The major weakness of the Gal Oya organization program was that farmers were expected to undertake construction at the field-channel level without pay. Somewhere between 30% and 60% of the field channels were completed (N. T. Uphoff, personal communication). It probably was an unrealistic hope on the part of the planners to expect farmers to do hard physical work, with little immediate payoff, based simply on a nascent community spirit at the same time that private contractors were making substantial, often lucrative, profits for undertaking the same type of work. The Irrigation Department itself was not able to keep to its planned schedule, complicating still further the task of trying to motivate farmers to do those tasks on time.

No one would argue – least of all the ARTI/Cornell team – that the Gal Oya project operated without minor problems, and sometimes major problems. They faced high turnover (95%) among the IOs, who would leave their temporary jobs when permanent positions opened in the Ministry of Education or elsewhere. Some IOs were fielded with inadequate training. The supervision given to the program was thin on the ground. Some Irrigation Department officials and some farmers were not as responsive as others. But, overall, the modest cost of the program was more than offset by the increased yields resulting from successful introduction of water rotation procedures (Perera 1986, p. 105).

On balance, the Gal Oya project represents a dramatic turnaround in a system in which there once was little hope of gaining farmer cooperation

in the use of water and maintenance of field canals. Beyond gaining the coordinated effort needed to maintain the field channels and equitably distribute water, thus enhancing the efficiency of the system, the project has left organizations in place that can continue to develop new skills and new problem-solving abilities.

Given the perverse incentives that beset all of the participants in Gal Oya prior to the project, it seems unlikely that the farmers or the officials by themselves would have overcome the structure of the situations they faced without external intervention. The type of intervention adopted in the Gal Oya project, however, was not that of a central agency regimenting the farmers by enforcing rules designed by others, although that had been the conception of the intervention in the initial project documents. The ARTI/Cornell team specifically rejected that model of external regimentation. Instead, they chose to facilitate the problem-solving capabilities of local farmers and officials by introducing "human catalysts" who were to work directly with farmers and officials at the field-channel level trying to solve problems. Only after some initial success in getting farmers to undertake collective actions that required some working together did any movement toward more formal organization take place, and even then the field organizations were deliberately kept simple and oriented toward problem-solving. Farmer-representatives were selected through consensus, rather than having "leaders" elected by majority vote. Consensus was the dominant rule used in making decisions at all tiers. Given the spoils systems that had evolved in Sri Lanka, the fact that the day-to-day problem-solving regarding irrigation and agricultural problems could be taken away from politicized channels was an extremely important step.

Mutual trust and reciprocity were nourished on a face-to-face basis prior to attempts to organize farmers into larger groups. At the distributory-channel level, formal organizations were developed by the farmers without following a single, externally authorized model. Eventually, farmers were organized on four mutually reinforcing levels and were given recognition and encouragement. Most important, farmers saw that their own proposals were treated seriously, for the first time, by irrigation officials, and they saw definite results.

The Gal Oya project demonstrates how external agents may help appropriators overcome perverse incentives that lead to suboptimal outcomes, even when traditions of mutual distrust and animosity have been reproduced over several generations. Such problems may be intractable from "inside" the situation unless the major participants holding diverse positions can simultaneously be shown the necessity for major changes in the incentive structure facing them all.[25] The amount of external intervention

need not be large nor expensive. Nor is it necessary to maintain large numbers of catalysts in the field for a long time. For a program such as this to be successful, it is necessary that both farmers and irrigation officials come to view the resulting farmer organizations as legitimate and permanent tools for coping with the long-term problems involved in the governance and management of any complex irrigation system.[26]

THE FRAGILITY OF NOVA SCOTIAN INSHORE FISHERIES

The cases discussed earlier have illustrated some of the problems that make it difficult for CPR appropriators to develop effective rules for limiting entry and use patterns. Now I wish to turn to a different type of problem – that of fragile CPR institutions. Some fragile institutions devised by CPR appropriators are still in use and effective. These institutions exist, however, in a broader setting that renders doubtful their continued use and effectiveness.

The eastern coast of Canada is dotted with small fishing villages where fishing has been the major economic activity for generations. The fishers in many of these villages, particularly those located in Nova Scotia and Newfoundland, have developed their own rules governing the use of nearby fisheries. These local rule systems control who can enter the fishery and how local fishing grounds are divided among fishers using different technologies. In some cases the fishers have established lottery systems to allocate the best locations for setting traps or nets.[27] The local rules that have evolved for one Nova Scotian village are described in considerable detail by Anthony Davis (1984) for a village he calls "Port Lameron Harbour."

Almost all of the 99 fishers currently using Port Lameron Harbour are descendants of fishers who settled in the area during the last decades of the eighteenth century. They all fish from relatively small boats, even though 10 of the 52 boats fish in the offshore waters. Most inshore boats cost less than $30,000, whereas offshore boats tend to cost around $50,000. The average crew size on the inshore boats is 1.8, and on the offshore boats 2.5 (A. Davis 1984, p. 135).

The fishers engaged in the offshore fishery are on the water throughout the entire year, repairing their boats from time to time as needed. The inshore fishery is conducted from the end of March through December, when the boats are hauled up on the shore for repair and refitting. Both types of crews use a diversity of fishing technologies and seek out various species (cod, halibut, herring, mackerel, lobster), depending on the time of year. There are differences in value, size, and technologies between the

inshore and offshore fishing boats, but they are not as substantial as the difference between the various types of fishers in Bodrum and the Bay of Izmir described earlier.

Most of the fishing villages along the southwestern coast of Nova Scotia have broadly defined fishing territories.[28] The Port Lameron Harbour inshore fishery zone extends outward for about 25 kilometers and along the coast for about 20 kilometers. The offshore boats use the outer portion of that fishing ground and also go considerably farther to sea. The territory used primarily by Port Lameron fishers is divided into several subzones, each devoted to a particular type of technology. Herring and mackeral gill nets are set in a rectangular area beyond the harbor but close to shore. If they were set farther inshore, they would restrict travel in and out of the harbor, and if set farther to sea they could be destroyed by the strong currents. Similar areas are set aside for lobstering, when it is in season, and for various potentially conflicting technologies used to obtain cod and halibut.

Basically, the Port Lameron fishers have divided their territory on pragmatic grounds: which microenvironments are best suited for which technologies at particular seasons of the year. These use patterns "reflect practical and informal resource management strategies developed by a community of fishermen through years of experience" (A. Davis 1984, p. 145). Not all technologies are mutually compatible in this environment. Four of the captains of offshore boats, for example, purchased offshore groundfish gill nets in 1975 when substantial federal subsidies were offered for such purposes. Their use, however, substantially interfered with the operations of the other inshore and offshore boats. As a result of the intraharbor opposition to the use of those gill nets, all four captains had disposed of that gear by 1980.[29] The division of the territory into zones to be used by fishers using particular technologies not only reduces the externalities that the use of one technology may impose on others but also constitutes a low-cost system for apportioning a reasonable yield to all participants. The cost of monitoring an apportioning scheme based on an easily observable factor – what technology a boat is using – is much lower than the cost for one based on the quantity of fish harvested.

The claim of Port Lameron fishers to the use of their fishing grounds is based on tenure: For generations, they and their families have fished and jointly managed this resource. As expressed by a local fisher,

> I've fished here all my life. So did my father and his father. Men in my family have been fishin' here for a long time. If anyone's got a right to fish here it's me and I'm no different than most of the fellas fish'n here. (A. Davis 1984, p. 145)

They see themselves as having exclusive rights to their lobster territory, which can yield up to 40% of a fisher's yearly income. In addition, they exercise the right of first access (and the right to refuse access in years of scarcity) to the remaining zone. Although some fishing by neighbouring fishers is tolerated in good years, the property lines are drawn tight when the fish are scarce. The years of scarcity are, of course, exactly the years when conflict over territory can erupt. Policing their boundaries is something that all fishers do. The burden of enforcement must be borne by the local fishers, as they cannot call on external authorities to enforce their local rules of access. Davis illustrates how this enforcement is done:

> For example, a Port Lameron Harbour fisherman, after setting his longline gear, watched a fisherman from a neighboring harbour set his gear close to and, on occasion, across his line. Subsequently, the Port Lameron Harbour fisherman contacted the "transgressor" on the citizen band radio to complain about this behaviour. Other Port Lameron Harbour fishermen who were "listenin' in" on the exchange demonstrated support for their compatriot by adding approving remarks once the original conversation had ended. The weight of this support, coupled with the implied threat of action, i.e., "cutten' off" the offender's gear, compelled the erring fisherman to offer his apologies. (A. Davis 1984, p. 147)

This rule system is fragile because it is not recognized by federal authorities in Canada, particularly the Department of Fisheries and Oceans (DFO). Fishery policies in Canada have undergone substantial changes over the years. At an earlier date, the provinces played a much more important role in the regulation of inshore fisheries. That was particularly the case in Newfoundland, which was not included as part of the confederation until 1949. The regulatory stance taken by Newfoundland authorities was to provide arenas in which conflict between fishers using different territories and different technologies could be resolved. The Newfoundland fisheries regulations basically codified into law the fishing rules devised in local settings (K. Martin 1979).

The federal stance toward local rules has been exactly the opposite. Current Canadian policy gives "little credence to the ability of local customary regulations to adequately police the fishery" (Matthews 1988, p. 6). Federal officials presume that the entire eastern coast is an open-access fishery.[30] They have adopted the dominant policy orientation described in Chapter 1, namely, that there are only two options available: private property rights and government regulation. Ruling out private property leads to an official policy of federal-government regulation:

> The federal government . . . carries the jurisdictional responsibility for conserving fisheries resources . . . and for allocating the distribution of these resources among

competing users. Since the establishment of private-property rights in fishery resources is impracticable in the great majority of cases, the state's responsibility for resource conservation and allocation cannot be delegated.

(Government of Canada 1976, p. 20)

The deep-sea fishery off the eastern coast has long been an open-access fishery, as most offshore fisheries are. The competition from foreign fleets for these productive fishing grounds led to severe stock depletion in many instances prior to 1976, when Canada claimed jurisdiction over a 200-mile extension beyond its coastline under the "Law of the Sea Convention." That extension of Canadian authority enabled Canadian officials to begin to cope with the open-access nature of the far-offshore fisheries. That extension of authority also led Canadian fishery planners to believe that they were then "in a position to 'rationalize' all aspects of the fishing industry including the inshore and processing sectors" (Matthews 1988, p. 8).

Many of the government's initial steps have been related to efforts to license fishing vessels, as well as the fishing activities of different sorts. Given that many full-time and part-time fishers fear that licensing is only the beginning of an effort to reduce the number of fishers in the industry in general, many individuals who were not currently active in fishing obtained commercial fishing licenses so as to ensure that they would already have licenses if limits were later imposed. Further, given the variety of fishing technologies used by Port Lameron fishers, the immediate response of fishers in that community was to obtain licenses for technologies they were not using in case they might need them in the future. Similar practices were undertaken in other regions. Parzival Copes (1983, pp. 16–17) reported that the number of fishers registered in Newfoundland rose from 15,351 in 1974 to 35,080 in 1980, and he estimated that there were only 21,297 persons actually fishing.

The importance of such "defensive" licensing practices was brought home to Port Lameron fishers who had not obtained licenses to set gill nets to obtain herring for their bait. When federal officials then froze the number of licenses available, without prior notice, and threatened sanctions against those found using gill nets illegally, conflict exploded in the community:

Several fishermen reacted angrily when told that they could not obtain a license unless they currently held one and that fisheries officers would confiscate the unlicensed set nets. One man exclaimed that: "If they touch my nets they'll get a surprise!" (A. Davis 1984, p. 157)

Protest meetings were held along the entire coast, leading federal officials

to back off long enough to allow fishers to obtain herring licenses whether or not they intended to sell herring. The entire experience reinforced local feelings that federal officials would tend to act arbitrarily without consultation and devise regulations that were not well tailored to the local circumstance:

> What do they know about what we do? Fisheries Officers are only around here now and then. How do they know what's best for us? We've fished here for a long time and we know what's best for our ground. We know what it can take.
>
> (A. Davis 1984, p. 156)

Instead of finding means for strengthening locally evolved rules systems to ensure that access and use patterns would continue to be controlled in those territories where effective rule systems had already been devised to match local environmental and technological systems, Canadian policy has been to develop one standard set of regulations for the entire coast. If future Canadian policies produce still further counterproductive reactions on the part of the fishers, they may fail to gain control of the open-access deep-sea fishery and lose control of some inshore fisheries previously subject to entry control.

It is difficult to tell exactly what the future holds for fisheries like that offshore of Port Lameron Harbour. If national policies were to change, and officials were to try to develop a set of nested rules that would help enforce the local regulations that have been developed over the years, while focusing most of the new regulatory effort on the far-offshore fisheries that are indeed open-access, then this fragile rule system could survive, adapt, and enable fishers to make effective use of this local resource indefinitely into the future.[31] However, if Canadian authorities continue to try to develop a single policy for all fisheries along the entire eastern coast, then eventual deterioration of the locally evolved system seems probable. Further, it is doubtful that any national agency can ever have the extensive time-and-place information needed to tailor a set of rules to the particulars of local situations.

Federal officials in Canada are not the only officials who have presumed an absence of local institutions for regulating CPRs and have taken actions that have either threatened or destroyed existing institutions. Cordell and McKean (1986) describe a form of sea tenure developed by poor, black raft fishers living along the coast of Bahia in Brazil – tenure that is not recognized by national, regional, or local governments in Brazil. Further, the official policy of the Brazilian government is open access, rather than the limited-access system of the raft fishers. Brazilian national fishing codes

define all Brazilian territorial waters as public waters *open to any Brazilian boat* registered in a Brazilian port.

Several scholars have documented what occurred when the government of Nepal passed the "Private Forests Nationalization Act" (Arnold and Campbell 1986; Bromley and Chapagain 1984; Chapagain 1984; Messerschmidt 1986). Whereas the law was officially proclaimed to "protect, manage, and conserve the forest for the benefit of the entire country," it actually disrupted previously established communal control over local forests. Messerschmidt (1986, p. 458) reports what happened immediately after the law came into effect:

> Nepalese villagers began free riding – systematically overexploiting their forest resources on a large scale. The usual explanations for this free riding are that the villagers felt they had lost control of their forests, and they were distrustful of government control and national resources policy.

In 1978, the government of Nepal reversed its policy and began to encourage the transfer of forest land back to village control, with quite encouraging results in regard to forestation efforts (Arnold and Campbell 1986). Similar stories of disruption of fragile CPR situations, when central-government officials have presumed an absence of local institutions, can be told for many other parts of the world.

LESSONS TO BE LEARNED FROM COMPARING THE CASES IN THIS STUDY

The purpose of presenting these instances of success, failure, and fragility is to determine what these cases have in common. Now that the cases have been described, I shall use them for two types of analysis. First, I shall compare the extant institutions using the design principles described in Chapter 3: Which of the design principles derived from the robust institutions described in Chapter 3 characterize the other cases? If the cases of institutional failure and fragility are characterized by design principles similar to those of the robust institutions, then perhaps those principles should be rejected as not helping to distinguish among robust, fragile, and failed institutions. Second, I shall analyze the situational and regime characteristics that appear to affect the capacities of individuals to change their institutions (as described in Chapter 4 and, for cases dating from earlier times, in Chapter 3), as well as factors that appear to limit the capacities of individuals to change their own institutions (or prevent external changes being imposed on them), as described in this chapter. The first analysis is

the topic of this concluding section. The second analysis is addressed in Chapter 6.

As a first step toward assessing the validity of the proposed design principles, I have arrayed all of the cases discussed in this study in Table 5.2. For each case, I have indicated which of the design principles clearly apply, which apply in a weak form, and which clearly do not apply. The long-enduring cases presented in Chapter 3 obviously are characterized by these principles, because the principles were devised to summarize factors common to these cases. The institutions developed in Raymond Basin, West Basin, and Central Basin to prevent their destruction are also characterized by these design principles. Those institutions have already shown themselves capable of surviving for 30 or 40 years. I am willing to presume they are robust.

These principles also clearly differentiate between the success and failure cases. Turning to the failure cases, none of the principles characterize the two Turkish fisheries (Bay of Izmir and Bodrum), where severe rent-dissipation problems continue unabated. Only one of the principles characterizes the Kirindi Oya irrigation project in Sri Lanka (clear boundaries); two characterized the Mawelle fishery after 1938, when rent dissipation became a severe problem (congruent rules and monitoring); two characterized Raymond, West, and Central basins prior to the institutional changes initiated there (conflict-resolution mechanisms and recognized rights to organize); three characterized the Mojave case (collective-choice arenas, conflict-resolution mechanisms, and recognized rights to organize). Thus, no more than three of the design principles characterized any of the cases in which CPR appropriators were clearly unable to solve the problems they faced.

In this chapter, I characterize the CPR institutions in Port Lameron, Canada, as fragile. I also consider the institutions devised in Alanya, Turkey – though ingenious – to be fragile, as well as those devised for the Gal Oya project in Sri Lanka. Let me explain why. Although the rules devised in Alanya provide an elegant way to solve an assignment problem, they do not address the problem of limiting access to the local fishery. At the current time, the number of fishers desiring to fish in Alanya does not threaten the viability of the fishery. But if more individuals were to want access to the fishery, the problem of rent dissipation that characterized Mawelle could well arise in Alanya. In the past, collective choices were made partly through the facilities of a local co-op and partly through discussions in the local coffeehouse. Without a regular arena for collective choice, it would be difficult for the Alanya fishers to adjust their rules in the future if conditions were to change.

Table 5.2. *Design principles and institutional performances*

Site	Clear boundaries & member-ships	Congruent rules	Collective-choice arenas	Monitoring	Graduated sanctions	Conflict-resolution mechanisms	Recognized rights to organize	Nested units	Institutional performance
Törbel, Switzerland	yes	yes	yes	yes	yes	yes	yes	NR[a]	robust
Japanese mountain villages	yes	yes	yes	yes	yes	yes	yes	NR	robust
Valencia, Murcia, & Oriheula, Spain	yes	yes	yes	yes	yes	yes	yes	yes	robust
Raymond, West, & Central basins (current)	yes	yes	yes	yes	yes	yes	yes	yes	robust
Alicante, Spain	yes	yes	yes	yes	yes	yes	yes[b]	yes	robust
Bacarra-Vintar, Philippines	yes	yes	yes	yes	yes	yes	yes	yes	robust
Alanya, Turkey	no	yes	weak	yes	yes	weak	weak	NR	fragile
Gal Oya, Sri Lanka	yes	yes	yes	yes	[c]	weak	weak	yes	fragile
Port Lameron, Canada	yes	yes	weak	yes	yes	yes	no	no	fragile
Bay of Izmir & Bodrum, Turkey	no	no	no	no	no	no	weak	no	failure
Mawelle, Sri Lanka	no	yes	no	yes	yes	no	no	no	failure
Kirindi Oya, Sri Lanka	yes	no	no	no	no	no	no	no	failure
Raymond, West, & Central basins (earlier)	no	no	no	no	no	yes	yes	no	failure
Mojave groundwater basins	no	no	yes	no	no	yes	yes	no	failure

[a]NR = not relevant.
[b]With two major exceptions, from 1739 to 1840 and 1930 to 1950.
[c]Missing information.

In regard to Gal Oya, boundaries and membership have been clearly designated, congruent rules have been devised and monitored, and collective-choice arenas have been set up. Until the rights of farmers are clearly recognized and guaranteed and conflict-resolution mechanisms are in place, however, I am unwilling to assume that these are robust institutions. Given the long history of central control, it would be difficult for farmers in Gal Oya to continue their organized efforts if a major change in the Irrigation Department were to place in office engineers who presumed that local farmers had little to offer. The fragile cases stand as intermediate cases in terms of the design principles. Enough of the principles are in use to enable appropriators to solve some of their immediate CPR problems, but one would be hesitant to predict institutional endurance unless further institutional development occurs and the arrangements come closer to meeting the full set of design principles.

The cases discussed in this volume compose a limited set. Further empirical and theoretical work is needed before one can have a high degree of confidence that this set of design principles is the best way to distinguish among robust, fragile, and failed institutions. Several colleagues and I currently are collecting information on a large set of empirical cases to determine if the pattern of relationships shown on Table 5.2 is replicated. An initial explanation of why these design principles would be associated with robust institutions was presented in Chapter 3. Sufficient support for those initial theoretical speculations is presented in Table 5.2 that further theoretical and empirical analyses appear warranted.

6

A framework for analysis of self-organizing and self-governing CPRs

In Chapter 1, I discussed three models that are used to justify the policy recommendation that external governmental authorities should impose solutions on individuals who jointly use CPRs: Hardin's tragedy of the commons, the prisoner's dilemma game, and Mancur Olson's logic of collective action. All three models lead to the prediction that those using such resources will not cooperate so as to achieve collective benefits. Further, individuals are perceived as being trapped in a static situation, unable to change the rules affecting their incentives.

The cases presented in this study are from a universe of relatively small scale CPRs (the largest involves about 15,000 appropriators), each located within a single country. The appropriators in these cases are heavily dependent on a flow of scarce resource units for economic returns. The cases illustrate that some, but not all, appropriators in these settings solve what are thought to be second-order dilemmas to provide their own institutions. Various institutional arrangements are devised to accomplish these results. Marketable rights to the flow of resource units were developed in Alicante and in three of the California groundwater cases, but the resource systems themselves did not become private property. Forms of public instrumentalities were also used in the California groundwater cases and several other cases, but none of the success cases involved direct regulation by a centralized authority.

Most of the institutional arrangements used in the success stories were rich mixtures of public and private instrumentalities. If this study does nothing more than shatter the convictions of many policy analysts that the *only* way to solve CPR problems is for external authorities to impose full private property rights or centralized regulation, it will have accomplished one major purpose. At the same time, no claim is made that institutional

arrangements supplied by appropriators, rather than by external authorities, will achieve optimal solutions. The Mojave case clearly illustrates this point. But the survival, over long periods of time, of the resources described in Chapters 3 and 4, as well as the institutions for governing those resources, is testimony to the achievement of at least a minimal level of "solution."

This study has an additional purpose beyond challenging the presumption that universal institutional panaceas must be imposd by external authorities to solve smaller-scale, but still complex, uncertain, and difficult, problems. The observation that the world is more complex than it is presented in these models is obvious, and not useful by itself. What is needed is further theoretical development that can help identify variables that must be included in any effort to explain and predict when appropriators using smaller-scale CPRs are more likely to self-organize and effectively govern their own CPRs, and when they are more likely to fail. Such theoretical development not only should provide more useful models but also, and more important, should give us a general framework that can help to direct analysts' attention to important variables to be taken into account in empirical and theoretical work.

The models described in Chapter 1 are not wrong. When conditions in the world approximate the conditions assumed in the models, observed behaviors and outcomes can be expected to approximate predicted behaviors and outcomes. When individuals who have high discount rates and little mutual trust act independently, without the capacity to communicate, to enter into binding agreements, and to arrange for monitoring and enforcing mechanisms, they are not likely to choose jointly beneficial strategies unless such strategies happen to be their dominant strategies. The collapse of the Pacific sardine fishery (McHugh 1972) and the collapse of the Antarctic blue whale fishery (Clark 1977) are tragic testimony to the capacity of these models to predict outcomes in empirical situations approximating the theoretical conditions.

Instead of being wrong, these are special models that utilize extreme assumptions rather than general theories. These models can successfully predict strategies and outcomes in fixed situations approximating the initial conditions of the models, but they cannot predict outcomes outside that range. They are useful for predicting behavior in large-scale CPRs in which no one communicates, everyone acts independently, no attention is paid to the effects of one's actions, and the costs of trying to change the structure of the situation are high. They are far less useful for characterizing the behavior of appropriators in the smaller-scale CPRs that are the focus of this inquiry. In such situations, individuals repeatedly communi-

cate and interact with one another in a localized physical setting. Thus, it is possible that they can learn whom to trust, what effects their actions will have on each other and on the CPR, and how to organize themselves to gain benefits and avoid harm. When individuals have lived in such situations for a substantial time and have developed shared norms and patterns of reciprocity, they possess social capital with which they can build institutional arrangements for resolving CPR dilemmas.

When models that assume no communication and no capacity to change the rules are applied to the smaller-scale CPRs, they are applied out of their range. Applying models out of range can produce more harm than good. Public policies based on the notion that all CPR appropriators are helpless and must have rules imposed on them can destroy institutional capital that has been accumulated during years of experience in particular locations, as illustrated by the Nova Scotian fishery cases.

That models are used metaphorically in applications to a wide diversity of situations, rather than to a limited set of conditions, should not be blamed entirely on policy analysts and public officials. Fads and fashions sweep through academia as well as elsewhere. Among many academics there are strong preferences for tight analytical models that will yield clear predictions. To make a model tractable, theorists must make simplifying assumptions. Many of these assumptions are equivalent to setting a parameter (e.g., the amount of information available to participants, or the extent of communication) equal to a constant (e.g., complete information, or no communication). Because the resulting model appears to be relatively simple, with only a few "moving parts," it may be considered by some to be general, rather than the special model that it is. Apparent simplicity and generality are not, however, equivalent. Setting a variable equal to a constant usually narrows, rather than broadens, the range of applicability of a model.

Further, policies based on models that represent the structures of situations as unchanging or exogenously fixed, even if repeated, lead to policy recommendations that someone external to the situation must change the structure. The analyst attempting to make a clear prediction about equilibria must hold some variables constant (and thus exogenous) while exploring the effects of a limited number of endogenous variables conceived to be under the control of those *in* the situation. These models demonstrate what individuals will do when they are in a situation that they cannot change. We do not learn from these models what individuals will do when they have autonomy to craft their own institutions and can affect each other's norms and perceived benefits. Nor do we learn how the capacity of innovators to develop institutions that can lead them toward better, rather

than worse, outcomes for themselves and for others might be enhanced or inhibited by the structures of the institutional arrangements of the surrounding political regime. It would, of course, be possible to develop models to describe how individuals can change the structure of the situation they face over time, but current policy analyses are based on the static models discussed in Chapter 1.

Analyzing the in-depth case studies can deepen one's appreciation of human artisanship in shaping and reshaping the very situations within which individuals must make decisions and bear the consequences of actions taken on a day-to-day basis. The appropriators in Alanya, Törbel, the Japanese mountain villages, Valencia, Ilocos Norte, the California groundwater basins, and even Mawelle all transformed the structures they faced, moving from a structure in which a set of unorganized individuals made independent decisions about using a CPR that yielded scarce resource units to a structure in which a set of organized individuals made decisions in a sequential, contingent, or frequency-dependent manner. The Sri Lankan farmers living on the large settlements were not able to transform the structure of incentives that they faced until external agents initiated small-scale changes that eventually were used as the foundation for major institutional changes. The fishers of Bodrum and the Bay of Izmir continue to experieince rent dissipation and appear unable to change the structure of the situation they face. The desert dwellers of Mojave may mine their underground basin dry, even though they tried to solve appropriation and provision problems by devising new, but inappropriate, institutions.

THE PROBLEMS OF SUPPLY, CREDIBLE COMMITMENT, AND MUTUAL MONITORING

Why is it that some appropriators can supply themselves with new rules, gain quasi-voluntary compliance with those rules, and monitor each other's conformance to the rules, whereas others cannot? As discussed in Chapter 2, institutional supply, credible commitment, and mutual monitoring are not easily explained using current institutional theories. In Chapter 3, I offered an initial explanation for credible commitments and mutual monitoring in which CPR rules conform to a set of design principles. The explanation also draws heavily on the assumptions made in Chapter 2 about fallible, norm-adopting individuals who pursue contingent strategies in complex and uncertain environments. Such individuals can be expected to make contingent commitments to follow rules that

- define a set of appropriators who are authorized to use a CPR (design principle 1),

- relate to the specific attributes of the CPR and the community of appropriators using the CPR (design principle 2),
- are designed, at least in part, by local appropriators (design principle 3),
- are monitored by individuals accountable to local appropriators (design principle 4), and
- are sanctioned using graduated punishments (design principle 5).

When individuals are presented with rules meeting these criteria, a safe, advantageous, and credible commitment can be made. The commitment is to follow the rules so long as (1) most similarly situated individuals adopt the same commitment and (2) the long-term expected net benefits to be achieved by this strategy are greater than the long-term expected net benefits for individuals following short-term, dominant strategies.

This is an advantageous strategy, because if most individuals follow it, they will be better off than they would be following short-term, dominant strategies. It is safe in that individuals following it cannot be exploited for long by others who break their commitments. If more than a minimal level of rule-breaking occurs, any individual following this contingent strategy can adjust his or her rate of rule conformance downward until the rule-following behavior of others returns to an acceptable level. An announced self-commitment to follow such a strategy – "I will if you will" – is credible when there is monitoring, because each person knows that unprovoked deviations are likely to be discovered. When an individual's rule infractions are discovered, the probability increases that others will reduce their rates of rule conformance to the detriment of that individual.

Because sanctions are graduated, individuals who commit themselves to a contingent strategy also know that if an emergency were to occur, in which following the rules would be disastrous, an occasional deviation would be subjected to only a small fine or other punishment. Similarly, an individual who makes an occasional error will face moderate sanctions. The imposition of some sanctions reassures the rule-breaker that deviations by others are also likely to be discovered. The way in which rules are enforced is forgiving of occasional lapses or errors and allows appropriators to avoid the high costs that can result from rigid application of uniform rules in a changing and uncertain environment. Continued rule infractions, however, will lead to an increase in the severity of sanctions.

If occasional rule infractions are not discovered, the rule-breaker is even better off in the short run. However, if one were to break the rules several times without discovery, one might revise one's estimate of the efficacy of the current monitoring system in deterring others from similar infractions. That would lead an occasional rule-breaker to adopt a higher rate of

rule-breaking behavior. Obviously, as undetected rule infractions become more frequent and CPR conditions become worse, the higher will be the probability that other individuals will increase their rates of rule-breaking behavior. Unless monitoring efforts are increased to reverse this trend, rule compliance will cascade downward. Thus, monitoring and graduated sanctions are necessary to keep the rate of rule-following high enough to avoid triggering a process in which higher rates of rule infractions fuel subsequent increases in rates of rule infractions.

Making a contingent rule-following commitment requires that individuals obtain information about the rates of rule conformance adopted by others. Otherwise, an individual cannot wisely pursue this contingent strategy. One way to obtain this information is to serve as a monitor from time to time. When the rules in use conform to the design principles discussed in Chapter 3 (enabling individuals to design rules that will keep monitoring costs low) and individuals adopt contingent strategies, individuals are also motivated to monitor each other to obtain the information they need to pursue this contingent strategy. Similarly, if individuals begin monitoring others and learn that others comply most of the time with a set of rules, they are more likely to be willing to adopt and/or continue contingent strategies.

Adopting contingent strategies enhances the likelihood of monitoring. Monitoring enhances the probability of adopting contingent strategies. Adding the capacity to use graduated sanctions initially for their informational value and eventually for their deterrence value, one can begin to understand how a complex configuration of rules used by strategic individuals helps to solve both the problems of commitment and the problems of mutual monitoring. The weight of the explanation does not fall on a single variable. Where individuals follow rules and engage in mutual monitoring, reinforcing institutional arrangements and individual strategies bolster one another so as to maintain enduring patterns of consistent, but not perfect, rule-following behavior.

What remains unexplained is how some appropriators overcome, and others do not overcome, the problems associated with collective provision of delicately calibrated institutions that create situations in which individuals find it advantageous, credible, and safe to pursue contingent commitments to rule compliance and mutual monitoring. Initial aspects of an explanation for institutional supply were presented at the end of Chapter 4, where the incremental, sequential, and self-transforming nature of institutional supply was analyzed in the context of a facilitative political regime. Most of the failure cases presented in Chapter 5 showed a different picture in which individuals were unable, because of internal and external

variables, to overcome the problems of collective provision of new rules.

Recent efforts to modify the theory of collective action to explain the achievement of collective benefits by individuals acting independently have focused almost entirely on variables that are internal to the situation. One or more of the following variables are consistently shown to influence outcomes:

1 the total number of decision makers,
2 the number of participants minimally necessary to achieve the collective benefit,
3 the discount rate in use,
4 similarities of interests, and
5 the presence of participants with substantial leadership or other assets.

These same variables are relevant to an explanation of the supply of institutions, because this is clearly a problem of collective action. Several of the cases can be explained using this set of variables alone. In Alanya, a relatively small number of fishers (100) who planned to live and fish in Alanya for many years (low discount rate) and who had very similar interests (all used the same technology) were able to organize and devise new rules, even though no one had substantial assets. In Bodrum and the Bay of Izmir, larger numbers of fishers (400 and 1,700), some of whom lived locally and some of whom came from some distance to fish there (disparate discount rates), and who had dissimilar interests (many different types of technologies in use, and four to six subgroups in each), were not able to organize and devise new rules, even though some of them had substantial assets.

But several anomalies exist.[1] The numbers of appropriators in two of the successful groundwater basins were quite large (700 and 750), the disparity of interests was substantial, and discount rates were relatively high, given all of the alternative opportunities available to entrepreneurs. The numbers of irrigators in the Spanish *huertas* were even larger (2,400, 4,800, 13,300, and 13,500), and the systems were large enough that upstream and downstream differences were substantial. Although the number of major groundwater producers who together could have made a substantial difference in groundwater conditions was less than the total number of pumpers, a similar relationship did not hold in the Spanish *huertas*. At the other extreme, the number of fishers in Mawelle was just over 200, and all had similar interests and low discount rates. Neither leadership nor the type of production function helps to account for the differences in results.

The most frequently used theories of collective action are too sparse and too difficult to interpret to be fully satisfactory as foundations for effective

policy analysis of institutional change. By "too sparse," I mean that key internal and external variables needed to explain self-organization are missing from the consideration. By "difficult to interpret," I mean that the theories do not yield clear implications for recommending public policies. What policy implications should one draw, for example, from knowing that the size of a group increases the difficulty of organizing collective action? Should one simply presume that small groups will take care of themselves, and that external authorities will have to govern and manage the CPRs used by larger groups? The anomalous cases illustrate that this is an inappropriate implication.

Let us take another look at the larger CPRs (within the universe of cases considered) and how those that have succeeded in solving problems of collective action have done so. All of these are characterized by design principle 8: the use of nested enterprises. The larger organizational units in these systems are built on previously organized smaller units. In the Spanish *huertas*, the fundamental organizational unit is the tertiary canal. The cost of organizing a group of farmers living near to one another and appropriating directly from the same canal is considerably less than the cost of organizing a large group of farmers many of whom never come into direct contact with one another. But once the smaller units are organized, the marginal cost of building on that organizational base is substantially less than the cost of starting with no prior base. Several of the Spanish *huertas* are three or four layers deep.

In the Philippine federation of *zanjeras*, the smallest unit is a work team of 5 to 10 members. Each of the individual *zanjeras*, comprising 20 to 75 members, is organized independently. Only after these units were in place did they federate into a larger unit. In the very large agricultural settlements in Sri Lanka, efforts to organize the farmers failed until the ARTI/Cornell team started to organize small, face-to-face groups of farmers to solve small problems that could be tackled effectively through ad hoc cooperation. Only after those first efforts to organize small, ad hoc groups of neighboring farmers were successful did they move to establish formal organizations of the farmers sharing field canals. Eventually the system that evolved in Gal Oya was four layers deep.

In the Raymond, West, and Central basins, the first step was the creation of a small, voluntary private association that enabled producers to obtain and disseminate accurate information about the condition of their resource. From there, several further enterprises were established, each built on the substructure that had already been created. Pumpers were able to call on public facilities – courts, a state department of natural resources, legislatures, special elections – to obtain information and to engage in

constitutional decision making that would be considered legitimate and enforceable. In Mojave, by contrast, the approach was to organize a very large unit and attempt to assign, all at one time, water rights for 15 different basins and an underground river system.

Success in starting small-scale initial institutions enables a group of individuals to build on the social capital thus created to solve larger problems with larger and more complex institutional arrangements. Current theories of collective action do not stress the process of accretion of institutional capital. Thus, one problem in using them as foundations for policy analysis is that they do not focus on the incremental self-transformations that frequently are involved in the process of supplying institutions. Learning is an incremental, self-transforming process.

If we now look at the smaller systems in which appropriators were not able to organize, we learn a second lesson. In Mawelle, a small group of 200 was not able to enforce its own prior rules basing entry to the CPR on family membership, nor was it able to induce government officials to enforce the national rule excluding new entrants. A small group of appropriators was able to influence national officials to prevent formal rules from being enforced. How the activities and policies of external political regimes can affect the level and type of self-organization to achieve collective benefits is not one of the five variables (see the foregoing list) included in current theoretical explanations of collective action. In Newfoundland, small groups of local fishers had been able to devise and maintain their own rules, but those CPR institutions were rendered frail when national authorities refused to recognize their existence.

On the basis of the case studies, I would argue that the activities of external political regimes were positive factors in helping most of the groundwater producers in southern California to self-organize, but such activities were negative factors in preventing continued self-organization in Mawelle and threatening it in Newfoundland. A theory of self-organization and self-governance of smaller units within larger political systems must overtly take the activities of surrounding political systems into account in explaining behavior and outcomes. To distinguish between the successful and unsuccessful instances of self-organization to solve CPR problems, one must take account of how the strategies of external actors affect the costs and benefits of CPR appropriators.

A third problem with current theories relates to the way that information and transactions costs are assumed away. To assume that complete information is freely available and that transactions costs can be ignored does not generate theoretical explanations that can be used in a setting where information is scant, potentially biased, and expensive to obtain and where

most transactions are costly.[2] Why individuals monitor each other's rule conformance would be difficult to explain using the assumption of complete information.

To summarize the foregoing discussion, there are three problems with the current theories of collective action that reduce their usefulness for providing a foundation for policy analysis of institutional change in smaller-scale CPRs. Current theories do not take into account

1 the need to reflect the incremental, self-transforming nature of institutional change,
2 the importance of the characteristics of external political regimes in an analysis of how internal variables affect levels of collective provision of rules, and
3 the need to include information and transaction costs.

Having recognized these problems, we can next ask how to start bridging the gap between current theories of collective action and empirical instances of collective action in CPR situations so as to move toward the development of more relevant theories of institutional change for policy analysis.

What is needed in the development of useful theory for the analysis of CPR situations – as well as many other important policy questions – is a somewhat different orientation toward the theoretical endeavor related to policy analysis. Clear analytical models provide an important part of the theoretical foundation for good policy analysis, but not the entire foundation. To get clear results from a model, some variables are omitted or consciously or unconsciously held constant. Models suggest to the analyst likely behaviors and outcomes in a situation with a *particular* structure. They do not tell the analyst how to discover the structure of the situation in order to conduct an analysis. Models that use assumptions such as complete information, independent action, perfect symmetry, no human errors, no norms of acceptable behavior, zero monitoring and enforcement costs, and no capacity to change the structure of the situation itself help the analyst derive precise predictions.

Models that make such assumptions do not, however, direct the attention of the policy analyst to some of the problematic variables of the situation that affect the incentives and behaviors of individuals. Assuming complete information about participant behavior does not push the analyst to examine how individuals in field settings obtain information, who has what information, and whether or not information is biased. Assuming independent action does not push the analyst to ask if individuals take into account the effects of their actions on the choices made by others. Assum-

ing zero-cost monitoring does not push the analyst to examine cost and effectiveness for various monitoring rules. Assuming fixed structure does not push the analyst to examine whether or not and how individuals change their own rules and how the surrounding political regime enhances or inhibits institutional change.

Frameworks that relate whole families of models together also provide an important part of the theoretical foundation for policy analysis, because they point to the set of variables and the types of relationships among variables that need to be examined in conducting *any* theoretical or empirical study of a particular type of phenomenon. From a framework, one does not derive a precise prediction. From a framework, one derives the questions that need to be asked to clarify the structure of a situation and the incentives facing individuals. Once the incentives are clarified, the theorist can analyze a situation and predict likely behavior in terms of choice of strategy and the consequences that are likely to result.

Consequently, instead of building a specific model of institutional supply, I shall develop a framework to summarize the lessons to be learned from examining successful and unsuccessful efforts by CPR appropriators to change their institutions. The framework identifies sets of variables that are most likely to affect decisions about continuing or changing rules. The framework can be used by theorists to develop more precise theories, and models of theories, of institutional choice. It can also be used to organize further empirical research to generate findings about the relative importance of particular variables in the context of other configurations of variables.

A FRAMEWORK FOR ANALYZING INSTITUTIONAL CHOICE

Institutional-choice situations, both constitutional-choice and collective-choice situations, as defined in Chapter 2, affect the rules used in operational situations. Decisions made in collective-choice situations *directly* affect operational situations. Decisions made in constitutional-choice situations *indirectly* affect operational situations by creating and limiting the powers that can be exercised within collective-choice arrangements (creating legislative and judicial bodies, protecting rights of free speech and property, etc.) and by affecting the decision regarding who is represented and with what weight in collective-choice decisions. Rather than examining constitutional-choice and collective-choice processes separately, I refer to both when I use the term "institutional-choice situation."

To analyze an institutional-choice situation, one needs to view it from

the perspective of the individuals making choices about future operational rules. Individuals who make institutional choices also make operational choices. When individuals face the question whether to retain or change status quo rules, the situation changes, but the individuals remain the same. Thus, one should use a similar conception of the individual when thinking about operational and institutional choices. In Chapter 2, I use a general conception of rational action involving four internal variables – expected benefits, expected costs, internalized norms, and discount rates – that affect individual choices of strategies in any situation. Individuals are perceived as weighing expected benefits and costs in making decisions as these are affected by internal norms and discount rates. Using this concept of rational action, one predicts that individuals will select strategies whose expected benefits will exceed expected costs. Without knowledge of the situational variables that affect benefits and costs, such a prediction is vacuous. This general conception of rational action places most of the explanatory weight on situational variables, rather than on assumptions made about the internal calculation process.[3]

In an institutional-choice situation, as shown in Figure 6.1, the basic alternatives available to an individual are (1) to support the continuance of the status quo rules or (2) to support a change in one or more of the status quo rules. Although more than one alternative may be considered at a time, the ultimate decision is between an alternative set of rules and the status

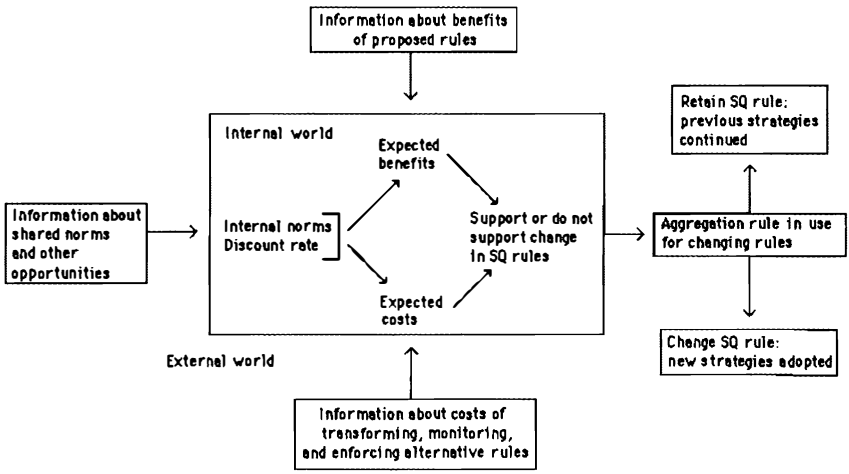


Figure 6.1. Summary of variables affecting institutional choice.

quo set of rules.[4] The strategies available to an individual are "to support" rather than "to choose" because no single individual makes institutional choices in other than totally monocratic systems. Whether or not a change in rules will be accomplished will depend on the level of support for the change and the aggregation rule used in the institutional-choice situation.

How an individual evaluates expected benefits in an institutional-choice situation depends on the information available to the individual concerning the benefits (or harm) likely to flow from an alternative set of rules as compared with the benefits (or harm) likely to flow from continued use of status quo rules.[5] How an individual evaluates expected costs depends on the information available to the individual concerning (1) the up-front costs involved in transforming status quo rules to an alternative set and (2) the net costs of monitoring and enforcement involved if one changes to an alternative rule configuration. Similarly, internal norms and discount rates are affected by the information that individuals have concerning the norms shared by other relevant individuals and concerning the range of opportunities that may or may not be available to them outside a particular situation. Data concerning *benefits, costs, shared norms*, and *opportunities* are *summary variables* that affect an individual's decision to support or not support a change in the status quo rules.

If the following three conditions are met, the institutional analyst need only ascertain the values of the summary variables to predict individual strategies:

1 Accurate summary measures exist for each summary variable.
2 Individuals completely and accurately translate information about net benefits and net costs into expected benefits and expected costs.
3 Individuals behave in a straightforward, rather than a strategic, manner.

The first condition is equivalent to stating that a valid and reliable benefit–cost analysis has been conducted to identify the net benefits of an alternative set of rules and that all of the net costs of transforming, monitoring, enforcing, and governing related to the alternative rules are known. Whereas policy models frequently assume that objective benefits and costs exist and can simply be used by individuals in making choices, individuals in natural settings have to invest resources to obtain information about benefits and costs.

Many of the calculations undertaken in field settings do not involve monetized costs or benefits. The Philippine farmers who invest their own labor to build and maintain their irrigation systems are able to judge the value of their labor in this activity versus the alternatives available to them. The costs of devoting 50 days to the *zanjera* are poignantly apparent to any

farmer trying to support a family. Further, it is also quite apparent how his agricultural yield responds to communal irrigation. The amount of labor contributed by each farmer is recorded in an attendance book kept by the *zanjera* secretary, but because they are not paid for this labor, it is not recorded elsewhere. Nor is the food produced for consumption recorded in market transactions. Individuals who are closely involved in such situations can make accurate judgments about the costs and benefits of alternative rules systems, taking into account a variety of monetized and nonmonetized benefits and costs. Individuals located in an administrative center will find it far more difficult to make good judgments about relative benefits and costs of alternative rules, because many of these costs and benefits are not recorded and summarized in the information available to those external to the situation.

The second condition is equivalent to stating that individuals are attentive to all available information and know how to weight that information in an unbiased manner. If both the first and second conditions were met, subjective benefits and costs would closely approximate objective benefits and costs. The third condition is equivalent to stating that individuals do not behave opportunistically in order to try to obtain benefits greater than those obtainable through straightforward behavior. This condition implies that individuals reveal their evaluations honestly, contribute to collective benefits whenever formulas exist for equitably assigning costs, and are willing to invest time and resources in finding solutions to joint problems. If this condition were met, some of the strategic behavior posited to occur in all social dilemmas would disappear.

Unfortunately for the analyst, few field settings are characterized by these three conditions, or even one or two of them. Variables such as the benefits of using an alternative set of rules or the costs of monitoring and enforcing a set of rules are rarely recorded in a form that an analyst (or the individuals making institutional choices) can resolve by simple computation. Consequently, one must go beyond the *summary variables* in analyses intended to be used in policy settings to the *situational variables* that affect them.

Evaluating benefits

Let me illustrate this process by discussing the situational variables that affect the summary variable "information about net benefits of alternative rules." For a participant or an analyst to develop a measure of the net benefits of an alternative set of rules, questions such as the following need answers:

1 What are the predicted average flows and the predicted values of resource units in the future under a proposed set of rules, as compared with the status quo rules?
2 How variable is the flow of resource units expected to be under a proposed set of rules, as compared with the status quo rules?
3 What quality differences will occur under a proposed set of rules, as compared with the status quo rules?
4 How long is the resource itself likely to generate resource units under a proposed set of rules, as compared with the status quo rules?
5 Will conflict be reduced, stay the same, or increase under a proposed set of rules, as compared with the status quo rules?

The ease or difficulty of answering these questions, as well as the specific answers to be obtained, will depend on a number of situational variables, including (1) the number of appropriators, (2) the size of the resource system, (3) the variability of resource units over time and space, (4) the current condition of the resource system, (5) market conditions, (6) the amount and type of conflict that has existed in the past, (7) the availability of recorded data on current conditions and historical appropriation patterns, (8) the particular status quo rules, and (9) the particular proposed rules (Figure 6.2). The first variable in this list – the number of appropriators – is included in most theories of collective action. The remaining situational variables are rarely considered.[6]

The larger the resource system and/or the number of appropriators, and the more unpredictable the flow of resource units and the market prices for these units, the more difficult and costly it is for anyone to obtain accurate information about the condition of the resource itself and the likely value of the flow of resource units under any set of rules. This can be offset, to some extent, if data on resource conditions, resource-unit quality, prices, and appropriation levels are recorded regularly. Prices and appropriation levels may be recorded for an inshore fishery, for example, if fishers bring all the fish they have caught to a single port to be sold. If fish are purchased by one or a few buyers, records of fish landings may be kept, and the purchaser may have a good picture of the harvesting patterns in these grounds. If the purchaser is motivated to share this information with the fishers, such as when the fishers create a marketing cooperative, the fishers may also gain accurate information about their prior catches and variations in the value of the catch over time. But if the purchaser is a monopolist, who has strategic reasons for withholding information, the purchaser may know much more than the fishers know about overall harvesting patterns.

The establishment of an official monitor (such as the watermaster in the

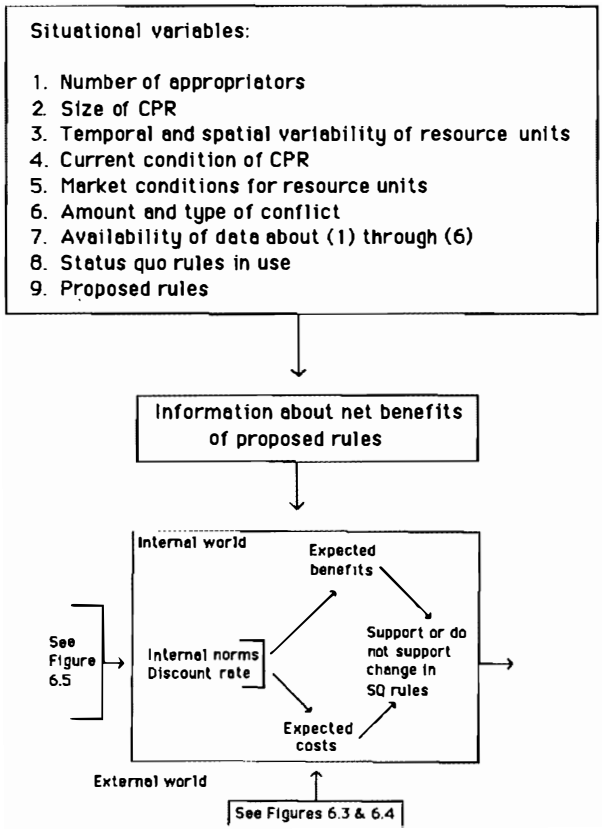


Figure 6.2. Situational variables affecting judgment about the benefits of an institutional choice.

groundwater cases and the local officials in the Swiss and Japanese mountain commons) provides information to appropriators that they would not otherwise obtain, information about appropriation levels and the condition of the resource system itself. The presence of appropriator organizations, such as cooperatives or voluntary associations, usually will increase the amount of information obtained and disseminated among appropriators concerning the variables that will affect whether or not a change in rules will produce a net benefit.

Thus, whether or not an individual perceives any benefits to be derived from a change in rules will depend on (1) the objective conditions of the

CPR, (2) the type of information that the current institutional arrangements generate and make available to individuals, and (3) the rules proposed as alternatives. It should now be clear that whether or not benefits can be obtained by changing rules is not a "fact" that simply exists in the world to be used by anyone – appropriators, analysts, or public officials – who wants to improve welfare. Information about benefits must be searched for, organized, and analyzed.

Evaluating costs

Information about costs is also strongly affected by situational variables. Two major costs affect institutional choice. First are the up-front costs of transforming the rules. If the expected costs of transforming the rules are higher than the net benefits to be gained, no further cost calculations will be made. Appropriators will retain their status quo rules that produce fewer benefits than would alternative rules, because the costs of changing the rules are higher than the benefits to be obtained. If the ex ante costs of transforming the rules are not too high, expected changes in ex post costs will also be evaluated, including the effects of proposed rules on monitoring and enforcement costs. We shall first examine the situational variables that affect information about transformation costs (Figure 6.3).

Transformation costs. Transformation costs are the resources devoted to the process of considering a rule change (Buchanan and Tullock 1962). Many of the variables considered important in current theories of collective action, as listed earlier, affect transformation costs. Transformation costs are, for example, positively related to the number of individuals making institutional choices, the heterogeneity of interests at stake, and the proportion of individuals minimally necessary to achieve a change in status quo rules (set by the rules that govern the process of changing the rules). Transformation costs are lower when skillful leaders are involved. Because transformation costs are up-front costs, they are less likely to be affected by the discount rates used by participants. The sum of transformation costs is not affected by the presence of individuals who have substantial assets at stake, but the likelihood that these costs will be paid is positively related to the presence of individuals who will derive substantial benefits from a change in rules.[7]

Several variables affecting transformation costs are not included in the list cited earlier, however. The type of proposed rule, for example, affects transformation costs. The transformation costs of setting up a strictly private association of appropriators to discuss common problems are con-

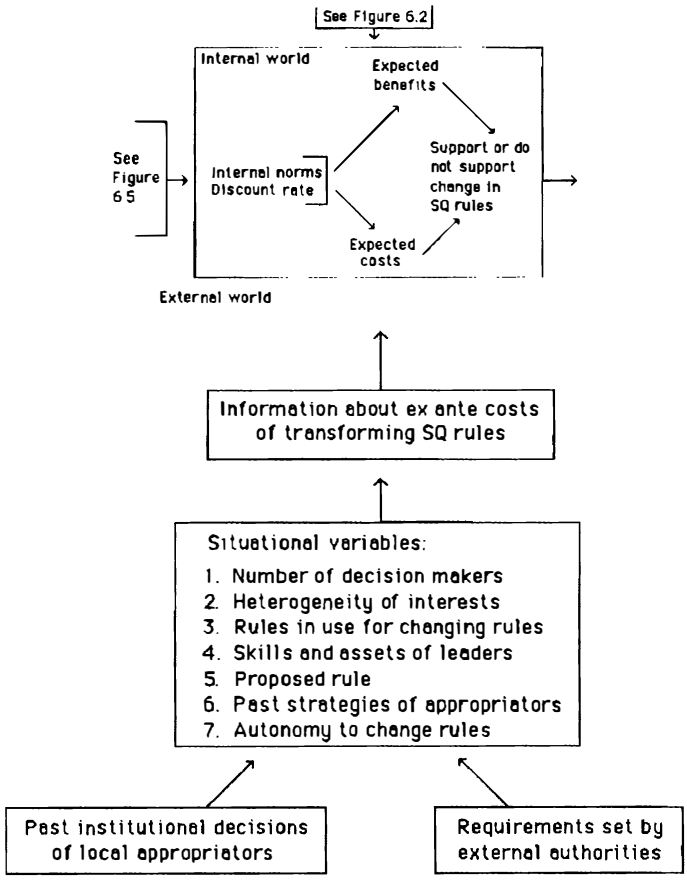


Figure 6.3. Situational variables affecting judgement about the costs of transforming status-quo rules.

siderably less than the transformation costs of creating a local public jurisdiction that can impose taxes on all citizens living in its boundaries. Rules are normally changed sequentially. Proposed rules with positive expected benefits and low transformation costs are likely to be adopted before rules with high transformation costs. If appropriators start with low-cost changes, they can gain experience concerning the costs of changing the rules in their setting before attempting changes that will require substantial transformation costs. If the transformation costs for changing some rules are low enough, one or two individuals may receive sufficiently

high benefits from the change to pay the entire costs themselves. Consequently, some of the steps in the process of institutional development may not be second-order dilemmas, even though others may have this structure. Further, achieving the benefits of small rule changes will transform the calculus involved in evaluating larger changes.

The norms that individuals share concerning appropriate strategies when engaging in collective choice will affect transformation costs directly and indirectly. When individuals adopt confrontational strategies, for example, transformation costs rise sharply (Scharpf 1989). When some individuals fear that others will attempt to organize minimal winning coalitions to impose costs on losers, that will affect their willingness to adopt changes that would reduce the inclusiveness of the rules to be used in the future. Thus, appropriators who share norms that restrain opportunistic behavior can adopt rules that are less costly to operate than are the rules adopted by appropriators who do not share such norms.

The rules instituted at one time will also affect the transformation costs (or costs of governing) at a later time. Changes in operational rules will affect benefit levels and their distribution to appropriators. Major changes in the level and distribution of benefits can increase or decrease the level of conflict among appropriators and the consequent difficulty that individuals will have in achieving future agreements.[8]

Whether or not appropriators have substantial autonomy to change their own rules will also affect the costs of transformation. Highly centralized regimes attempt to rely on the same operational rules in all locations within their territory.[9] If that is the case, local appropriators must convince a central authority to change the rules in use in all similar settings or convince the authority that an exception can be made in their case. In an honest regime, considerable time must be devoted to any effort to change rules set by central authorities. Time is spent in bureaucratic offices explaining the problem and what is wanted and consulting with others who will be affected by a change, in order to forestall their opposition. Time is spent waiting for an answer. If the request is turned down, time may be spent in appeal processes. In a corrupt regime, bribes may be sufficient to get officials to authorize a rule change or to ignore the fact that local appropriators are using a set of internal rules different from those legally required.[10] Also, in a corrupt regime, an influential person may be able to prevent a rule change by bribing an official.

In a regime that allows substantial local autonomy to engage in constitutional and collective choices, appropriators may be authorized to select their own rules so long as they follow certain procedures. The required procedures may vary from informal mechanisms that will ensure consulta-

tion to formal mechanisms including signed petitions, special elections, legislation, and court proceedings. The aggregation rule to be used frequently is specified in these procedures. The more inclusive the aggregation rule that must be used in making constitutional- or collective-choice decisions, the higher the costs of decision making, and the lower the losses that will be suffered by those protected by status quo rules (Buchanan and Tullock 1962).

Where regular procedures exist for transforming rules, appropriators may be able to estimate transformation costs precisely. If a charter of association is required before setting up private associations or cooperatives, a lawyer can provide a close estimate of the cost of drafting such a charter. If calling a special election to create a district requires 1,000 signatures on a petition, experienced organizers can provide a relatively good estimate of the cost that will be involved in obtaining those signatures.

Where appropriators face officials who have considerable discretion whether or not to allow them to change the rules, estimating transformation costs may be difficult. If such permission has required substantial legal or illegal payments in the past, appropriators may not attempt to change the rules for fear that the costs will be far greater than the benefits to be obtained. One would thus expect less rule innovation and change by appropriators living under political regimes that give regional and national officials considerable discretion whether or not to authorize changes in the rules governing access and use of a CPR, as compared with a jurisdiction in which more autonomy is allowed.

The autonomy of individuals to change their rules will be affected by the location of their CPR and the effectiveness of the political regime under which they live. Autonomy may not be formally extended, but may result primarily because of the distance between a CPR and the nearest administrative or political officials. Appropriators living in remote CPRs usually have more autonomy than those located near governance centers. Whether or not a particular CPR is remote obviously is also affected by the number of officials the political regime employs, the effectiveness of the administrative and political apparatus of the political regime, and the extent of the communication and transportation facilities involved.

The situational variables that affect information about transformation costs are themselves affected by the institutional requirements set by external authorities and the past institutional decisions made by local appropriators. The autonomy of a set of local appropriators to make their own rules is, of course, strongly dependent on what is allowed or forbidden by central authorities, modified by distance and the capacity of the external

authorities to enforce their rules. The rules that govern the process of changing the rules, the number of decision makers who must be involved, and the resultant heterogeneity of represented interests are affected by the past decisions made by external authorities or local appropriators or both.

Once decisions of a particular type have been made, future options will be strongly affected. To understand institutional-choice processes, one must view them as historical processes whereby current decisions are built on past decisions. Prior decisions may open up some future options for development, and close out others.[11] The groundwater pumpers of Raymond Basin did not necessarily recognize that as soon as they allocated a defined quantity of water to each and every pumper, a market in water rights would emerge, but that is what happened. Similar markets appeared in West Basin and Central Basin. Once a watermaster had been appointed to monitor the usage patterns of all pumpers, the cost of administering a pump tax on withdrawals was substantially less than it would have been if a different type of legal settlement had been adopted. On the other hand, once water rights were assigned on a proportional basis, any future rules that might have protected the rights of municipal water companies above the rights of others using those basins were precluded from further consideration.

Thus, the past exerts its influence on institutional choices in several ways. Current operational rules – the status quo rules – are the results of past decisions. Status quo operational rules always protect some individuals and expose others. A proposed change in these rules must be supported by a set of individuals large enough to have the authority to change them, given status quo collective-choice or constitutional-choice rules for changing the rules. In almost all procedures used in a given collective-choice or constitutional-choice arena, the status quo rules will have a privileged procedural position. Past institutional choices open up some paths and foreclose others to future development.

Monitoring and enforcement costs. When appropriators contemplate changing their rules, part of the calculation has to do with the costs of monitoring and enforcing the new rules. Observing the activities of a diverse set of individuals and assessing whether or not their actions or the outcomes they produce are permitted by a set of rules involves the use of time and other resources that could be devoted to other activities. Monitoring activities frequently are undertaken by the appropriators themselves, either as they go about their normal activities (such as fishers who watch for boats owned by outsiders) or as a special job into which they rotate

(such as irrigators, each of whom is responsible for inspecting an irrigation canal for a specified period of time). Maintaining courts, police, and detention facilities to enforce rules also involves the use of resources that could be utilized productively for other purposes.

Monitoring costs are affected by the physical attributes of the resource itself, the technology available for exclusion and appropriation, marketing arrangements, the proposed rules, and the legitimacy bestowed by external authorities on the results of institutional choices (Figure 6.4). The larger the resource, the greater the costs of "fencing" and/or patrolling the boundaries to ensure that no outsider appropriates. For many natural resources, such as fisheries, fencing is physically impossible. Even maintaining effective markers may be costly. Inshore fisheries, particularly those located in lagoons or bays, involve lower exclusion costs than do offshore

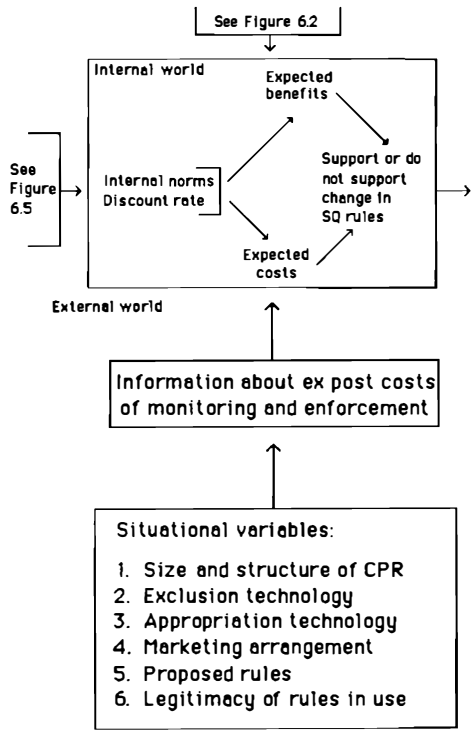


Figure 6.4. Situational variables affecting judgments about monitoring and enforcement costs.

fisheries. For resources such as groundwater basins or oil pools, the resource units move underground to the area that is most heavily pumped. Even determining the physical boundaries of such resources requires expensive geologic studies. Once the boundaries are well established, however, the presence of a renegade well may be difficult to disguise. The primary cost of exclusion may then be the legal action required to stop an unauthorized user from continuing to use a resource.

Factors that enhance the capacity of users to see or hear one another as they are engaged in appropriation activities tend to lower monitoring and enforcement costs. Alternatively, if appropriators all return to the same location at the end of their activities, so that the quantity of resource units each has acquired is open for casual inspection, monitoring costs will be low. The presence of a shared norm that rules decided on by the appropriators themselves should be followed will offset many physical disadvantages in monitoring a particular resource. Shared norms related to the legitimacy of the rules and the imperative that they be followed will reduce the costs of monitoring, and their absence will increase those costs. The availability of low-cost facilities for recording and disseminating information about regulated activities will also decrease monitoring costs.

Rules themselves vary in terms of monitoring and enforcement costs. The more frequent the required monitoring, the greater the resources devoted to measurement. Rules that unambiguously state that some action – no matter who undertakes it – is proscribed are less costly to monitor than are rules that require more information about who is pursuing a particular behavior and why.

Rules specifying the opening and closing dates of seasons, such as those used in Swiss and Japanese mountain commons, are far less costly to monitor than are rules that specify a quota for every appropriator in regard to a quantity of appropriation activities (e.g., acre-feet of water pumped, or tons of fish caught). Anyone found appropriating from the resource before or after the official season is unambiguously breaking the rules. Any appropriator can challenge such unauthorized use without fear that the charge will later be declared unfounded. Rules limiting harvesting technology, such as those used in the Nova Scotian fisheries, are also less costly to enforce, as compared with rules specifying a quantity of a resource to be withdrawn.

Rules that bring together those who would be tempted to cheat and those who would be particularly harmed by such cheating are also easier to monitor than are rules that depend on accidental discovery of a rule-breaker by someone who may be only indirectly harmed by the infraction. When irrigators using a canal are assigned particular time slots, as in

Murcia and Orihuela, each is motivated to be sure to receive his full time slot of water and to be sure that the next irrigator does not try to take water too soon. At the time of a switch from one irrigator to the next, both are likely to be present. They ensure by their presence that the rules are being followed. Monitoring the rules devised in the Alanya fishery involves minimal costs, for similar reasons.

Rules that place a limit on the quantity of resource units that can be produced during an entire season or year are more costly to enforce. Whether or not it is economically feasible to use quotas (which may be marketable) will depend on the regularity of the flow, the amount of storage in the CPR, the types of records that can be kept routinely, and the value of the resource units themselves.

In addition to the physical attributes of the resource and the specific rules contemplated, another factor affecting monitoring and enforcement costs is whether or not the authorities of the surrounding jurisdiction recognize the legitimacy of local rules. The Mawelle case documents clearly that when external authorities refuse to enforce a local rule excluding participants, or even their own rule, local appropriators may not be able to keep new entrants out, even though they strongly desire to do so. In some areas of the world, regional or national governments are supportive of locally developed property systems, and local appropriators are able to count on the help of government officials, at relatively low cost, to exclude outside appropriators if the threats of local appropriators are not sufficient.

In those areas where national governments fail to respect the property rights that local appropriators have developed for themselves (such as Nova Scotia and Newfoundland), exclusion costs can become very high (Cordell and McKean 1986; A. Davis, 1984; Matthews and Phyne 1988). In fact, indigenous institutions that have evolved in remote locations may become untenable at later junctures if those areas become attractive to external users who have the backing of a regional or national government. Some national governments have provided considerable economic support for the development of modern fishing fleets that have then successfully invaded inshore fisheries that previously were "owned" by local fishers. Without the advantage of being considered legitimate, a small group of local appropriators can face high costs in trying to exclude well-financed, government-supported users who do not have local property rights.

Evaluating shared norms and other opportunities

How individuals weight their own assessments of benefits and costs will depend on the norms that they internalize and the discount rates that they

utilize. Coleman (1987a) distinguishes between norms that are internalized by individuals, where the sanctioning for nonconformity is an internal cost (e.g., guilt, anxiety, lowered conception of self-worth), and shared norms, where the sanctioning for nonconformity comes from others who are part of the same group and exhibit social displeasure if a norm is broken. Individuals frequently internalize a shared norm, in which case lack of conformity involves both internal psychic and external social costs.

Appropriators who live near the CPR from which they appropriate and who interact with each other in many situations other than the sharing of their CPR are apt to develop strong norms of acceptable behavior and to convey their mutual expectations to one another in many reinforcing encounters (Figure 6.5). The reason for the general hostility of inshore, small-boat fishers toward large-scale trawlers is not simply that the appropriation technology used by the trawlers is so much more powerful than theirs. Often the operators of trawlers live elsewhere, belong to different ethnic or racial groups, and share few of the local norms of behavior. They do not drink in the same bars, their families do not live in the nearby fishing villages, and they are not involved in the network of relationships that depend on the establishment of a reputation for keeping promises and accepting the norms of the local community regarding behavior.

Appropriators who are involved in activities that take them away from their CPR and into an economy in which other opportunities exist are most likely to adopt a high discount rate than are appropriators who presume that they and their children are dependent on the local CPR for major economic returns. It is also the case that shared norms can affect discount rates as much as can information about other opportunities. Individuals

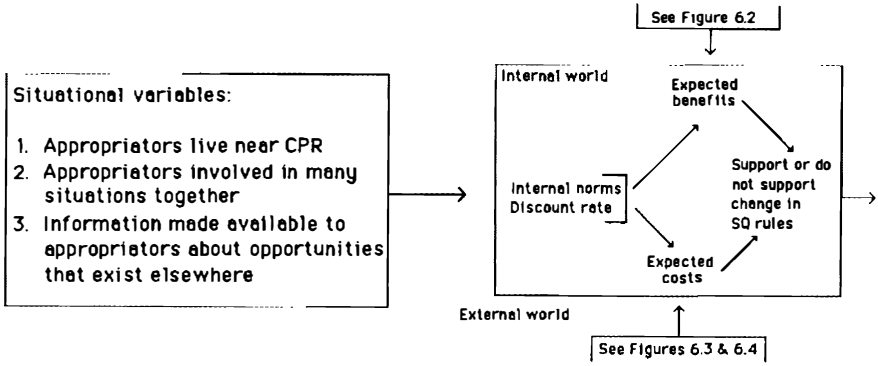


Figure 6.5. Situational variables affecting internal norms and discount rate.

living in a community where disregard for the future is censured by others will have a lower discount rate than will individuals living in a community where no opprobrium is attached to seeking short-term gain in preference to long-term benefit.[12]

The process of institutional change

One can predict that in a highly competitive environment, those who do not search for and select alternative rules that can enhance net benefits will lose out to those who are successful in adopting better rules. It is the operation of firms in competitive, or at least contestable, markets that enables theorists to predict that surviving firms will choose strategies that will maximize profits (Alchian 1950). Theoretical equilibria exist in market models after all of the inefficient or non-profit-maximizing firms have been eliminated. The process of getting to equilibrium is not the focus of these models; rather, they focus on the characteristics of the market and the firms in the market at theoretical equilibrium. That many firms do not maximize profits prior to equilibrium is unimportant when the theoretical question of interest concerns the characteristics of actors who are present at equilibrium. The institutional arrangement of an open market and the theoretical interest in static equilibria enable theorists to posit maximization of a single variable – profits – as an internal decision rule for rational individuals in a market situation. Further, price is a sufficient statistic for summarizing an incredible amount of specific information of value to an entrepreneur. Profit maximization is a useful theoretical tool for predicting behavior in static market situations; it does not enable a theorist to predict which firms are most likely to survive or to predict innovative technological or institutional changes.[13]

CPR situations are rarely as powerful in driving participants – even survivors – toward efficiency as are competitive markets. Nor is there any single variable, such as market price, that can be used as the foundation for making rational choices in a CPR environment. Simply following short-term profit maximization in response to the market price for a resource unit may, in a CPR environment, be exactly the strategy that will destroy the CPR, leaving everyone worse off. Nonmonetized relationships may be of importance. It is thus not a judicious theoretical strategy to presume that choices about rules are made to maximize some single observable variable. The level of uncertainty when selecting new rules is far greater than the level of uncertainty when selecting pricing strategies when demand and supply are fixed. The intended outcomes of using new rules are not automatically achieved. They depend on many future choices to be made by

many different individuals as to how they interpret the meaning of the rules and whether or not they will follow the rules, monitor each other, and impose sanctions on nonconformance.[14]

Instead of viewing decisions about changes in rules as mechanical calculation processes, a better theoretical stance is to view institutional choices as processes of making informed judgments about uncertain benefits and costs. It is then possible to draw on the empirically supported theoretical work of social psychologists concerning the processes of human judgment in an effort to characterize the institutional-choice process.[15] All human judgment in uncertain and complex environments is subject to several known biases.

Individuals weight, for example, potential losses more heavily than potential gains (Hardin 1982; Kahneman and Tversky 1979). Consequently, individuals will differentially weight the expected benefits of avoiding future harms more heavily than the benefits of producing future goods. From this, one can derive several general predictions about situational variables that are apt to lead individuals to adopt new rules to protect CPR resources. The propensity of political leaders to discuss CPR problems in terms of "crises" is far more understandable once one takes into account that individuals weight perceived harms more heavily than perceived benefits of the same quantity. Further, one should expect that resource systems that can be rapidly destroyed (such as fish populations that cluster together rather than disperse) are far more difficult to govern by appropriators, or anyone else, than are CPRs that are somewhat more resilient following damage.

One should expect individuals to be willing to adopt new rules that will restrict their appropriation activities when there are clear indicators of resource degradation, generally perceived to be accurate predictors of future harm, or when leaders are able to convince others that a "crisis" is impending. Gilles and Jamtgaard (1981), for example, argue from several empirical studies that whether grazing areas are used to produce milk or wool or meat can affect the ability of the appropriators to learn more rapidly about adverse conditions, should they arise. Milking occurs daily, and variations in yield are rapidly apparent to the herders. Wool is sheared less frequently, but the quality of wool is immediately apparent to those who herd sheep. The quality of meat produced for market is monitored less frequently and may not even be known by herders. Consequently, the quality and timeliness of the information that CPR appropriators obtain about their resource vary according to how a resource unit is used, as well as across resource types. The problems of groundwater pumpers in obtaining accurate and valid information about the condition of their CPR are

more daunting than those of herders, regardless of the final products of herding activities.

As compared with uncertain benefits and costs extending over time, up-front transformation costs are easier to calculate and sometimes are substantial. All appropriators pay more attention to immediate costs than to benefits that will be strung out over the future. Given the tendency of decision makers to weight prospective losses more heavily than possible gains, transformation costs take on added importance in the judgments made by appropriators in regard to changing their rules. It is highly unlikely that CPR appropriators will pay immediate transformation costs to change their rules if the discounted net benefits of a rule change are not expected to be large.

The capacity of individuals to make accurate estimates of frequency-based probabilities is also quite limited. Individuals are apt to weight recent events more heavily than events more distant in a long history of experience. One should expect rule changes to be made after a series of relatively bad yields from a CPR, but not to be made after a series of relatively good years. Proponents of new institutions related to water supply problems pray for dry weather immediately preceding special elections or other decision points affecting institutional choice.[16] When the quantity of resource units varies wildly from season to season, it is particularly difficult for appropriators to obtain accurate estimates of average yields and to make reasoned judgments about the meaning of low yields. It is easy to argue that the resource has had low yields in the past and has recovered, when that has been the shared experience. It is far more costly to keep accurate records over a long period of time and to gain sufficient technical expertise to make accurate predictions about the future.

The particular set of rules that appropriators, or others, contemplate rarely contains all possible rules that might be used to govern an operational situation. The rules that are proposed are likely to be in a repertoire of rules already familiar to those who propose them. Given the substantial uncertainty associated with any change in rules, individuals are less likely to adopt unfamiliar rules than they are to adopt rules used by others in similar circumstances that have been known to work relatively well. In a setting in which considerable experimentation has occurred with diverse rules, appropriators learn about the effects of different rules by analyzing the experiences of appropriators using similar CPRs with different rules.

In southern California, for example, groundwater pumpers in West Basin and Central Basin were able to learn from the experience of those in Raymond Basin before they adopted variants of the rules used in Raymond Basin. Institutional arrangements that encourage communication among

individuals facing similar problems, such as regionwide associations, increase the knowledge base about how different rules work in practice. The wrong lessons can also be learned. Some of the water users in the Mojave Desert presumed that they could apply the strategy of litigation and formation of special districts, as used in Raymond, West, and Central Basins. Instead of applying the lesson by starting with small incremental changes at the basin level before attempting to build interbasin institutions, they went to the interbasin level first, before designing intrabasin institutions. What worked as an incremental bottom-up strategy at the basin level did not work when attempted at a regional level.

So far, I have not addressed the individual differences that may exist among individuals involved in an institutional-choice situation. The benefits to be derived from status quo rules or alternative rules may not be perceived similarly by all appropriators from a given CPR. If a current set of rules protects one subset of appropriators, while leaving others exposed to future harm, the two groups will evaluate the status quo rules differently. Some appropriators may be protected by their physical location (rather than by the rules in use) so as to be less exposed than others. Upstream appropriators (such as the city of Hawthorne in West Basin) may view proposed rule changes to restrict appropriation rates as providing few benefits to them. Because of their physical location, they will derive benefits from access to the CPR long after others have been eliminated. Proposed rules are apt to have strong distributional effects (Libecap 1989).

Predicting institutional change

Clearly, we can reject the notion that appropriators are incapable of supplying their own institutions to solve CPR problems, but we cannot replace it with a presumption that appropriators will adopt new rules whenever the net benefits of a rule change will exceed net costs. Net benefits and costs from a change in the operational rules related to a CPR do not exist in the world as independent variables easily available to CPR appropriators or officials of external regimes to use in a simple maximization calculation. Benefits and costs have to be discovered and weighed by individuals using human judgment in highly uncertain and complex situations that are made even more complex to the extent that others behave strategically.

Designing and adopting new institutions to solve CPR problems are difficult tasks, no matter how homogeneous the group, how well informed the members are about the conditions of their CPR, and how deeply ingrained are the generalized norms of reciprocity. Given the strong temptations to shirk, free-ride, and generally act opportunistically that usually

are present when individuals face CPR problems, overcoming such problems can never be assured. No strong external pressures drive individuals toward positive solutions to such problems. To the extent that there are strong pressures toward unique outcomes, they are more likely to be the deficient equilibria posited in the three models discussed in Chapter 1. We know that it is possible for individuals to use their capacities for self-reflection, communication, and self-commitment to design new rules to solve CPR problems, but we cannot assert necessity. Further, if individuals find rules that work relatively well, they may have little motivation to continue the costly process of searching for rules that will work even better. "If it ain't broke, don't fix it" applies as much to institutional capital as to physical capital.

Having stressed the importance of specific situational variables as they affect human judgments about the benefits and costs of institutional changes, I shall now summarize what I think can be said about predicting institutional change. To do this, it is essential to consider not only the variables that characterize a particular CPR situation but also the type of external political regime under which the CPR is operated.

To start this examination, let us consider a CPR in which appropriators face problems in a remote location under a political regime that is basically indifferent to what happens with regard to CPRs of this type. This is a "zero condition" in regard to the role of an external regime in affecting internal choices. In such a setting, the likelihood of CPR appropriators adopting a series of incremental changes in operational rules to improve joint welfare will be positively related to the following internal characteristics:

1 Most appropriators share a common judgment that they will be harmed if they do not adopt an alternative rule.
2 Most appropriators will be affected in similar ways by the proposed rule changes.
3 Most appropriators highly value the continuation activities from this CPR; in other words, they have low discount rates.
4 Appropriators face relatively low information, transformation, and enforcement costs.
5 Most appropriators share generalized norms of reciprocity and trust that can be used as initial social capital.
6 The group appropriating from the CPR is relatively small and stable.

These variables are weakly ordered, beginning with those that I think are most important in affecting the likelihood of individuals agreeing to new rules that will improve welfare, and ending with those that I think are

somewhat less important. Although considerable emphasis has been placed on the size of the group involved in collective-action problems, I consider the first five variables to be more important than the number of persons involved.[17]

Most CPRs in the modern world are not found in isolated settings. The closer the CPR is to other centers of economic activity, the more likely it is that the population of the area, the value of the resource unit, and the activities of appropriators in nearby CPRs will change in ways that will adversely affect the outcomes achieved in the subject CPR. In nonremote locations, the orientation of the ruling political regime can make a substantial difference in whether local appropriators supply their own institutions or are dependent on external authorities to solve their problems.

Individuals who are not able to supply new rules in an indifferent setting may succeed in adopting new rules under a political regime that allows substantial local autonomy, invests in enforcement agencies, and provides generalized institutional-choice and conflict-resolution arenas. In other words, regional and national governments can play a positive role in providing facilities to enhance the ability of local appropriators to engage in effective institutional design. This positive role is quite different from the one envisioned in proposals to centralize control of natural resources. I illustrated this difference in Chapter 1 with the analysis based on Games 2, 3, and 4, on the one hand, and Game 5, on the other. The difference is also illustrated in the cases by the strategies adopted by the Department of Water Resources in California, as compared with the Canadian Department of Fisheries and Oceans in Newfoundland. I strongly doubt that the groundwater pumpers of Raymond, West, and Central basins would have been able to craft the institutional innovations that they devised had it not been for the professional informational services provided by the U.S. Geological Survey and the California Department of Natural Resources. Although the appropriators paid a share of the costs of the technical studies performed, they did not have to cover the full costs, and the governmental agencies already had substantial information about the geologic structure of southern California in hand.

Further, if they had not been able to use an equity court proceeding, it would have been extremely difficult to arrive at a negotiated settlement of water rights that would have been considered legitimate by all participants. Again, the participants paid a share of these costs, as did the state of California. Other generalized institutional facilities were used when local appropriators drafted state legislation and negotiated with others across the state to take their interests into account. This proposed legislation was then enacted by the state legislature, and it provided the foundation for

organizing several special-purpose districts and interdistrict arrangements.

The role of the surrounding political institutions in the California groundwater cases did not stop simply with providing generalized facilities. State and local officials also have oversight responsibilities. When special districts were considered, the proposed boundaries of new districts had to be reviewed to ensure that nonbeneficiaries, who would receive nothing for the taxes they contributed, would be excluded. Although the court was willing to agree to a negotiated settlement drawing on a new concept negotiated around a bargaining table, the participants would not have received similar approval for any negotiated settlement that would have taken water rights from some participants and given them to others. The oversight of local and state officials to ensure equitable solutions was an important factor in reaching those solutions. Given the heterogeneity of interests, the lack of accurate information about the groundwater basins, the large number of participants, the relatively high discount rates, the unwillingness of participants to rely on voluntary reciprocity, and the high transformation costs, it is highly doubtful that had these CPR appropriators faced an indifferent political regime they would have been able to supply new institutions to solve the difficult problems facing pumpers in Raymond, West, and Central basins. The failure of the Mojave pumpers to achieve similar success helps to illustrate that even given such a political regime, successful resolutions of difficult problems are not guaranteed.

Having considered the effects that indifferent and facilitative regimes can have on the likelihood that appropriators will adopt new rules that will enhance joint outcomes, let us turn to what can be expected from a regime whose officials presume that they, rather than the appropriators, must solve CPR problems. Let us first posit honest officials, who are seriously interested in helping to solve CPR problems. Once national or regional governmental officials indicate that they consider it their responsibility to solve CPR problems, one can expect local appropriators who do not already have local institutions in place to wait for the government to handle their problems.[18] If someone else agrees to pay the costs of supplying new institutions, it is difficult to overcome the temptation to free-ride. Then the problem for some appropriators is how to present the "facts" of the local situation in such a way that officials who may not know the local circumstances well will be led to create institutions that will leave some individuals better off than others.[19] Those individuals who have the resources to enable them to make the best case to external officials are most likely to gain rules (or exceptions to rules) that will advantage them the most.

One can expect that honest, hard-working regional or national officials may well supply new CPR institutions well adapted to local circumstances

in some of the CPRs under their jurisdiction. But the tendency to try to impose uniform rules throughout a jurisdiction, rather than specialized rules that apply to localities within a jurisdiction, makes it extremely difficult for such officials to set up and enforce rules that will seem effective and fair to local appropriators. Trying to get local appropriators to commit themselves to follow rules that are perceived to be ineffective and inequitable is difficult, and the costs of monitoring and enforcing such rules are bound to be higher than for rules crafted by participants to fit local circumstances.

If, instead of honest officials, one posits corrupt centralized regimes, the problems involved in institutional supply become more difficult. It may be possible for local appropriators to create their own local institutions outside the legal framework. One would expect, however, that any set of local appropriators capable of accomplishing that difficult task would be very homogeneous, would have good information about their CPR and about the behaviors of their peers, would have very low discount rates, and generally would exhibit all of the desirable characteristics listed earlier in the extreme. A more probable result would be that experienced by the settlers in the Kirindi Oya irrigation system in Sri Lanka, where no one cooperated with anyone else, and all lived in a hydrologic nightmare.

A CHALLENGE TO SCHOLARSHIP IN THE SOCIAL SCIENCES

This framework for analyzing problems of institutional choice illustrates the complex configurations of variables that must be addressed when individuals in field settings attempt to fashion rules to improve their individual and joint outcomes. The reason for presenting this complex array of variables as a framework rather than as a model is precisely because one cannot encompass (at least with current methods) this degree of complexity within a single model. When one chooses to model relationships, one can include only a subset of variables, and even then it is usually necessary to set some of these equal to zero or to an absolute value. The typical assumptions of complete information, independent action, perfect symmetry of interests, no human error, no norms of reciprocity, zero monitoring and enforcement costs, and no capacity to transform the situation itself will lead to highly particularized models, not universal theories. It is as essential to map the terrain for a family of models as it is to develop specific models. If the social sciences are to be relevant for analyses of policy problems, the challenge will be to integrate efforts to map the broad terrain and efforts

to develop tractable models for particular niches in that terrain. Each CPR can be viewed as a niche in an empirical terrain.

The intellectual trap in relying entirely on models to provide the foundation for policy analysis is that scholars then presume that they are omniscient observers able to comprehend the essentials of how complex, dynamic systems work by creating stylized descriptions of some aspects of those systems. With the false confidence of presumed omniscience, scholars feel perfectly comfortable in addressing proposals to governments that are conceived in their models as omnicompetent powers able to rectify the imperfections that exist in all field settings.

In contemporary conceptions of social order, "the government" often is seen as an external agent whose behavior is exogenous to the situation being modeled. Sugden argues that policy analysts taking this view see themselves as analyzing the behaviors of private individuals and then advising "the" government as to what should be done:

> Most modern economic theory describes a world presided over by a *government* (not, significantly, by governments), and sees this world through the government's eyes. The government is supposed to have the responsibility, the will and the power to restructure society in whatever way maximizes social welfare; like the US Cavalry in a good Western, the government stands ready to rush to the rescue whenever the market "fails", and the economist's job is to advise it on when and how to do so. Private individuals, in contrast, are credited with little or no ability to solve collective problems among themselves. This makes for a distorted view of some important economic and political issues. (Sugden 1986, p. 3)

Illustrative of this distorted view, and of direct relevance to the analysis of institutional change in CPR settings, is a study by Rolph (1982, 1983) concerning efforts to regulate CPRs, including the set of southern California groundwater basins examined in Chapter 4. Having described the general problem of overuse in relation to such resources, Rolph indicates that "the government (any of the three branches) is called upon to allocate user rights as a means of limiting a production or a consumption activity" (Rolph 1983, p. 51). In regard to the groundwater users, she writes that "they turned to the government for a program that would limit use equitably among the existing users" (Rolph 1983, p. 51). She was puzzled by what appeared to her to be a contradiction in that users were allowed to acquire private property rights to what was a public or a communal resource. She argues that "if the government had foreseen a future shortage of the resource, it might have laid claim to it in 'the beginning,' before any users had made investments" (Rolph 1983, p. 51). As she puzzles about options, she asks this:

> As the government steps in to limit use, should it simply allocate complete property rights to a small sub-group of the users while stripping the rest of their limited communal rights? Alternatively, should it take the resource from its present users and redistribute it? Or should it first take away and then sell back the resource to its present users? (Rolph 1983, pp. 51–2)

What I find remarkable about Rolph's observations in regard to the groundwater cases is that the only policy actor she sees as being relevant is the amorphous, fictitious, and omnicompetent entity called "the government." The users are viewed as turning to "the government for a program," rather than themselves struggling to find workable and equitable solutions to difficult problems within arenas provided by courts, by legislative bodies, and by local authorities.

The models that social scientists tend to use for analyzing CPR problems have the perverse effect of supporting increased centralization of political authority. First, the individuals using CPRs are viewed as if they are capable of short-term maximization, but not of long-term reflection about joint strategies to improve joint outcomes. Second, these individuals are viewed as if they are in a trap and cannot get out without some external authority imposing a solution. Third, the institutions that individuals may have established are ignored or rejected as inefficient, without examining how these institutions may help them acquire information, reduce monitoring and enforcement costs, and equitably allocate appropriation rights and provision duties. Fourth, the solutions presented for "the" government to impose are themselves based on models of idealized markets or idealized states.

We in the social sciences face as great a challenge in how to address the analysis of CPR problems as do the communities of people who struggle with ways to avoid CPR problems in their day-to-day lives. The theoretical enterprise requires social scientists to engage in model-building,[20] but not limit theoretical inquiry to that specific level of discourse. We need to appreciate the analytical power that can be derived from the prior intellectual efforts of important contributors such as Hobbes, Montesquieu, Hume, Smith, Madison, Hamilton, Tocqueville, and many others.[21] Contemporary studies in the theory of public and social choice, the economics of transactions costs, the new institutional economics, law and economics, game theory, and many related fields[22] are making important contributions that need to be carried forward in theoretically informed empirical inquiries in both laboratory and field settings.

Notes

1. REFLECTIONS ON THE COMMONS

1 Attributed to Merrill M. Flood and Melvin Dresher and formalized by Albert W. Tucker (R. Campbell 1985, p. 3), the game is described (Luce and Raiffa 1957, p. 95) as follows: "Two suspects are taken into custody and separated. The district attorney is certain that they are guilty of a specific crime, but he does not have adequate evidence to convict them at a trial. He points out to each prisoner that each has two alternatives: to confess to the crime the police are sure they have done, or not to confess. If they both do not confess, then the district attorney states he will book them on some very minor trumped-up charge such as petty larceny and illegal possession of a weapon, and they will both receive minor punishment; if they both confess they will be prosecuted, but he will recommend less than the most severe sentence; but if one confesses and the other does not, then the confessor will receive lenient treatment for turning state's evidence whereas the latter will get 'the book' slapped at him. In terms of years in a penitentiary, the strategic problem might be reduced" to the following:

	Prisoner 2	
Prisoner 1	Not confess	Confess
Not confess	1 year each	10 years for prisoner 1 3 months for prisoner 2
Confess	3 months for prisoner 1 10 years for prisoner 2	8 years each

R. Kenneth Godwin and W. Bruce Shepard (1979), Richard Kimber (1981), Michael Taylor (1987), and others have shown that commons dilemmas are not always prisoner's dilemma (PD) games. Dawes (1973, 1975) was one of the first scholars to show the similarity of structure.

2 Hardin's model easily translates into the prisoner's dilemma structure. Many problems related to the use of common-pool resources (CPRs) do *not* easily

translate. Simple games such as "chicken" and "assurance" games are better representations of some situations (M. Taylor 1987). More complex games involving several moves and lacking dominant strategies for the players are better able to capture many of the problems involved in managing CPRs.

3 Hardin recommends "mutual coercion, mutually agreed upon" as a solution to the problem, but what "mutual agreement" means is ambiguous given his emphasis on the role of central regulators; see Orr and Hill (1979) for a critique.

4 A howling debate raged for some time, for example, regarding whether the number of participants involved was positively, negatively, or not at all related to the quantity of the good provided (Buchanan 1968; Chamberlin 1974; Frohlich and Oppenheimer 1970; McGuire 1974). Russell Hardin (1982) resolved the controversy to a large extent by pointing out that the effect of the number of contributors was largely dependent on the type of collective benefits being provided – whether or not each unit of the good was subtractable. Thus, the initial debate did not lead to clarification until implicit assumptions about the type of good involved had been made explicit.

5 J. A. Moore (1985, p. 483), reporting on the education project for the American Society of Zoologists.

6 See, for example, Berkes (1987), Berkes and Kislalioglu (1989), Berkes and Pocock (1981), A. Davis (1984), K. Martin (1979), Matthews and Phyne (1988). For strong critiques of Canadian policy, see Pinkerton (1989a,b) and Matthews (1988).

7 Michael Taylor (1987) analyzes the structure of Hobbes's theory to show that Hobbes proposed the creation of a Leviathan in order to avoid the equilibrium of situations structured like prisoner's dilemmas. See also Sugden (1986).

8 Stillman (1975, p. 13) points out that those who see "a strong central government or a strong ruler" as a solution implicitly assume that "the ruler will be a wise and ecologically aware altruist," even though these same theorists presume that the users of CPRs will be myopic, self-interested, and ecologically unaware hedonists.

9 The form of regulation used in Game 2 would be referred to in the resource economics literature as a "pure quota scheme." Alternative regulatory instruments that are frequently proposed are a "pure licensing scheme" and a "pure tax scheme." As Dasgupta and Heal (1979) point out, however, it is "the" government in each of these schemes that takes control of the resource and sets up the regulatory scheme. "The idea, in each case, is for the government to take charge of the common property resource and to introduce regulations aimed at the attainment of allocative efficiency" (Dasgupta and Heal 1979, p. 66). All of the models of these various schemes assume that the costs of sustaining these systems are nil (as in Game 2). Dasgupta and Heal repeatedly stress that these costs are *not* nil in field settings and may affect whether or not any of them actually will solve a commons problem or the relative efficiency of one scheme versus another. But Dasgupta and Heal's careful warnings about the importance of the relative costs of various constitutional arrangements are rarely heeded in the policy literature.

10 More accurately, the sum of the two types of errors must be less than 0.50, given the fixed parameters of this game, for the restructured game to have a (*C*, *C*) equilibrium. I am grateful to Franz Weissing, who suggested this par-

ticular analysis for illustrating the problem of incomplete information on the part of a central agency.

The last two decades of work in social-choice theory also have revealed other problems that may be involved in any system where a collective choice about policy must be reached through mechanisms of collective choice. Even if complete information is available about the resources, problems associated with cycling and/or agenda control can also occur (McKelvey 1976, 1979; Riker 1980; Shepsle 1979a).

11 This overlooks the fact that in a dynamic setting the decision whether to manage the meadow at a sustainable level or to "mine" it rapidly will depend delicately on the discount rate used by the private owner. If the discount rate is high, the private owner will "overuse" a commons just as much as will a series of unorganized co-owners. See Clark (1977) for a clear statement of how overexploitation can occur under private property.

12 And it should be pointed out that the private-rights system is itself a *public* institution and is dependent on public instrumentalities for its very existence (Binger and Hoffman 1989).

13 My thanks again to Franz Weissing, who suggested this symmetric version of the contract-enforcement game. I had originally modeled Game 5 giving one herder the right to offer a contract, and the second herder only the right to agree or not agree to it.

14 See the interesting paper by Okada and Kleimt (1990), in which they model a three-player contract-enforcement game using the rule that any two (or three) persons who agree can set up their own contract to be enforced by an external agent. They conclude that three persons will not make use of a costless enforcement process, whereas two may. The article helps to illustrate how very subtle changes in conditions make important differences in results.

15 Williamson (1983) argues, however, that the numbers of actual unresolved PD situations in long-term business relationships have been exaggerated because economists have overlooked the contracts that businesses negotiate to change the structure of incentives related to long-term contracts.

16 Much of the literature in the new institutional economics tradition has stressed the importance of private orderings in the governance of long-term private contracts (Galanter 1981; Williamson 1979, 1985).

17 When considerable competition exists among arbitrators for the job of monitoring and enforcing, one can assume that arbiters are strongly motivated to make fair decisions. If there is no competition, then one faces the same problem in presuming fair decisions as one does in relation to a public bureau with monopoly status.

18 Simply iterating the PD game is not a guaranteed way out of the dilemma. The famous "folk theorem" that cooperation is a possible perfect equilibrium outcome is sometimes misrepresented as asserting that cooperation is the only equilibrium in repeated games. In addition to the "all cooperate at every iteration" equilibrium, many other equilibria are also possible. Simple repetition without enforceable agreements does not produce a clear result (Güth, Leininger, and Stephan 1990).

19 Private orderings frequently are mistaken for *no* order, given the absence of an official formal legislative or court decision. See Galanter (1981) for a review of the extensive literature on private orderings.

20 The formal game-theoretical structures and outcomes of this and three other sets of rules for allocating fishing sites are analyzed by Gardner and E. Ostrom (1990).

21 See, for example, the cases contained in National Research Council (1986), McCay and Acheson (1987), Fortmann and Bruce (1988), Berkes (1989), Pinkerton (1989a), Ruddle and Akimichi (1984), Coward (1980), and Uphoff (1986c). In addition to these collections, see citations in F. Martin (1989) for the extensive literature contained in books, monographs, articles, and research reports. There are also common-property institutions that break down when challenged by very rapid population growth or changes in the market value of the products harvested from the CPR. As discussed in Chapter 5, however, fragility of common-property systems is much more likely when these systems are not recognized by the formal political regimes of which they are a part.

22 That the "remorseless logic" was built into Hardin's assumptions, rather than being an empirical result, was pointed out by Stillman (1975, p. 14): "But the search for a solution cannot be found within the parameters of the problem. Rather, the resolution can only be found by changing one or more of the parameters of the problem, by cutting the Gordian knot rather than untying it."

23 See Shepsle (1979a, 1989a), Shepsle and Weingast (1987), Williamson (1979, 1985), North and Weingast (1989), and North (1981).

24 One can search the development literature long and hard, for example, without finding much discussion of the importance of court systems in helping individuals to organize themselves for development. The first time that I mentioned to a group of AID officials the importance of having an effective court system as an intervention strategy to achieve development, there was stunned silence in the room. One official noted that in two decades of development work she had never heard of such a recommendation being made.

2. AN INSTITUTIONAL APPROACH TO THE STUDY OF SELF-ORGANIZATION AND SELF-GOVERNANCE IN CPR SITUATIONS

1 For physical resources, this translates into the relation between usage and natural deterioration, on the one hand, and investments made in maintenance and repair, on the other hand (E. Ostrom, Schroeder, and Wynne 1990).

2 Let me state at this point that the term "appropriator" is used in some legal systems to denote a person who has a particular legal *claim* to withdraw resource units. In Chapter 4, for example, certain groundwater pumpers are referred to as "appropriators" in a legal sense as those whose claim to water is not based on their using water on their own land; it is based on a "first-in-time, first-in-right" basis. Other than in Chapter 4, I always use the term "appropriator" to refer to all individuals who actually withdraw or somehow utilize the resource units of a CPR, regardless of the source of their legal claim to do so. Some actual appropriators may have no legal claim (e.g., squatters). In Chapter 4, I try to indicate carefully when the term is being used as a legal term for right-holders and when it is being used in the more general sense that I have just defined.

3 See, for example, the debate about the effect of group size on the provision of a good, as summarized by Hardin (1982, ch. 3).

4 The early work on public goods was written by Bowen (1943) and P. Samuelson (1954, 1955). See the distinction between public goods and CPRs in V. Ostrom and E. Ostrom (1977a). For recent reviews of the literature on collective goods, see Cornes and Sandler (1986).

5 Thus, this distinction between a public good and a CPR is nontrivial. A person who contributes to the provision of a pure public good does not really care who else uses it, or when and where, so long as enough other individuals share the cost of provision. A person who contributes to the provisions of a CPR cares a great deal about how many others use it, and when and where, even if the others all contribute to its provision.

6 See Radnitzky (1987) and Stroebe and Frey (1980) for a similar approach.

7 The concept of average yield may not be meaningful in regard to all biological resources (Schlager 1989).

8 See Berkes (1989) for a description of the strategies temporarily adopted by the Cree Indians near Hudson's Bay when an influx of nonnative trappers threatened the beaver stock. Legislation passed in 1930 legally recognized American-Indian communal and family territories, allowing the Cree to anticipate long-term survival for a key CPR. Since 1930, the Cree have successfully managed the beaver stock using the rules that had been tested by centuries of trial and error prior to the arrival of Europeans on the North American continent.

9 See Coleman (1987c, 1990) and Opp (1979, 1982, 1986) for extended analyses of the relationship between norms and rational-choice theory.

10 Sequential, contingent, and frequency-dependent behaviors may, of course, occur in unorganized settings. Some very interesting game-theoretical results have relied on the potentialities of individuals to rely on such forms of coordinated activities alone, without changing the underlying structures (Kreps et al. 1982; Levhari and Mirman 1980; Schelling 1978).

11 An important aspect of organizing a legislative process, for example, is the set of rules that specify the steps through which a bill must be processed before it becomes a law.

12 Changing the positive and negative inducements is the type of intervention that has received the most attention in the social sciences.

13 Alchian and Demsetz (1972) overtly posit that the key problem underlying reliance on a firm to organize behavior, rather than reliance on the independent actions of buyers and sellers in a market institution, is that of an interdependent production function. When the production function is interdependent, the marginal contribution of any one owner of an input factor will depend on the level of other inputs. One cannot tell from an examination of outputs alone how much any individual contributed. Rewarding inputs requires high levels of monitoring that are not needed when factors are combined additively. Williamson (1975), drawing inspiration from Coase (1937), argues that this is only one source of the need for organized firms. Williamson relies more on the costs of transacting in a market in which all act independently, as contrasted with a firm in which individuals agree ex ante to coordinate their activities ex post.

14 This stylized version does not do full justice to the extensive work on the theory of the firm, and I certainly do not recommend any policy prescriptions

on the basis of this sketch. Because my purpose is only to show how the theory solves the collective-action problem, I am presenting only this barebones outline. Readers are advised to see the work of Coase (1937), Alchian and Demsetz (1972), and Williamson (1975, 1985).

15 This discussion of the theory of the state draws most heavily on the work of scholars who base their theory of the state on Hobbes; it does not reflect the full range of debate about the theory of the state (Breton 1974; Levi 1988a; Niskanen 1971; M. Taylor 1987). My purpose in discussing the theory of the firm and the theory of the state is not to explore those theories but to point up the absence of an accepted theory for how individuals self-organize without an "external" leader who obtains most of the benefits. As Vincent Ostrom has so well demonstrated (1986a, 1987, 1989), when the "theory of the state" is used as the theory underlying a concept of democratic self-governance, basic contradictions exist. As long as a single center has a monopoly on the use of coercion, one has a state rather than a self-governed society.

16 Both are also subject to limits imposed by span-of-control problems: The cost of monitoring increases with the size and diversity of a firm or a state.

17 See Feeny (1988b) for an insightful discussion of the supply of institutions.

18 See, for example, the studies by Schelling (1960), Elster (1979), Brennan and Buchanan (1985), Levi (1988a,b), Shepsle (1989a), North and Weingast (1989), and Williamson (1985).

19 Reading a working paper by Shepsle (1989a) made me recognize how important this problem is to understanding CPR problems, as well as many other problems of interest to an institutional analyst.

20 This is how the literature on the "economics of crime" models the decision to comply or not (Becker 1968; Ehrlich 1973; Ehrlich and Brower 1987); for an insightful critique, see Tsebelis (1989).

21 Elster is not completely sure that the dilemma of mutual monitoring is always "decisive." He points to the possibility that tasks may be organized so that monitoring can be done without additional effort.

22 Assuming, of course, that the empirical observations are valid and the differences between predictions and observations are substantial.

23 Ciriacy-Wantrup and Bishop (1975) carefully distinguished between an open-access CPR, in which no one has any property rights, and a closed-access CPR, in which a well-defined group owns property in common. "Common-property resources" is a term that is still used inappropriately in many instances to refer to both open-access and closed-access CPRs.

24 Exactly how one models this depends on many underlying parameters. One that is essential to the prediction of full rent dissipation is that the underlying appropriation function (usually called a production function in this literature) is characterized by diminishing returns (Dasgupta and Heal 1979, p. 56). Although this is a reasonable assumption to make in many environments, the dependence of the incentive structure on underlying parameters, such as the shape of the appropriation function, is a key point I am trying to make. CPRs vary substantially in regard to their values on these underlying parameters. Two CPRs identical in almost all respects, except the range of variation found in regard to a important underlying parameter, may need quite different representations in terms of their strategic structures.

25 A third appropriation problem has to do with technological externalities.

Because none of the cases in this volume clearly illustrates this problem, I do not discuss it here; see Gardner, E. Ostrom, and Walker (1990).

26 This intimate relationship between solving appropriation problems and solving provision problems has frequently been ignored by contemporary designers of large-scale irrigation systems. It has almost uniformly been assumed that because farmers' interests are so clearly affected by the construction of field canals and the maintenance of distribution works, they will simply organize themselves to take care of providing and maintaining these small-scale works once the large-scale public works have been provided by a national government. But that assumption is based on two fallacies. The first is that the simple presence of a collective benefit is sufficient to assure that individuals will organize to obtain it. The second is that farmers who are not assured a reliable supply of water will make significant investment in provision (R. Chambers 1981).

27 See Frey (1988), Brennan and Buchanan (1985), Buchanan (1977), and Buchanan and Tullock (1962).

28 "Common knowledge" is an important assumption frequently used in game theory and essential for most analyses of equilibrium. It implies that all participants know x, that the participants know that each of the others knows x, and that the participants know that each of the others know that each of the others knows x (Aumann 1976).

29 Heckathorn (1984) models this as a series of nested games.

30 These levels exist whether the organized human activity is public or private. See Boudreaux and Holcombe (1989) for a discussion of the constitutional rules of homeowner associations, condominiums, and some types of housing developments.

31 See, for example, Alexander Field's critiques of the work of institutional theorists who have attempted to develop rational-choice theories of institutional choice (Field 1979, 1984).

32 In designing the constitution of an irrigation community, for example, setting up a legislative body requires determining how many representatives there should be. Determining the number of representatives will be affected by the physical layout. If there are 5 canals, having one representative from each canal may work well. If there are 50 canals, the participants may want to cluster canals into branches in order to select representatives. Whatever constitutional choice is made about how many (and how to select) representatives, the effects on appropriation practices will come about as a result of decisions made at both a collective-choice level and an operational level. It is extremely difficult to predict these with any exactitude prior to experience in a particular setting.

3. ANALYZING LONG-ENDURING, SELF-ORGANIZED, AND SELF-GOVERNED CPRs

1 A substantial debate has been engendered among institutional economists and economic historians over the issue of whether or not long-enduring institutions are optimally efficient. The way the question is addressed in many instances leads to an automatic yes or no answer, depending on what variables are considered as constraints on the problem. If information and transactions

costs are not considered, no real-world institution can ever be optimally efficient. If all information and transactions costs are included as fixed constraints, all long-enduring institutions are automatically optimally efficient. Neither position is very useful in evaluating institutions. I prefer to argue that optimality is not well defined in a changing environment, including the capacity to change the institutional rules themselves. One must use criteria other than optimal efficiency to evaluate long-enduring institutions (Binger and Hoffman 1989; Furubotn and Richter 1989; Harris 1989; North 1989).

2 As Demsetz (1967, p. 354) stated his concerns about negotiation costs, "it is conceivable that those who own these rights, i.e., every member of the community, can agree to curtail the rate at which they work the lands if negotiating and policing costs are zero. Each can agree to abridge his rights. It is obvious that the costs of reaching such an agreement will not be zero. What is not obvious is just how large these costs may be. Negotiating costs will be large because it is difficult for many persons to reach a mutually satisfactory agreement, especially when each hold-out has the right to work the land as fast as he pleases. But, even if an agreement among all can be reached, we must yet take account of the costs of policing the agreement, and these may be large also."

3 I had hoped to include an analysis of the persistence of "common lands" in feudal and medieval England. The famous "enclosure acts" of British history have been presented in many history books as the rational elimination of an obviously inefficient institution that had been retained because of an unthinking attachment to the past for an overly long time. Recent economic historians, however, have provided an entirely different picture of English land-tenure systems before the enclosure acts and even of the process of gaining enclosure itself (Dahlman 1980; Fanoaltea 1988; McCloskey 1976; Thirsk 1959, 1967). Many of the manorial institutions share broad similarity with the long-enduring institutions described in this chapter: a clear-cut definition of who is authorized to use common resources; definite limits (stinting) on the uses that can be made; low-cost enforcement mechanisms; local rule-making arenas to change institutions over time in response to environment and economic changes. Common-field property institutions were transported to New England, where they flourished for close to 100 years, until exclusion costs became low enough and/or transactions costs rose to produce a slow evolution from larger to smaller commons, eventuating in private tenure (B. Field 1985a,b). Even the presumed increased efficiency of enclosure has come into question. R. C. Allen (1982) concludes, for example, that the eighteenth-century enclosures of open fields *redistributed* the existing agricultural income, rather than expanding total income through enhanced efficiency (Yelling 1977).

4 In personal correspondence, Netting clarifies that citizens in Törbel were "rigidly restricted to descendants in the male line, and the children of women who married outside men were excluded, even though these women and their offspring could inherit private property." Netting reflects that Törbel is a case of a "closed corporate community" in the sense developed by Wolf (1986), because "citizenship closes access to communal resources both to members of neighboring communities who might be direct competitors and to national or colonial states attempting to wrest control from local inhabitants."

5 Restrictions on the use of common grazing lands based on the "home feed

base" of the user were common throughout most of feudal Europe. The Forest Service and Bureau of Land Management in the United States currently allocate grazing permits based on the home feed base of the applicant and the carrying capacity of the grazing area (Ciriacy-Wantrup and Bishop 1975).

6 Stevenson (1990) examines milk yields for 245 grazing areas in Switzerland and finds that milk yields from common property fall below the yields for private-property alps, but he does not include production or transactions costs in his analyses, and thus no conclusions can be reached concerning efficiency. He finds that grazing pressure on the Swiss commons is *lower* than on private land.

7 The communally organized forests in Törbel appear to have been well managed through the years, as were the meadows, but some Swiss villages were not able to manage their forests as well as they managed their meadows. Some of the commonly owned forests were divided among villagers to become individually owned woodlots. The lots generally were too small for effective management, and they degenerated until intervention occurred in the nineteenth century (Ciriacy-Wantrup and Bishop 1975). Price (1987) provides an overview of the development of legislation in Valais, Graubünden, and Bern.

8 Villages that are no longer dependent on their commons for essential forest products complementary to agricultural productions frequently have leased the land and used that income to finance other village projects. See Sharma (1984), as well as McKean's work, for a discussion of the uses of leases.

9 Hayami (1975) comments on the substantial asset that village organization in Japan has been for modern development, in contrast to many Asian countries. The same point is stressed by Sharma (1984), who describes the extensive participation of villagers from all walks of life in village governance and the consequent organizational skills that exist at the village level.

10 Many Muslims remained for a long time in the territories recaptured by the Spanish crown. As individual Muslim families departed, their land and homesteads were granted to Spanish families. Considerable effort was expended to determine how the irrigation systems worked and to maintain the water-distribution procedures as they had operated prior to the reconquest. In 1244, for example, Don Peregrin, one of the knights of James I, ordered several Muslims who had been irrigation officials before the reconquest to appear and "take an oath on pain of their persons and goods" to "tell the truth about the waters, in what way they used to apportion them in the time of the Moors" (Glick 1970, p. 233).

11 Limited parcels of land in the eastern part of Spain have acquired irrigation rights since the reconquest as new irrigation projects have expanded the supply of water.

12 The medieval term for this same position was *cequier*.

13 See Glick (1970, pp. 64–8) and the references he cites for a discussion of the history of the tribunal and the dispute over its origins.

14 The syndic is the agent of the *hereters* and is removable by them. In medieval times, the syndics of Valencia were selected for a limited and nonrenewable term by election, lottery, or competitive bidding. The Tormos Canal, for example, used a competitive bidding system. At a public meeting of the *hereters*, the person who submitted the lowest price to administer the canal was assigned responsiblity to administer the canal for three years at the price set in

his bid. Each bidder had to estimate how large a staff he would need to employ in order to monitor the use of the canals by the irrigators and allocate water in times of drought without conflict erupting. He also needed to estimate the cost of cleaning the central canals once a year and monitoring the work of the *hereters* in cleaning the canal frontage that bordered their lands. The total bid of the lowest bidder was divided into pro rata sums assigned to the *hereters* according to the amounts of *regadiu* land owned, and thus proportional to the amounts of water obtained (Glick 1970, p. 38). Where a syndic was elected, he also had to determine an annual budget and submit it to the *hereters* for approval prior to their obligation to pay a pro rata assignment of the costs of managing the canal. In modern times, the syndics are elected for a two-year term and can succeed themselves. The assessment rate is now determined annually by an executive committee chaired by the syndic.

15 These rules are both complex and very specific. Maass and Anderson (1986, p. 27) provide a summary of the procedures used on the Bennager Canal. "The first laterals that draw from this canal are two small ones, with rights to continuous water, serving approximately 13 ha each. Shortly thereafter the water encounters its first lengua by which it is divided into two continuous streams in two laterals. The right lateral receives one-third of the water and is called *Terç*, meaning one-third in Valencian. With the aid of a gated control structure, Terç then supplies two regions. Water is run in a lateral to Alacuás on Wednesdays and Thursdays and in one to Picaña on the remaining days of the week."

"The two-thirds of the water that flows into the left lateral of the first divisor is separated subsequently into two equal streams by a lengua called the White Cross. Immediately the left one of these streams is further divided into two equal parts, and each of these then supplies smaller laterals and farms by turn, one after the other. The right lateral at the White Cross supplies four channels that run water in succession, one day each."

"This system is interrupted every Thursday for sixteen hours when all the water available at the White Cross is diverted to a single lateral called Thursday (*Dijous* in Valencian) that serves 12 ha and irrigates at these hours only. For two weeks in a row the sixteen hours are those after sunrise on Thursday; for the third week they are the hours before sunrise on Friday, an arrangement designed to distribute the burden of irrigating at night. For the remaining eight hours on Thursdays the water is divided normally at the White Cross, but that flowing into the right lateral is given each week in succession to one of the four channels served by that lateral in order to preserve the proportions and the timing used normally in that service area."

16 Glick indicates that the "picture of daily irrigation problems and the methods used to deal with them" represented by the fine books of Castellón "should be applicable to the Valencian huerta as well" (1970, p. 54).

17 For a researcher who has ridden with police officers in high-crime districts of metropolitan areas, this is an amazing level of activity.

18 The somewhat higher percentage (58 as contrasted to 42) of infractions due to error or negligence, instead of overt illegal attempts to obtain water, represented a slightly higher recorded infraction rate.

19 Glick's reflection on this infraction rate is as follows: "Again, this is indicative of the way in which the fine structure fine-tunes the system. In Castellón the

ditch rider imposed the fines summarily. The more formal, weekly court in Valencia no doubt reflects greater demand for water, hence stiffer penalties, including the humiliation of being called before the Tribunal" (T. F. Glick, personal communication).

20 In personal correspondence to me, Glick indicates the following: "The role of fines in Castellón appears to have been designed, first, to make the system more flexible. The fines for cheating are set low enough so that if you really need some more water it's worth the fine. In this sense it's another kind of internal switch. The system countenances low-level cheating. High-level cheating (or challenging the ditch rider) lands you in the king's court, so it was pretty clear where the limit of personal risk lay. Second, it helps maximize the efficiency of the distribution arrangements, inasmuch as careless waste of water is fined. Third, low-level damage to a neighbor's field or to public property is included in the fine structure; this acts to head off conflict between individuals which, if allowed to fester, could be detrimental to the entire community."

21 When the irrigators in Alicante decided to construct Tibi Dam, they appealed to the crown for assistance: "Philip the Second responded with protection and limited aid. He gave license to the city of Alicante to build the dam and to borrow money for this purpose. Although he refused to provide capital because the work would in good part benefit existing landowners, he agreed, after obtaining approval from the church, to assign the proceeds of tithes and first fruits from the lands to be benefited (that is, 10 percent of their crops) to the city to amortize the costs of building the dam. . . . Finally, he agreed that authority and responsibility for distributing water from the dam would remain with the city so that the farmers did not lose control over their destinies to any significant degree" (Maass and Anderson 1986, pp. 119–20).

22 When landholding new-water rights are converted to nonagricultural purposes, the water rights associated with this land revert to the irrigation community, because these rights cannot be sold. Thus, the permanent holdings of the irrigation community increase slowly over time.

23 Maass also reports that the market appears to be very efficient: "To a foreigner who has had an opportunity to study the detailed reports of individual rotations, the close agreement among the hypothetical length of a rotation (determined by the number of rights), the hours and minutes of water actually released from the regulating basins, and the hours and minutes of albalaes collected from farmers is uncanny. Thus shareholders who claim their scrip either use it or sell it – the market is efficient, and the scrip that are not claimed are sold at auction by the syndicate. The surprisingly short periods of running water not covered by scrip are almost always accounted for by minor breaks and disruptions in the distribution network and ordinary canal losses" (Maass and Anderson 1986, p. 116).

24 A private firm pumps groundwater from deep wells near Villena, located about 70 km from Alicante. Farmers can purchase Villena water by the hour, which is then delivered in the community's canals on those days when Tibi water is not being delivered. Another alternative is water brought by a private firm from the lower reaches of the Segura River delta. That firm had already invested in massive pumps to lift the water out of the delta and transport it to several nearby communities, and in 1924 the Alicante irrigation syndicate

funded the extension of a canal by 25 km so that this water could be delivered to Alicante. This water is sold in a daily auction, but the minimum and maximum prices are predetermined under a provision of the initial concession by the national government allowing the firm to export Segura River water. Relationships between Alicante irrigators and both of these private firms have been conflict-ridden and tense at many junctures in their history.

25 Wittfogel (1957), in his brief discussion of Spanish irrigation institutions after the reconquest, does not distinguish between the "Spanish absolution" of Castile and the more democratic institutions of eastern Spain. For some time it has been the accepted wisdom that the well-organized sheepherders guild (the Mesta) was responsible both for increasing the power of the Castilian monarch and for retarding development in Castile by delaying the development of well-specified property rights in land (Klein 1920). However, recent work by Nugent and Sanchez (1980), using an approach that is quite consistent with the one adopted herein, raises some substantial questions about that conventional view.

26 For an interesting account of the path of evolutionary change in North America, as contrasted with South America, see North (1986a).

27 Until 1923, when the first government-financed irrigation project was constructed, the communal irrigation society was the only form of irrigation management in the Philippines. In 1982 there were approximately 5,700 community irrigation systems in the Philippines, serving approximately 45% of the irrigated area (World Bank 1982, p. 8). For an interesting account of the early efforts to stimulate irrigation-service associations in the Philippines, see Bromley, Taylor, and Parker (1980).

28 Additional *atars* may be issued if a new irrigation canal is added to an old system by new members, who can acquire shares by constructing the new works and then bearing their share of maintenance for the entire system.

29 The position of a cook seems strange, but at each of the major work seasons of the *zanjera*, all those working are fed by the cooperative, which is one of the positive inducements used to encourage participation in the extremely difficult labor required by these systems. The cook is very important in this system!

30 I seriously doubt that the farmers would be willing to contribute this high a tax rate in monetized form, even if they were operating in a fully monetized economy. When a farmer contributes labor, he knows how the tax is being allocated, whether or not it is being used for the purpose for which it was levied. When a farmer contributes money, he may fear that it will be diverted to the pockets of bureaucrats or put to other uses beyond the purpose for which it was contributed.

31 Siy points out that this figure underestimates the actual amount of labor supplied to construction and maintenance, because the families of *zanjera* members and members of neighboring *zanjeras*, who receive the drainage waters of this sytem, also contribute labor for major projects. Siy estimates that at least 1,000 additional person-days are contributed by those who do not have direct obligations (Siy 1982, p. 95).

32 Siy refers to the labor contributed to the maintenance of the system as a "voluntary" contribution. Given that there is a high probability that nonparticipation will be sanctioned by members of the *zanjera* and/or the federation, calling this a voluntary contribution is misleading. What *is* voluntary is

joining or not joining the *zanjera*. Those who do not want to abide by the rules can obtain a good price for their land and thus exit. The price of this voluntary decision to join or remain a member, however, is to forgo discretion whether or not to contribute a certain amount of labor each year.

33 Although the level of participation described by Siy is very high, it is not unique in Third World settings. Pradhan (1984) describes an equally sophisticated irrigation system – the Chattis Mauja system – constructed 150 years ago in Nepal, covering 7,500 acres of land irrigated by farmers living in 54 different villages. Also a federal structure, it is organized at village, district, and central levels, in addition to working informally with three other farmer-managed systems. The Chattis Mauja system has a strong record for mobilizing labor input – over 60,520 man-days during 1981 – from at least 3,000 farmers working to desilt the main canal and other arduous tasks.

34 It appears, however, that those who own less than a full *atar* share have a somewhat higher absentee rate, particularly those who own less than a fourth of a share, but this is not true in regard to the contributions of materials by members owning less than a full share (Siy 1982, p. 99)

35 Computed from Siy (1982, p. 144, Table 38).

36 I do not think it is possible to elucidate necessary *and* sufficient principles for enduring institutions, as it takes a fundamental willingness of the individuals involved to make any institution work. No set of logical conditions is sufficient to ensure that all sets of individuals will be willing and able to make an institution characterized by such conditions work.

37 It is sometimes argued that the rules defining common property need not be as completely specified and detailed as those defining private property. Runge (1986, pp. 33–4) argues, for example, that "if common property – the individual right to joint use – is the norm, comparatively fewer claims must be assigned and defined. Less clarity in the assignment of rights (at least by Western standards) may also result. However, this is balanced against reduced social costs of assignment and definition." This is true if one means that the physical boundaries for individual use do not have to be mapped, but only the boundaries of the resource. It is certainly not true in regard to the detailed rules that are necessary for governing how the common owners are to appropriate from and provide for the resource.

38 On the other hand, that external authorities did not meddle (with the exception of Alicante) was very important. An appropriator who was unhappy about the way rules were enforced in one of these systems was not able to go to a politician at a higher level and get a reversal in return for political support. Thus, external authorities did not *unglue* the structure that local appropriators had put together. This stands in contrast to several of the cases discussed in Chapter 5.

39 A high level of quasi-voluntary compliance is present in other long-serving CPR institutional arrangements. The Chisasibi Cree, for example, have devised a complex set of entry and authority rules related to the fish stocks of James Bay, as well as the beaver stock located in their defined hunting territory. Fikret Berkes (1987, p. 87) describes why these resource systems and the rules used to regulate them have survived and prospered for so long: "effective social mechanisms ensure adherence to rules which exist by virtue of mutual consent within the community. People who violate these rules suffer not only

a loss of favour from the animals (important in the Cree ideology of hunting) but also social disgrace. This is no light matter, as seen in the case of the beaver boss who was forced to abandon his position because he neglected to remove his traps at the end of the trapping season."

40 In some systems not described in this chapter, guards are paid a proportion of the crop at the end of the year. With this type of payment, the guard's income is dependent on keeping the reliability of the system as high as possible so that the farmers being served can produce as much on their fields as possible.

41 See the discussion in Harsanyi and Selten (1988, pp. 19–20) about self-commitment moves in noncooperative games. The particular self-commitment move that I suggest here is less extreme that a commitment to follow the rules in every instance as long as everyone else also follows the rules in every instance. Given that modest levels of rule-breaking continue to occur in all long-enduring CPR institutions, while the overall level of rule conformance is very high, I think that my statement of the self-commitment move captures the commitment of appropriators in field settings.

4. ANALYZING INSTITUTIONAL CHANGE

1 See William Blomquist's reports (1987a,b, 1988a–e, 1989, 1990) for more detailed analyses of the origins of the institutions for governance and management of the three basins described here, plus analyses of several other basins that have devised different institutional arrangements to achieve self-governing systems.

2 The actual costs of imported water far exceed the wholesale price charged by the Metropolitan Water District of Southern California (MWD) for imported water, because considerable portions of the capital costs of constructing the aqueducts bringing water from the Colorado River and from northern California have been paid from property taxes and are not reflected in the wholesale prices charged by MWD.

3 The stock of water in a groundwater basin also is of value – independent of its future use as a subtractable quantity of water. The stock of water held in a basin holds "the water being pumped closer to the land surface, which reduces pumping costs" (Nunn 1985, p. 872). These cost savings are collective benefits available to all pumpers.

4 See Louis Weschler (1968) and William Blomquist (1988d) for discussions of the settlement in Orange County, where producers overtly rejected the idea of a legal settlement of rights and established the Orange County Water District in the early 1930s to administer a pump tax and replenish the basin by a variety of means. Blomquist (1988e) discusses a still different set of water rights that developed in the San Fernando Valley because of the strong "pueblo rights" of the city of Los Angeles.

5 The information presented in this section is based on the work of Blomquist (1988a).

6 The city of Pasadena was the logical initiator of litigation. The city owned overlying land and used water on that land, in addition to being a senior appropriator from the basin.

7 A proportionate cutback is an example of a solution that conforms to Reinhard Selten's general equity principle (Selten 1978b), whereby some individuals (*n*)

are allocated some acre-feet of water (s) according to a standard of distribution that defines how much water (s_i) will be allocated to each group member (i). The weight (w_i) assigned to each group member is a historical-use rate. An equitable distribution is one that satisfies the following condition:

$$\frac{s_1}{w_1} = \frac{s_2}{w_2} = \ldots = \frac{s_n}{w_n}$$

8 It is interesting to note that the procedure used in the Raymond Basin case, and subsequently in West Basin, Central Basin, and San Gabriel Basin, leads to a "solution" to this problem that is close to but not the same as that recommended by Nash (1950): point C. Mutual prescription has not been uniformly adopted as "the" solution concept used in all southern California groundwater litigations. In the San Fernando Valley, for example, the city of Los Angeles had been granted and has tenaciously defended a preeminent right to water. The California Supreme Court overturned an initial effort by the trial court to impose a mutual-prescription solution on all parties. The California Supreme Court found, in essence, that the mutual-prescription solution was an equitable solution, but it was not the only equitable solution that could be used in these types of situations (*City of Los Angeles v. City of San Fernando*, Superior Court Case No. 650073, 1968) (Blomquist 1988e). Water producers in Chino Basin also negotiated a settlement that allocated water rights that was broadly similar to the mutual-prescriptioin solution, but took into account a variety of specific problems that would have arisen if that formula had been applied in a mechanical fashion (Lipson 1978). I appreciate the opportunity to have discussed the logic of this outcome with Roy Gardner.

9 The judge in such a case is in a delicate position. The proposed solution was truly radical and was not based on any of the existing water-rights doctrines. If he accepted a negotiated settlement that he could not justify in his finding, he would be overruled by a higher court. On the other hand, there was no clear-cut alternative on which to base his decision. He was in as uncertain a situation as were the litigants.

10 *City of Pasadena v. City of Alhambra et al.*, Superior Court Case C-1323.

11 Cal. 2d 908, 207 P.2d 17 (1949).

12 The case was appealed, and a costly and time-consuming appeal procedure could not be avoided.

13 Thus, an N of 19 producers could function as an effective coalition to control most of the production from the basin; see Schelling (1978) on the concept of a minimal effective group.

14 One-half of the $25,000 allocated for that purpose came from federal funds, one-fourth was paid for by the county, and the remaining one-fourth was allocated on a pro rata basis to the nine signatory communities.

15 Although there is insufficient space in this chapter to discuss the structure and operational characteristics of the West Basin Water Association, the importance of its activities can hardly be overemphasized. The formal voting rules of the association prevented any potential subgroup from dominating the decisions made within the association. Given the voluntary status of the association, no actions were taken by the association until a consensus was reached. Because actions were being pursued in many different arenas at the same time, major water producers could coordinate activities and monitor the perfor-

mances of public officials (and their fellow water producers) in the context of the regular quarterly meetings, the Executive Committee meetings, and the meetings of the working committees of the association. See E. Ostrom (1965) for a detailed discussion of the operational characteristics of the association.

16 The policy of open files was also of immense value to my research; as a young graduate student, I was shown the filing cabinets and invited to read and make copies of any or all correspondence, minutes, reports, etc., contained therein.

17 In 1945 the Dominguez Water Corporation withdrew over 10,000 acre-feet from the basin, or about 15% of the total withdrawals.

18 The reason for the change in position was well documented, because once city officials recognized how exposed they were, they also had to recommend to the citizens of Inglewood that the city join the West Basin Water District to obtain MWD imported water. The mayor had vigorously opposed such a move only three years before. The mayor was repeatedly asked for a clarification for his change of heart. The following statement was printed in the September 26, 1950, *Inglewood Daily News*: "I have been asked many times the reason why I now support Metropolitan Water District, in view of my opposition to it in 1947. This is a very reasonable question and I feel that it is my obligation to answer this question. . . .

"On October 24, 1945, a case was filed in the Superior Court [that] asked that the Superior Court determine the rights of all water producers in the West Coast Basin and to allocate the available water therein equitably among all of the water producers.

"When this case was filed, your City Council employed the legal firm of Stewart, Shaw, and Murphy to defend the City of Inglewood on this action. . . . I quote from a letter received by the City Council from Arvin B. Shaw, Jr., 'I believe that there is a reasonable ground to hope to establish for the City of Inglewood, a preferred position, based on priority of water rights as an appropriator of water for many years.' . . .

"Some time prior to the filing of a California Water Service Company suit, there had been pending in another section of Los Angeles County a case known as the 'Raymond Basin Case.' This case was in many points substantially similar to the one in which we were being sued. . . . The substantial and pertinent portion of the Supreme Court decision was to the effect that all water users from a common basin must be treated exactly alike.

"On May 10, a conference participated in by William Renshaw, water engineer, F. R. Coop, administrative officer, and myself, was held with Arvin B. Shaw. . . . While much of the information given us by Shaw was in confidence, I have received his permission to quote from a confidential letter as follows: 'The decision of the Supreme Court in the Pasadena case, however, is to my mind, clear to the effect that you would not be given priority and that all overlying users in the West Basin, as well as appropriators, would be treated on an equal basis of right; in substance, would be required to prorate water production downward to a point which is within the safe yield of the Basin.'"

19 A major factor in the success of the committee was that T. B. Cosgrove was appointed to it; he was the attorney for the Dominguez Corporation and other related firms. Prior to his appointment to the Settlement Committee, he had vigorously fought against the litigation and strongly articulated a position that the Dominguez rights were superior to those of the others using the basin. No

one was likely to agree to curtail production without Dominguez participating. Cosgrove came to play an active role on the committee. By the time an agreement had been drafted, he had changed his strategy to one of cooperation with other water producers. In fact, one member of the committee gave him credit for drafting the form of the interim agreement, and he was commended for his outstanding contribution to the committee (West Basin Water Association, minutes, August 26, 1954). Cosgrove did not, as a result, obtain as many water rights for his firm as he might have if he had continued his opposition (see note 22).

20 They later defined "Prescriptive Rights, 1949" as "the highest continuous production of water by each user for beneficial use in any five-year period prior to October 1, 1949, as to which there was no cessation of use by it during any subsequent continuous five-year period prior to October 1, 1949" (interim agreement, p. 2). The 1944 water year was selected for comparison because many producers thought that initiating litigation in 1945 would lead to a determination of rights based on the water year that had just been completed.

21 See Mnookin and Kornhauser (1979) for a discussion of bargaining procedures related to private matters, such as divorce settlements, that also occur in the shadow of the law.

22 Because an authoritative list of rights as of 1944 was never compiled, it is difficult to determine exactly who won and who lost in this fight over the proportionate sharing of the basin. The shift was not very large, in any case. In digging back through the referee's report and the final stipulated agreement, my best estimate of the relative positions of the 35 largest producers from the basin is the following:

	Estimated water rights, 1944	%	"Prescriptive Rights, 1949"	%
Overlying landowners				
12 industrial firms	16,135	36	25,876	41
8 large agricultural users	2,061	5	1,628	3
	18,196	41	27,504	44
Appropriators				
9 public districts or municipalities	9,764	22	14,375	23
6 private utilities	16,179	37	20,889	33
	25,943	59	35,264	56
Total	44,139	100	62,768	100

The California Water Service slipped from estimated rights of just over 5% to prescriptive rights of just under 5%. The Dominguez Water Corporation, which had opposed a settlement until T. B. Cosgrove was asked to head the committee of attorneys, slipped from estimated rights of 18% to prescriptive rights of 15%.

23 The city of El Segundo and Standard Oil withdrew water from wells located to the west of Hawthorne and near to the coast. Their fields consequently lay

in the path of the saltwater wedge moving at an accelerated rate toward the pumping trough beneath Hawthorne. Standard Oil had already reduced its own water withdrawals severely in 1952, because it feared that salt water would soon engulf its well lying between Hawthorne and the sea. Under the interim agreement, Standard Oil pumped about two-thirds of its "rights." El Segundo also was not pumping its full rights during that time period, for the same reason. The city of Inglewood, lying to the north of Hawthorne and inland, was not threatened by immediate saltwater intrusion, but Inglewood's pumping costs were considerably increased as a result of the lowered water table.

24 In September of 1957, for example, officials from Torrance, Inglewood, and El Segundo met with representatives of the city of Hawthorne "in an effort to persuade the City of Hawthorne to become a part of the Interim Agreement and petition to curtail pumping." The Inglewood official reporting on the meeting stated that "Hawthorne City officials had indicated that they would take the matter under consideration but that press releases implied that there was small likelihood that the City would become a party to the Agreement" (WBWA, Executive Committee, minutes, July 12, 1957, p. 4).

25 Many of the small producers had abandoned their rights as imported water became generally available to the basin. Others had sold their rights to the larger producers once the interim agreement had been signed and an active market for water rights had developed.

26 The total expenditure for the watermaster service for 1985 in Raymond Basin was $112,471, and in West Basin $151,800 (Watermaster reports for 1985).

27 See Blomquist (1990) for a description of the process in the San Gabriel Basin. Participants in that basin adopted several of the cost-saving strategies developed in the Central Basin case. Blomquist is just now completing studies in three additional basins – San Fernando, Chino, and Mojave – in which legal and environmental conditions are quite different. No settlement has yet been reached in Mojave, where the asymmetries of the interests of various parties are far greater than in any of the other cases involved. See the discussion of the Mojave case in Chapter 5. The city of Los Angeles holds a preeminent water right in the San Fernando Valley, and the final court decision adjudicating rights in that basin is quite different from those in the basins that relied on mutual prescription. The settlement in Chino Basin was reached by producers drawing on the experiences of all of these other basins.

28 Carl Fossette, the executive director of both associations, as well as the director of the Upper San Gabriel Water Association, played a remarkable role in helping the water producers in all of these interlinked basins to change the structures of institutions affecting their behaviors. His importance derived from several factors: (1) The number of overlapping positions he finally held. In addition to his role as executive director of three private water associations, he eventually became the general manager of the West Basin Municipal Water District, the Central Basin Municipal Water District, the Upper San Gabriel Municipal Water District, and the Central and West Basin Water Replenishment District. (2) The duration of his activities. He was appointed to his first position in 1946 and continued an active role in all three of the basins until he retired in 1974. Even after retirement at age 67, he continued an active role as a director representing Central Basin on the board of directors of the

Metropolitan Water District of Southern California, where he was vice-chairman during 1980–2 (Fossette and Fossette 1986, p. iv). (3) His tolerance for conflict and his commitment to conflict resolution. Fossette was able to sit through tough bargaining situations without losing his temper. The association minutes document his repeated efforts to bring contesting parties together in informal working settings to try to work out mutually agreeable relationships. (4) His ability to represent the interests of West, Central, and San Gabriel water producers to external agencies, including California state legislators. Fossette became the chief advocate for proposals developed within these basins that needed support from countywide, regionwide, or statewide public agencies.

29 Markets for water rights have emerged in all of the southern California basins that used litigation to assign defined water shares to parties. In all of these cases, agricultural users have slowly sold their rights to water companies or utilities, who can utilize the rights to avoid building expensive surface storage facilities. See R. Smith (1988) for a discussion of the advantage of tradable water rights.

30 Interview by Elinor Ostrom with John Johams of the watermaster service, November 17, 1960.

31 *Dominguez Water Corporation v. American Plant Growers, Inc.* Case 668,965, Superior Court, State of California, County of Los Angeles.

32 The parties in Raymond Basin changed their watermaster in recent years; so the threat of a change is credible.

33 For a surface storage facility, one can empty and fill the reservoir frequently without harming the structure itself. The degrees of freedom in raising and lowering the water levels in a groundwater basin are considerably less than those involved in the use of a surface reservoir.

34 The possibilities included the Los Angeles County Flood Control District and the Metropolitan Water District of Southern California, both of which had decided interests in seeing that the water basins in the area were regulated. Water producers in West Basin and Central Basin wanted to cooperate with these larger agencies, but not be completely dependent on them.

35 The wide representation involved in this group led one observer of the process to comment that "the Committee of Twelve was made up of engineers, attorneys and representatives of irrigation districts, water districts, farm bureaus, cities, private utilities and the State of California itself. Into that group came a variety of viewpoints and a diversity of problems which was most beneficial. Instead of recommending solutions for particular areas or groups, the ideas of this committee were bound to be cross-sectional in their scope" (James K. Krieger, "Progress in Ground Water Replenishment," mimeograph April 15, 1955, p. 2).

36 In a report to the West Basin Water Association, Louis Alexander, a member of the "Committee of Twelve" active in both West Basin and Central Basin, stated that "the original concept for the bill was that an assessment on pumping only would be provided and . . . no ad valorem tax would be permitted. . . . [T]he farm element in the State had insisted upon an ad valorem tax rate provision and . . . the present bill represents a compromise between the two points of view" (West Basin Water Association, minutes, April 12, 1955, p. 8). The president of the association had called a special meeting of the full associa-

tion to consider a draft of both pieces of legislation before he acted to approve the final draft within the Committee of Twelve. At that meeting, he and other members of the Committee of Twelve were asked many questions and subjected to some criticism for not having accomplished all that the members of the association had wanted, but the members finally voted unanimously to support the drafts.

37 James Krieger explained that provision in the following way: "Certain existing public agencies believed that they had the facilities to accomplish replenishment. Some of these agencies had the facilities to replenish groundwater basins, but no means of raising funds to purchase the water to do the replenishment. They felt that they should be permitted to do the job, and that no new public corporation should usurp their functions" (Progress in Ground Water Replenishment," mimeograph, April 15, 1955, p. 6).

38 In other words, if the district comprised only West Basin, then the West Basin producers could sue the Central Basin producers to pressure them into curtailing their production. If the Central Basin producers controlled the district, they might not let the district initiate legal proceedings against them.

39 Each of those agencies had substantial threat power over the proponents of the new district, because the boundaries of the proposed district had to be approved by the Department of Natural Resources, and the district itself had to be approved by the voters. Significant opposition at either stage would substantially raise the costs of gaining approval and threaten the likelihood of approval. Among the issues that had to be resolved at that stage of the negotiations was the formula for distributing the costs of replenishment. The city of Los Angeles, for example, strongly opposed any imposition of a property tax on its residents to pay for the construction of the barrier, because its taxpayers had borne a higher burden through the years to pay for imported water, while the taxpayers in the other cities had received the benefit of much lower water costs. By using "zones-of-benefit districts" within the Los Angeles County Flood Control District, which did not include portions of the city of Los Angeles, to pay for barrier construction, a cost-distribution formula was developed that was agreeable to all parties.

40 The costs are also less than the total operating costs in neighboring Orange County, where producers did not litigate their water rights, but instead developed only a replenishment program without any control over withdrawal rates. The focus of their management program, therefore, has been entirely on the "supply side" of the equation (Blomquist 1987a).

41 The story of this negotiation is extremely interesting, and it illustrates the vitality and creativity of a polycentric public-enterprise system. See E. Ostrom (1965) for a detailed discussion of the early process, and see more recent reports of the Central and West Basin Water Replenishment District for later developments.

42 A reader might wonder why a flood-control district would be in the business of supplying replenishment services in the first place. When the Los Angeles Flood Control District was first established in 1915, it was given strong powers over both flood control and water conservation. Once it had lined most of the rivers in the county, the district emphasized water conservation in an effort to maintain its survival as a large-scale engineering firm in the public arena.

43 Several private firms in the area serve as the watermasters for other basins; so

the Department of Water Resources does not have monopoly authority to perform this service.

44 Those who have rights to the largest proportions of water to be withdrawn also pay the largest proportions of the pump tax, which is then used to replenish the basin and pay for the monitoring arrangements that exist. Property owners who have benefited from the provision of an effective water system in an arid region pay low property taxes to support the modest administrative structure involved. Because the rules were devised basin by basin, they are tailored quite specifically to the unique aspects of each groundwater basin.

45 The process described here is somewhat similar to the "learning by doing" that occurs in the development of complex technologies; see Rosenberg (1982) and Nelson and Winter (1982). Because this is a dynamic process of selecting among various rules, it is likely to have aspects of path dependence similar to those of technological change (Arthur 1989; David 1985).

46 This is another application of Selten's equity principle; see note 7.

47 All rules share a common syntax: Defined persons with particular attributes filling specific positions are (required, forbidden, or permitted) to take named actions under specified conditions.

48 See von Wright (1951, 1963) for an introduction to the foundations of deontic logic. The modal form of the three deontic operators is as follows: must not (forbid), must (require), and may (permit). John R. Commons continually used these modal operators to characterize the basic structure of working rules (Commons 1957).

49 See, for example, the discussion by Shimanoff (1980, pp. 43–6) regarding why permission should not be included as a deontic operator to define rules.

50 This distinction characterizes my previous work (E. Ostrom 1985b).

51 See Buchanan (1975, p. 59), who characterizes the origin of a constitution as a "leap out of the anarchistic jungle."

52 Any change in the parts of the syntax of a rule, identified in note 47, would constitute a change in a rule. Rules can change without producing changes in the outcomes likely to be produced in the resulting situation. Following Gardner and E. Ostrom (1990), I reserve the term "reform" for a change in a rule that produces a new outcome preferred to the outcome produced prior to the change in the rule.

5. ANALYZING INSTITUTIONAL FAILURES AND FRAGILITIES

1 Rent dissipation is defined in Chapter 2 in the section "Appropriation Problems."

2 Central-government encouragement and even financing of "modern" fishing vessels have caused similar conflicts between inshore and offshore fishers in many other locations. See McGoodwin (1980) for a description of this problem in Mexico. Dasgupta (1982, p. 17) describes how modern fishing vessels in India have been able to ignore historical rights of traditional inshore fishers.

3 William Blomquist (1989) describes this case in considerable detail, and I am much indebted to him for his insights and analysis based on his fieldwork.

4 The Karave caste is known for being entrepreneurial and oriented toward trading and other forms of acquiring wealth: "Nor was caste a significant barrier against the conversion of economic gains into social mobility. . . . The

[Karave] lack the ranked subsections which are found among" other castes (Alexander 1982, p. 233).

5 A description of the way these nets are used is provided later.

6 One way to think of what happened is illustrated in Figure 5.2. Prior to the increase in the price of fish, the marginal and average returns to be derived from the use of each additional net can be represented by MR_1 and AR_1. With a uniform marginal cost of constructing a net, fishers would have maximized their economic return by constructing X_1 nets, where the marginal return would equal marginal cost. Because they were already dissipating rent before the price increase, the fishers probably were close to the point where average return would intersect the marginal-cost curve, say X_2. When a substantial increase in the price occurred, both the marginal-return and average-return curves would be shifted dramatically upward. The optimal economic return would then be at X_3. It would appear that the fishers were constructing new nets beyond that point, say at X_4. They may not have suffered full rent dissipation, because shares in the nets were still actively sought. Full rent dissipation would occur at X_5. So the lure of continuing profits (even with negative marginal returns) would always tempt more fishers to enter. This analysis was developed in a very useful discussion with Jimmy Walker.

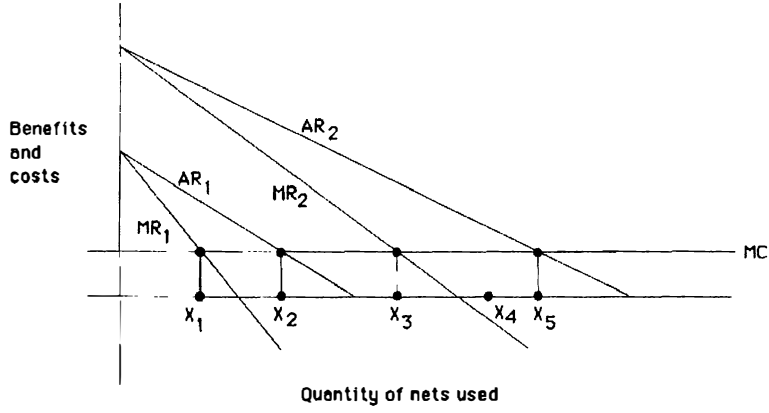


Figure 5.2. Rent dissipation in a fishery.

Paul Alexander's comment on reading this interpretation in an early draft of this manuscript was that he "would put more weight on political motives and the marked disparities in the returns to individual nets, in explaining why entry increased when marginal returns were negative, and probably recognized as such by the fishermen" (personal communication, August 2, 1988).

7 No matter how well a set of rules operates under one set of environmental and economic conditions, major changes – such as the price for a resource unit quadrupling – represent a substantial challenge to the capacity of an old set of rules to continue to produce outcomes that are efficient and fair.

8 Up to 1972, only Taiwan, Japan, and Korea experienced more rapid growth in the yield of paddy rice (N. T. Uphoff, personal communication).

9 The introduction of high-yield varieties has, in some villages, been associated with lower, rather than higher, yields (Byrne 1986).

10 This is not to imply that the participants are permanently trapped in this set of incentives, even though the social and political structures generating these incentives are difficult to change. It is particularly poignant that such vicious circles have been created in a country with a rich and very long history of successful irrigation using a diversity of indigenous institutions (Gunasekera 1981; Leach 1961, 1980).

11 Leach describes the system in effect during the 1950s in a single village that depended on a much smaller restored bund: "Whenever the Old Field is to be cultivated it is essential for the whole village to adhere closely to a predetermined program of work, for when the tank sluices are open the whole field can take water and when the sluices are shut the whole field must run dry. No plowing can be done on a dry field, but once the water has been let in to soften the earth, work must proceed everywhere simultaneously. Thereafter, to avoid loss by evaporation, the plowed fields must be sown and the crops carried through to harvest with the least possible delay.

"There must, therefore, be agreement about the dates on which the sluice will be opened, the date at which sowing will be completed, the varieties of rice that will be sown, and the dates at which it is planned to have harvest ready and the field drained. Under rules in force in 1954 the Village Cultivation Officer held a village meeting at the beginning of each cultivation season and formally agreed on these various dates with the assembled villagers" (Leach 1980, p. 108). Leach reports that this strict regimen was actually followed while he was there.

12 The British authorities were quite uncertain about what type of administrative and judicial arrangements they should establish, and they organized and reorganized both the administrative and conflict-resolution mechanisms related to irrigation several times during British rule. At each change, a key debate focused on how much authority could be entrusted to "native" tribunals or administrative officials. See Roberts (1980) for an excellent review of the 1856–71 period of British rule in Ceylon.

13 The recurring necessity for the exertion of considerable effort by British AGAs is revealed in a report by Edward Elliott, an AGA from 1863 to 1896, supervising a number of smaller irrigation systems (among other tasks). His report for 1871, as quoted by Roberts (1980, p. 200), contained the following: "Each year shows that incessant personal attention on the part of the Assistant Agent is necessary to carry out irrigation works by villages; to simply order the . . . Headmen to carry out any work may sound very fine, but, practically, the results are small, unless the Headmen be encouraged and supported by the Assistant Agent taking an active interest in their efforts; if the villagers see this and know that once they agree to any undertaking, everyone must contribute and that no shirking is allowed, all will combine cheerfully to carry out the work. But endless watching and numerous inspections are necessary."

14 Water meetings of this type have occurred in Sri Lanka for centuries (Gunasekera 1981). See the discussion of these institutions by Uphoff (1983).

15 The earlier land-tenure system in some parts of Sri Lanka had greatly reduced the level of conflict between head-enders and tail-enders, on the smaller tanks at least. The fields to be irrigated from a tank were laid out and assigned in

such a way that each farmer was assigned one block of land to farm in the top third of the area to be irrigated, another block in the middle section, and one block in the lower section. Thus, all farmers had a motivation to try to find ways of getting water to the tail end of the system. Further, when water shortages required a cutback, it was relatively easy to decide not to water the bottom third of the fields. Everyone participated in the sharing of this risk, and the mechanism for determining which fields would be watered was built into the design of the fields themselves (Leach 1961, 1980).

16 Fladby describes the patterns of interaction on a tract in Kirindi Oya during the early 1980s in the following manner: "The directing of water in [the minor agricultural season, when water is the scarcest] is similar to an early 19th century diplomatic Major Power game: No rules are sacred, alliances are formed, every move is answered with a counter-move and in the long run the only guiding line is self-interest. The role of the authorities is like that of an ineffectual trans-national organization . . . with some formal power, but without means to enforce it" (Fladby 1983, p. 191).

17 The increasingly partisan nature of the relationship between MPs and district administrative systems is described by Craig (1981).

18 A report by A. T. Corey (1986) lays out some of the severe problems faced on the huge Mahaweli set of projects planned to develop or improve water supply for 900,000 acres of land for over 200,000 new settlers (Jayawardene 1986). Among the problems Corey notes related to "Turnout Area H" are these: (1) Of the 119 allotments in the area, only 83 had received water during the year of his investigation. (2) Of those 83, only 49 received water through authorized project outlets; the rest obtained water through unauthorized cuts. (3) Rotation of water, where practiced at all, was haphazard. (4) An unauthorized breach was taking all of the water from one ditch, even though the downstream farmer had notified authorities and was afraid to take further action for fear of being "hammered" by the offending farmer (Corey 1986, pp. 158–9; Lundqvist 1986).

19 The deputy director for water management in the Irrigation Department told one member of the Gal Oya project team that if they could make progress in Gal Oya, they "could make progress anywhere else in the country" (Uphoff 1985c, p. 44).

20 In a personal communication, Norman Uphoff stresses that the decision to hire college graduates was initially taken to avoid hiring individuals with political connections, and the enhanced capacity of the IOs to communicate with the ID staff was an unforeseen but very positive consequence.

21 Exigencies in the field reduced the time available for data collection and pushed IOs into action earlier than planned.

22 Membership in FCOs and DCOs was at times a delicate issue, because many actual irrigators did not have legal claims to the water they used. A frequent accommodation to this problem was to involve all actual irrigators in the FCOs, and only legal irrigators in the DCOs. Some rotations had to be abandoned because farmers who "were using drainage water from the system for unauthorized cultivation broke open the closed gates" (Uphoff 1986a, p. 218, note 18).

23 Actually, farmer-representatives took the initiative to set up such area councils shortly after FCOs were formed and before many DCOs were in place. This

was possible because the program was not implementing a preconceived "blueprint," but wanted farmers to regard those organizations as their own and take responsibility for them.

24 Uphoff (1985c, note 32) discusses the change in official orientation: "One surprising but dramatic evidence of current ID responsiveness seen on the visit last January was the ID breaking down a freshly-built measuring weir off the Uhana branch canal to reduce its impediment to flow into a particular distributory. In the redesign meetings, farmers had insisted the size of the offtake for this D-channel was too small, but the ID insisted its calculations supported no change. When it became clear to the ID's Deputy Director himself that not enough water was reaching the tail-end of that distributory command area, he agreed to enlarge the offtake as soon as flow in the branch canal ceased and in the meantime to increase flow into the D-channel as much as possible, even if it cost the ID some funds and embarrassment. Actually, the respect it would gain from such an act of good faith should well outweigh those costs. We were pleased and surprised to find the Chief Irrigation Engineer for the district himself out checking the flow to the tail of the channel at 9:30 on a Sunday morning when we were making our own inspections (which he did not know about)."

25 Uphoff reports in a personal communication that one of the field-workers in Gal Oya, Nancy St. Julien, argued that free-riding has two faces: one that shows itself at the time of trying to establish a form of organization, and another that shows itself when their work has to be done to keep organized cooperation continuing. In this case, the first type of free-riding was harder to overcome, evidently, than the second type. The external IO was important in attempting to overcome the inertia of years of mistrust and unwillingness to work together. Sustaining the benefits of cooperation, once they became evident, was not as difficult.

26 Types of successful intervention strategies similar to those employed in Gal Oya have been used in the Philippines (D. Korten 1980; F. Korten 1982), in Nepal (Rahman 1981), in Bangladesh (D. Korten 1980), and in Thailand (Rabibhadena 1980).

27 Grate's Cove, Fermuse, and Twillingate in Newfoundland all use an annual lottery. A limited set of boats is eligible to participate in the lottery, which then is used to assign those vessels to particular locations. As described by one fisher, "we have a cod trap draw. There are only ten berths available and there are only ten crews fishing 'em. If a fellah has a berth one year he can enter the draw the next" (Matthews and Phyne 1988, p. 17). See also K. Martin (1979) and McCay (1978, 1979).

28 Similar findings concerning the development of property rights to fishing zones are described by Acheson (1975), Andersen (1979), and Faris (1972).

29 Subsidizing the purchase of new technologies has been a frequent strategy of national governments in relationship to fisheries, with results that have at times been disastrous. The effort to finance the acquisition of a new technology presumes that local fishers will not adopt efficient new technologies without external aid. The conservatism of fishers in regard to the use of new technologies may reflect an awareness that the management of complex resource systems depends on a delicate balance between the technologies in use and the entry and authority rules used to control access and use. If the adapta-

tion of new technologies is accelerated, the relationship between the rules and technologies in use may become seriously unbalanced. This is particularly the case when the rules have come about through long processes of trial and error and fishers do not possess legal powers to devise new rules and get them enforced. A focus on "production costs" alone, rather than on the total of production costs, transaction costs, and enforcement costs, leads to a narrow interpretation of efficiency (North 1986a,b). The rapid introduction of a "more efficient" technology by an outside authority can trigger the very "tragedy of the commons" that the same public officials presume will occur if they do not regulate the use of these fisheries. See Cordell and McKean (1986) for a discussion of the effects of the subsidization of a new technology on the Bahian coast of Brazil by national authorities.

30 A clear policy statement was contained in a federal policy guide issued in 1976: "In an open-access, free-for-all fishery, competing fishermen try to catch all the fish available to them, regardless of the consequences. Unless they are checked, the usual consequence is a collapse of the fishery: that is, resource extinction in the commercial sense, repeating in the fishery context 'the tragedy of the commons'" (Government of Canada 1976).

31 Such a vested system would need to be relatively complex and involve autonomy *and* exposure to scrutiny by external authorities regarding the legitimacy of the local rules.

6. A FRAMEWORK FOR ANALYSIS OF SELF-ORGANIZING AND SELF-GOVERNING CPRs

1 If the only anomalies were the cases described in this book, one could overlook a few cases that could not be explained. But these cases were selected to be illustrative of many others that are similarly difficult to explain using current theories.

2 The importance of information and transaction costs is stressed in the work of North (1978, 1981, 1989) and Williamson (1979, 1985).

3 For an insightful discussion of situational analysis, see Farr (1985).

4 Heckathorn and Maser (1987) stress that in many institutional-choice situations the decision is not between one alternative and the status quo rules, but rather among a series of proposed alternatives. They recommend that one view the process of narrowing the alternatives as a bargaining process. This is a useful way of understanding the elimination of various alternative sets of rules, but the final decision is between the best alternative set that individuals identify and the set of status quo rules in use.

5 That there is always a set of status quo rules (see discussion in Chapter 4) and that they remain in effect until changed helps to clarify the final choice made in these situations at any particular time. That a set of status quo rules will stay in effect until changed also stabilizes the structure of operational situations. A new set of rules must be perceived as generating more benefits than costs to at least a minimum winning coalition (whatever that may be) in an institutional-choice situation.

6 This list is the result of my effort to understand what I have read in many case studies at a more general level. I presume that this list will be refined over time

as propositions are more rigorously developed and tested. In other words, these are my informed conjectures subject to refutation.

7 If that were the case, the group would be a privileged group in Olson's terminology (1965).

8 Because the process of governing affects the future costs of governing, these processes are recursive. Decisions made within a structure will affect that structure in the future.

9 Tocqueville, in *The Old Regime and the French Revolution* (1955), deals with the general case in which there are uniform rules, but many seek exceptions for their situations. This generates a strict-rule/law-enforcement regime in which everyone comes to view the law as an obstacle to a reasonable course of action. The potentials for corruption are obviously great.

10 See Wade (1988) for an intriguing analysis of a CPR system in India that was managed entirely outside the formal governance system of India and was sustained by paying regular bribes to regional and national officials.

11 Institutional-choice processes are thus path-dependent (David 1988).

12 The relationships of the community to shared norms and internal norms and discount rates obviously could be developed much further than I have done in this sketch. Given the limitations of what can be covered in any one work, I have focused much more on factors directly affecting benefits and costs, as well as the role of designed rules as compared with evolved norms. The extensive work of James Coleman (1990) on norms is directly relevant to the argument that I am making here.

13 The empirical fact of massive numbers of failures is consistent with modern economic theory, but not the focus of its attention. If one attempted to explain why some firms fail, but others do not fail, one would need a theoretical apparatus different from that used for predicting characteristics of survivors at equilibria. The question being pursued in this study is why some CPR appropriators succeed and others fail to change the structures of incentives they face, and simple benefit maximiation is not a useful theoretical assumption for this purpose.

14 The difficulty and typical biases involved in estimating benefits and costs of future capital structures – whether physical irrigation works or the rules to be used to allocate irrigation water – are well documented in Chapter 5 of Ascher and Healy (1990). Ascher and Healy carefully document an almost universal bias toward overestimating benefits and underestimating costs of large-scale irrigation projects in Third World settings.

15 For good summaries of this extensive literature, see Dawes (1988) and Hogarth and Reder (1987).

16 The first attempt to create a special district in West Basin failed, at least in part because of a massive rainstorm that occurred on election day. The quantity of water in the gutters was substantially augmented by the efforts of one city administration that opposed the creation of a new district: They opened all of the fire hydrants for a "routine" flushing (Fossette and Fossette 1986, pp. 28–9).

17 Because many models *assume* the first two characteristics, they are not even considered. Recently, however, several scholars have explored the results produced by rules that have strong distributional effects and the importance of "grandfathering" current appropriations in order to gain agreement to rule

changes (Johnson and Libecap 1982; Karpoff 1989; Welch 1983).

18 Where local institutions already exist and appropriators find them to work well, given the problems they face, considerable resistance may be expected if other rules are imposed. Local appropriators may attempt to continue an "illegal" rule system for as long as they can make it viable, either because of lack of enforcement by central officials or because of the capacity to bribe central officials to ignore what is happening at the local level.

19 It is not just when external officials make rules that local appropriators try to present the facts of local situations in their favor. One can expect that tendency in all cases. But it will be difficult for a set of appropriators to convince others who are familiar with the local circumstances of "facts" that are at variance with the experience and advantage of those others, whereas it will be easier to sell such "facts" to individuals who are not familiar with the local situation.

20 See, for example, Gardner and E. Ostrom (1990), where we model the effects of four different rule configurations used to organize appropriations activities in inshore fisheries. There we compare equilibrium outcomes that are achieved when fishers follow specific rules in different physical environments. We do not claim to have developed a universal model of inshore fishery environments, nor do we claim to have explored all relevant rule configurations. Because we are developing models guided by a general framework, we recognize the part of the general terrain to which our models are relevant. Within that terrain, we are able to make precise predictions about equilibria and the logical relationships among the variables overtly included in the model.

21 See the recent publications by V. Ostrom (1987, 1989, 1990) for examples in which the work of these scholars provides the foundation for modern political theory.

22 Readers are referred to the list of references for the many important recent works by Buchanan, Coase, North, Shepsle, and Williamson that are substantially adding to our understanding of how institutions work.

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The governance of natural resources used by many individuals in common is an issue of increasing concern to policy analysts. Both state control and privatization of resources have been advocated, but neither the state nor the market has been uniformly successful in solving common-pool resource problems. After critiquing the foundations of policy analysis as applied to natural resources, Elinor Ostrom here provides a unique body of empirical data to explore the conditions under which common-pool resource problems have been satisfactorily or unsatisfactorily solved.

Dr. Ostrom first describes three models most frequently used as the foundation for recommending state or market solutions. She then outlines theoretical and empirical alternatives to these models in order to illustrate the diversity of possible solutions. In the following chapters she uses institutional analysis to examine different ways - both successful and unsuccessful - of governing the commons. In contrast to the propositions of the "tragedy of the commons" argument, common-pool problems sometimes are solved by voluntary organizations rather than by a coercive state. Among the cases considered are communal tenure in meadows and forest, irrigation communities and other water rights, and fisheries.

Governing the Commons makes a major contribution to the analytical literature on institutions and to our understanding of human cooperation.

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