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THE SURVIVAL AND PERFORMANCE OF IRRIGATION ORGANIZATIONS: AN INSTITUTIONAL ANALYSIS

A Dissertation Proposal

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The works of Garrett Hardin (1968) and Mancur Olson (1965) underscore the difficulty individuals face in taking collective action to advance their common interests. Their works have been used extensively in discussions about environmental and resource issues. According to their arguments, a commons dilemma easily arises when a scarce resource is jointly used by multiple individuals. The dilemma would lead to "over-exploitation" or "inefficient use" of the resource. For some biological systems, such as fisheries, "over-exploitation" may even lead to permanent destruction of their regenerative capabilities.

An important problem arises, therefore, as to how individuals can avoid the "tragedy of the commons" in relation to the use of valued resources such as irrigation systems, forests, and fisheries. Hardin (1968) himself argues that the dilemma can hardly be avoided unless a bureau, backed by coercive power, is established to manage the resource. Lewis and Cowen (1983), on the other hand, argue that it is possible even in an open-access resource to avoid the "tragedy of the commons" if some information, enforcement, and monitoring conditions are fulfilled. Others argue that the establishment of clear private property rights is the best way to avoid the problem (e.g., Demsetz,

1967). Still others suggest that some kinds of communal systems may be appropriate under certain conditions (e.g., Dahlman, 1980; National Research Council, 1987).

A brief survey of cases in natural resource management, however, indicates that there is no "one best way" to avoid the commons dilemma. We can find different combinations of private, communal, and public arrangements in well-managed natural resource systems such as water basins, in-shore fisheries, and grazing lands (E. Ostrom, 1986b). An important research problem, therefore, is how various institutional arrangements may be used to tackle different commons dilemmas. My dissertation will attempt to address this important problem in relationship to the organization of irrigation systems.

Commons Problems in Irrigation Systems

An irrigation system is a facility that provides a finite flow of water for multiple appropriators. It enables humans to cultivate crops in an area where the rainfall is either insufficient, erratic, or not in conjunction with the major growing season. Irrigation has become more and more important to the agricultural development of the world. Brown estimated that the irrigated area in the world nearly tripled between 1950 and 1985, amounting to around 271 million hectares in 1985 (Brown, et al., 1987: 125). Irrigation has become "a dominant part of man's relentless pursuit of enough to eat" (Bromley, 1982: 1). Not surprisingly, many international development agencies, governments, and farmers have increased their attention to irrigation development.

In irrigation, many potential problems may arise because the resource is owned and/or managed by a group of individuals. In most irrigation systems, multiple farmers appropriate water from a common source such as a canal, tank, or other temporary storage facility. The amount of water available to be appropriated in any particular time period is limited. Therefore, when and how much water a farmer withdraws from the flow may affect the opportunities for other farmers to obtain sufficient water for their farms. Independent and uncoordinated activities by individuals sharing a common source of water may create commons problems in several ways.

First, if individual cultivators try to take as much water as they can, even beyond the optimal requirements of their fields, their actions may harm other cultivators' interests without benefitting themselves. Second, in order to have the best yield, farmers need sufficient water to cultivate their crops at the right time during a growing season. However, in a situation where each farmer can withdraw water from the flow in total disregard of others, many farmers, especially those down-stream or in other disadvantaged positions, face great uncertainty about whether they can get the right amount of water at the right time. This uncertainty prevents farmers from adopting "more productive cultural practices because of an inability to count on the necessary water receipts when they are most needed" (Bromley, 1982, Summary). These problems can be alleviated if individuals coordinate or agree among themselves how to use the water resource system in a productive and equitable way.

Besides appropriation, cultivators may have to cooperate to maintain and sometimes build the water delivery facilities, such as

canals, ditches, pumps, etc., which are essential for effective retention and transportation of water. The maintenance of irrigation facilities involves two basic tasks. One task is to obtain actual manpower and financial resources to repair and improve the facilities. The maintenance of common facilities is frequently a collective good in the sense that once a facility is well maintained, it is difficult to exclude other irrigators from enjoying the benefit of a well operating system. Incentives exist for individuals to refrain from contributing to the maintenance, however hoping to benefit from others' contributions. If everyone acts likewise, there will be an "underinvestment" in the maintenance of the facilities.

2) The second task regarding maintenance concerns individuals' everyday use of the irrigation facilities. It is not enough just to expend resources to repair the facilities; it is also important that everyone use the facilities with care. Letting heavy animals walk across a canal may damage the canal; pushing a valve or a gate too hard may break an important part of the water delivery facility. A structure of incentives to induce individuals to use the irrigation system with care contributes to the long-term viability of the facilities. The overall problem of maintenance is further complicated by the patterns of appropriation. Whether a farmer is willing to contribute actively to maintain the irrigation facilities depends partly on his actual or potential share of water from the facilities. The problems of maintenance and those of appropriation are therefore closely linked.

Numerous cases exist around the world in which farmers have developed effective institutional arrangements to manage their

irrigation systems. In many of these cases, both collective decision-making arrangements and definite property rights systems pertaining to the control, appropriation, and use of the irrigation facilities and water are present. Indeed, institutional arrangements related to irrigation are always political, since they relate to the allocation and management of an extremely valued resource. Robert Chambers (1977) has described the problem succinctly:

> A central and universal issue in the distribution of irrigation water is who gets, what, and where. This is the very stuff of politics and it is surprising that political scientists, political anthropologists, and those who study political economy have not devoted more attention to it. Where water is scarce and often constraining and when individual farmers and communities of farmers compete for it, the focus is on the processes of allocation and acquisition which determine the access of users to water (1977: 345).

Although irrigation institutions have not yet been the focus of substantial work in political science, scholars in disciplines like sociology, anthropology, and agricultural economics have conducted a substantial amount of in-depth field research describing those institutions. Growing out of this intensive field work, hypotheses have been stated which link numerous variables to the capabilities of cultivators to organize and manage their own institutions. Many of these hypotheses have intuitive appeal. They have been stated by individuals who have considerable experience in the field and appear quite reasonable upon thoughtful reflection. What seem to be perfectly reasonable hypotheses, however, are at times directly contradicted by equally plausible hypotheses posited by another field worker. These hypotheses have not been integrated into a more general theory. Nor have they been subject to systematic empirical analysis

outside the experience of the field researchers. Furthermore, given the contradictory nature of some of the hypotheses, considerable work is needed to try to comprehend which hypotheses are consistent with one another and why.

In this dissertation, I will attempt to do two tasks. First, I will try to integrate these hypotheses into a more general theoretical framework derived from the fields of institutional analysis and transaction costs economics. It is my initial presumption that many of these hypotheses can be integrated into a more general theoretical framework. Ascertaining which hypotheses are consistent with the general framework and which ones are either inconsistent or unrelated to the framework is a contribution to the development of cumulative social science knowledge. Second, I will examine the strength of these hypotheses in explaining patterns of relationships in a wider set of cases than any used by the authors who originally formulated them. Thus, we will be able to ascertain not only their theoretical relevance but their empirical robustness.

Focus of the Research

What are the hypotheses? See p. 13

Throughout the world, one can find numerous kinds of irrigation systems providing water for multiple cultivators. If one conceptualizes a water delivery process as consisting of four stages -- production, distribution, appropriation, and use --, one can identify a wide variety of irrigation systems (see Plott and Meyer, 1975). For example, some systems are entirely managed by a government bureaucracy from the headworks (the production stage) down to the

appropriation facilities. Some systems are entirely owned and managed by a community of cultivators throughout all the stages of the delivery process. In others, a government agency is responsible for distributing water while local communities are responsible for organizing the appropriation of water.

No matter what form of ownership and management an irrigation system takes, multiple cultivators will be involved in the appropriation stage. It is also at this stage that many commons problems potentially arise. My dissertation, therefore, will focus on the institutional arrangements governing the appropriation activities of irrigation systems. Institutional arrangements governing other stages of the water delivery process in a system will be discussed whenever they are closely related to the appropriation activities of the irrigators.

In any institutional study, factors that can explain the origins, survival, and performance of the institutions in question are of crucial concern (E. Ostrom, 1985). A brief survey of the field research on irrigation systems indicates that there are few cases documenting the origins and evolution of the systems. Most of the research focuses instead on the structures and processes of irrigation systems in particular periods of time. This poses an almost insurmountable data problem as far as research on the origins of irrigation institutions are concerned. My research will therefore focus on the conditions for the survival and performance, instead of the origins, of irrigation institutions. An understanding of the factors accounting for the survival of an irrigation institution will be an important contribution to the study of irrigation management.

Even after there are rules governing the appropriation from a common property resource, built-in incentives may still exist for individuals to free-ride by breaking the rules, hoping that they will not be detected and punished. If an institution can survive, in the sense that most of its participants follow the rules most of the time, this shows that the institution is a possible instrument to ensure the continuous existence of the resource system. This will also provide us with some clues about why the particular institutional forms are adopted or evolved at the very beginning.[1] More generally, factors favorable to the survival of an organization may also be conducive to cooperation among individuals in particular types of situations.

A surviving institution, however, may not be the most efficient and equitable one possible. Furthermore, an institution that has survived for a long time may not have the ability to respond to contingencies and changes that may arise. The ability to transform and generate variety in response to environmental opportunities and challenges is a key to the long-term survival and development of an institution. A further question to ask, therefore, is the adaptability and performance of the surviving institution. This research will attempt to examine what institutional arrangements would enhance adaptability, efficiency, and equity of an irrigation system.

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[1] In the theoretical literature, especially transaction costs economics, many authors do not make an explicit distinction between origins and survival. I, however, think the distinction is important. In this regard, Langlois's discussion of the problem of "path-dependency" is instructive. He argued that a complete explanation of the structure of an organization "may have to suggest not only why a structure is efficient now but why it was efficient throughout its evolutionary history, which means specifying the process by which structures are selected" (1986: 21).

The Survival and Performance of Irrigation Institutions: A Brief Survey of the Literature

Although there is a general lack of case studies on the origins and evolution of irrigation organizations, scholars have frequently speculated about the factors inducing the development of irrigation organizations among cultivators. Their discussion may well serve as a starting point for us to conceptualize the conditions conducive to the survival of irrigation institutions in general. Wickham and Valera (1979), in a study of irrigation projects in the Philippines, conclude that in order to induce farmers to cooperate in managing their watercourses or tertiary canals, an effective system-wide management program is a requisite. In other words, farmers have no incentive to organize if they do not have a predictable or sufficient flow of water into their watercourses at the very beginning. Wade (1985), however, has made exactly the opposite argument. Drawing upon experiences in South India, Wade argues that the greater scarcity and uncertainty of the water supply, the greater the likelihood that a community of cultivators will develop collective arrangements and rules to regulate their water resource.

Some field researchers have also indicated the importance of defining a closed set of rights holders for an irrigation system. As Arthur Maass and Raymond Anderson (1986) argue, "The strength and coherence of local irrigation organizations in developed regions appears to be correlated with an irrigation community's success in limiting or stabilizing growth, thereby gaining security for its members" (p. 368).

Some scholars argue that the existence of definite property rights are important for the "successful" operation of an irrigation system. A proper correlation between rights/duties to the hydraulic facilities and those to the flow of water partly accounts for the continuation of cooperative effort in managing an irrigation system. Coward (1983; 1985), for example, argues that those who have invested resources in the development of the facilities usually have rights to a share of the water flow. Conversely, as pointed out by many others, those who own rights to water may have duties to contribute to the maintenance of the resource system as well as concurrent rights to participate in collective decision making about the system. According to Coward, "communal irrigation groups act cooperatively because they are partners -- common owners of important properties of irrigation works and water" (1983: 1).

Besides property rights, field researchers have discussed the typical features of the collective choice arrangements in irrigation systems extensively. Some scholars dispute whether collective choice institutions for irrigation should be village based or not. Wade (1985) argues that the village rather than the water delivery unit is a more viable organizational unit for water users associations since the village usually has established authority structures to mobilize collective actions (p. 23). Wade's position is supported by Hutapea, et al. (1979), who argues that "the boundaries of an irrigator group's area of responsibility, the irrigation command area, and village jurisdiction should coincide as nearly as possible" (p. 173). Coward (1980a), on the other hand, presents an opposite argument. He writes, "For purposes of irrigation organization the critical unit is the

'irrigation community,' composed of field neighbors, and not the village community, composed of residential neighbors, although in some instances the two groups may be the same" (p. 209). He argues that when cultivators from different villages share the terminal irrigation unit, it would be difficult to organize effectively along village lines. Furthermore, if the irrigation organization is dominated by village leaders, these leaders would tend to make use of their authority to influence the water distribution pattern to their own advantages. These two contrasting arguments can be linked to a more general point: the authority structure of an irrigation community and other political, social, and power structures are usually intertwined (Hunt and Hunt, 1974). However, whether village authorities and irrigation authorities are compatible or not remains open for dispute.

Hunt (1985) indicated that in many traditional, indigenous irrigation communities, mechanisms have been developed to hold the leadership accountable. The mechanism may include provisions for the appropriators to replace their leaders. Leaders' salaries or allowances may also depend on the contributions of the appropriators. Wade (1985), on the other hand, seems to argue that good or effective leadership depends less on these accountability provisions than the leadership's private interest in seeing that the public good is provided. He writes, "the robustness of the organization depends on its councillors all having a substantial private interest in seeing that it works; for all the kinds of functions we are considering here [i.e. grazing and irrigation management], that interest is greater the larger a person's landholding (assuming that landholdings are typically divided into scattered parcels)" (1985: 22).

Both Hunt and Coward emphasize that there have to be a nested group of mini-organizations if the area is too big for a single agent. According to Hunt (1985), the smaller subunits usually have a set of local leaders to operate the system at this mini-unit level. Similarly, Coward (1980a) argues "These small units would be self-contained and any irrigation problem could be easily isolated and overcome within such units. . . [Such an arrangement] also improves farmer cooperation and simplify irrigation extension" (p. 207).

In many irrigation systems, governmental agencies play an important role in regulating the appropriation activities of the cultivators. Scholars have developed some general arguments about the proper role of those agencies. Many argue that governmental agencies should refrain from interfering with the appropriation and maintenance activities of the local irrigators, if the irrigators are capable of managing the activities by themselves. Nevertheless, these agencies may act as arbitrators when there are serious disputes within and between irrigation communities. In order to make the arbitrating role effective, the agencies have to have a high degree of impartiality and independence from partisan local interests. Furthermore, effective information channels between the agency officials and cultivators are important (Harriss, 1977; Chambers, 1977; and Bottrall, 1978).

Some authors have commented on factors affecting the performance of an irrigation system. Some argue that the system of water rights may have great impact on the overall productivity of an irrigation system. In some irrigation systems, the rights are assigned to owners of riparian lands, and in some rights are assigned in proportion to the individuals' original contributions to the development of the

hydraulic facilities. Furthermore, water rights are transferable in some cases but not others. Some researchers argue that clear-cut, reliable, and transferable water rights provide an incentive for individuals to use it in the most efficient manner (Martin and Yoder, 1983a). Transferable rights also enable the trading of water shares such that the water can be obtained by individuals that can make the most productive use of it (Anderson, 1983).

One's physical position in the water system also matters. It is well documented by many field researchers that tail-enders are usually the first to suffer when there is a general shortage of water in the system (e.g., Maass and Anderson, 1986; Wade, 1987). These tail-enders may not be able to acquire the water they are legally entitled to, since the head-enders may have emptied the canal before the tail-enders can get any water. Unless some specific delivery rules are adopted to counter the problem, the tail-enders would not be able to enjoy a secure source of water regardless of the kinds of water rights they are legally entitled to. The rules governing the water delivery procedures have a great effect on the equity of the system (Chambers, 1977).

We can summarize the above arguments by the following hypotheses about the factors affecting the survival and performance of the institutions (organizations) governing the appropriation activities of an irrigation system:

Five hypotheses

(H1A) Water scarcity and uncertainty induce cooperation among cultivators (Wade). (H1B) Water scarcity and uncertainty discourage cooperation among cultivators (Wickham and Valeria).

(H2) The long-term viability of an irrigation organization depends on its ability to limit the number of water rights holders (Maass and Anderson).

(H3) In order to induce cooperative efforts in managing an irrigation system, greater rights should accompany greater duties, and vice versa (Coward).

(H4A) In order to facilitate cooperation, irrigation organizations should coincide with village boundaries (Wade). (H4B) In order to facilitate cooperation, irrigation organizations should be composed of field neighbors and not necessarily be village based (Coward).

(H5A) In order to maintain an effective and responsible collective choice body, mechanisms to hold leadership accountable are needed (Hunt and Coward). (H5B) Personal stake in the irrigation system itself induces effective leadership (Wade).

(H6) In order to enhance cooperation, appropriation activities should be organized on as small a scale as possible (Hunt, Coward, and Chambers).

(H7) Unless there is serious conflict within and between irrigation organizations, government agencies should refrain from intervening, otherwise, they will undermine the self-organizing capabilities of the irrigators (Chambers and Harriss).

(H8) In order to make their arbitrating role effective, intervening government agencies should be detached from, and impartial to, local partisan interests. (Chambers and Harriss).

(H9) Transferable water rights enhance efficient uses of water (Martin and Yoder, and Anderson).

(H10) For the sake of equity, special water delivery rules have to be adopted to ensure that tail-enders have a more reliable supply of water (Chambers).

A Theoretical Framework

In my dissertation, I will analyze the above and other similar hypotheses by reference to transaction costs economics and institutional analysis. Within transaction costs economics, a commons dilemma can be viewed as a situation in which individuals take actions

that leave them worse off than they otherwise would be if jointly agreed to take other actions. According to the logic of the Coase theorem, if transaction costs were not to exist, individuals would be able to coordinate to achieve the most efficient allocation of resources.[2] The "tragedy of the commons" can be interpreted as a result of high transaction costs which prevent individuals from entering into enforceable agreements that could make each of them better off. For example, in the prisoners' dilemma, transaction costs arise from the inability of the two prisoners to communicate with each other and to enter into an enforceable and mutually advantageous agreement. In order to explain or predict individual decisions in relation to a common resource, we therefore have to take into account the potential goods or bads involved and the transaction costs that may prevent individuals from seeking the goods or avoiding the bads.

In his works on contractual and governance structures, Williamson talks about two basic causes of transaction costs -- bounded rationality and opportunism (1973; 1975; 1979; 1986). According to the assumption of bounded rationality, individuals can only have limited ability to process information; it is costly to acquire information for transactions. In the case of common property resources, before individuals can start searching means to ensure a mutually beneficial outcome, they need the basic information about the physical and biological characteristics of the resource system they are using. They also need to know the participants who are

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[2] In his original formulation, Coase (1960) argued that the theorem applies to situations where private property rights are clearly defined. Cheung (1982) later extended the theorem by arguing that it applies to any property rights systems.

appropriating from the system, and the means of utilizing the system. Their existing information and their ability to gain further information affect their ability to develop institutions to solve the commons dilemma. The long-term survival and performance of the institutions also depend on whether the institutions can help individuals to process and make use of information necessary for the effective management of the resource system.

Opportunism is another important factor affecting the transaction costs in common property management. By opportunism, Williamson refers to efforts "to realize individual gains through lack of candor or honesty in transactions" (1973: 317). When applied to a commons situation, it means individuals' propensity to free-ride. Williamson's discussion of opportunism underscores that even after individuals have entered into some form of mutually agreed contract, they may still be tempted to "defect" or shrink if they believe the expected loss resulting from being detected and punished is less than the expected benefit of not cooperating. The long-term viability of an irrigation organization depends critically on the costs required to monitor and deter against opportunistic behavior of the participants.

From the above discussion, we may say that transaction costs are resources (time, energy, capital, etc.) required to overcome bounded rationality and opportunism such that individuals may arrive at, implement, and enforce mutually beneficial transactions and contracts. Depending on the specific situations, the kinds of costs involved in seeking and enforcing cooperation among individuals may differ. In cases where some institutions are already in place, the relevant transaction costs affecting the survival and performance of the

institutions can be analyzed at three levels: (1) the costs of making, implementing, and enforcing operational rules within the confine of the existing collective choice rules; (2) the costs of making, implementing, and enforcing collective choice rules under the existing constitutional rules; and (3) the costs of making, implementing, and enforcing constitutional rules.

At any one of the three levels, an individual will support a set of rules if the benefits to him of following and enforcing the rules are greater than the costs. The higher the net benefit the individual expects to obtain, the higher is the incentive to support the set of rules. According to this hypothesis, a cultivator would support an irrigation organization if it can bring him more benefit than it costs him to follow and enforce the rules of the organization.

Even though a set of rules offers net benefit to an individual, it does not mean that the set of rules is the most efficient and equitable in the context of the existing environment. Some other rules may bring even greater net benefit to the individual. An individual would prefer a new set of rules, if he or she could gain more benefits from the new rules than the transaction costs to change to the rules. Therefore, if the transaction costs for modifying rules are low, it is more probable that individuals may evolve rules of higher performance. On the other hand, if the transaction costs to change rules are high, it may affect the ability of individuals to respond to opportunities and challenges from the environment. An organization may survive for a long time, though the resource system itself may be poorly managed. Or in a case of drastic environmental changes, the organization or the resource system may disintegrate rapidly, if the organization fails to respond to the changes.

In an irrigation system, we may find groups of individuals who have different legal rights to appropriate water from the system, different degrees of reliance on the water source, and different levels of exposure to variation in the supply of water.[3] The benefit-cost calculus for individuals in different groups are not the same. Therefore, we have to first analyze how many potential groups of individuals are there in relation to an irrigation system and, then, see how typical individuals in each group would undertake the benefit-cost calculus regarding the existing institutional arrangements. After understanding how individuals in different groups evaluate and react to the rules, we can then proceed to analyze how individuals would interact to either sustain or transform the rules.

The institutional analysis framework as developed by Kiser and Ostrom (1982) posits three interacting elements -- attributes of goods and technology, configurations of rules, and attributes of community understanding -- that affect an action situation facing an individual. According to this framework, the potential factors affecting an individual's benefit-cost calculus can be classified in terms of these three basic elements. Further, since our focus is on the survival and performance of an institution, we may take the attributes of goods, technology, and community understanding as exogenous variables beyond the immediate control of the individuals concerned. The existing rules, on the other hand, can be regarded as endogenous variables subject to change by the participants. Our major theoretical task is

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[3] Here group refers to any set of individuals who share certain characteristics. It does not imply that they are necessarily organized.

then to explain why individuals choose to follow a set of rules, when they may try to change the rules, and how the rules may affect their welfare. Of course, even when we talk about rules, we may distinguish at least three levels of rules -- operational, collective choice, and constitutional choice. When we talk about individuals' decisions regarding the operational rules, we may have to take the collective choice and constitutional choice rules as given constraints beyond the individuals' immediate control. By the same token, when we talk about the making of collective choice rules, we may take the constitutional rules as given.

According to the framework just laid out, we can explain the survival and performance of an irrigation organization by the following logical steps:

(1) Identify the various groups of participants related to the irrigation organization.

(2) Identify the types of decision situations participants in each group face. (A participant may have to decide whether to follow the rules of a particular level. The participant may also have to decide whether to attempt to change the rules of a particular level.)

(3) Analyze how a participant calculates the expected benefits and costs regarding the particular decision he or she has to make. (The three basic elements -- attributes of goods and technology, configurations of rules, and attributes of community understanding --, would be factors that affect the expected benefits and costs facing the participant.) By this analysis, we can predict the actions of the participant.

(4) Analyze how participants in different groups interact to affect the survival and performance of the irrigation organization.

By using this framework of analysis, the systemic interrelationships among various hypotheses in the irrigation literature can be put into perspective. The empirical strength of

these hypotheses can then be tested by reference to multiple cases. It is also expected that by examining the systematic differences and similarities across cases, we may be able to generate some new hypotheses regarding the conditions for the survival and performance of irrigation institutions related specifically to the appropriation activities.

Research Design

As mentioned before, irrigation systems differ in terms of who is responsible for which stages of the water delivery process. In my dissertation, I will examine two major types of irrigation systems which are common around the world and have been studied by many researchers. First, a communal irrigation system is regulated or managed primarily by the local cultivators from the production through the use stage.[4] Second, a bureaucratic-communal irrigation system is a system in which government agencies manage some of the stages of the water production and delivery process while the local irrigators regulate the other stages. The most common form of this type is that of a government agency responsible for distributing water from a source while local communities regulate the appropriation and sometimes ~~of~~ the use of water.

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[4] This definition does not preclude that some government regulations or officials may influence activities in the systems.

Many scholars have undertaken field work on communal irrigation systems.[5] Many of the hypotheses discussed earlier come out of this field work. In the dissertation, I will examine cases of communal irrigation systems and try to delineate their systemic similarities and differences. I will try to assess the theoretical and empirical relevance of the hypotheses stated by the field researchers in light of these cases and the suggested theoretical framework.

Communal irrigation systems may have different institutional forms. In my analysis, I will subdivide these systems into two groups. First, a unitary system is managed by a single organization from the production down to the use stage of the water delivery process. Second, a federated system involves multiple appropriation organizations sharing water from the same production or distribution facilities. Above individual appropriation organizations, some higher-level organizations regulate the production or distribution patterns of the larger system. These higher level organizations may be constituted by representatives from different appropriation organizations, or directly by individual irrigators.

According to H6, "In order to enhance cooperation, appropriation activities should be organized on as small a scale as possible." Federated systems are institutional arrangements by which individuals may jointly use a large-scale water production and distribution facility while still organizing their own appropriation activities around numerous relatively small organizations. In the dissertation,

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[5] Some of the cases include: Bacdayan (1980), Beardsley, et al. (1980), de los Reyes, et al. (1980), Geertz (1980), Gray (1963), Grader (1960), Hunt and Hunt (1974), Martin and Yoder (1983a; 1983b; 1983c), Netting (1974), and Siy (1982).

I will first examine unitary systems and try to see how these systems are associated with different physical, cultural, and institutional environments. Knowledge about these unitary systems can help us to analyze the more complex federated systems. Since the focus of the dissertation is the appropriation stage of the water delivery process, I will only deal with organizations that specifically manage or regulate the appropriation activities in the federated systems. The other levels of organizations within the federated systems will be treated as external factors affecting the operations of the appropriation organizations.

H2 to H5 mostly deal with the institutional arrangements found to be associated with traditional, indigenous irrigation communities which have existed for long periods of time. In the dissertation, I will attempt to further specify the variables in these and other similar hypotheses according to seven types of rules that operate configurationally to affect the structure of an action situation (E. Ostrom, 1986a).[6] These rules include:

(1) Position rules that specify a set of positions and how many participants hold each position.

(2) Boundary rules that specify how participants are chosen to hold these positions and how participants leave these positions.

(3) Scope rules that specify the set of outcomes that may be affected and the external inducements and/or costs assigned to each of these outcomes.

(4) Authority rules that specify the decision function to be used at a particular node.

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[6] A set of rules are configurational in the sense that each rule operates as part of the configuration of rules. A change in one rule changes the entire configuration, thus creating a new institutional arrangement with the potential for creating new action situations.

(5) Aggregation rules that specify the decision function to be used at a particular node to map action into intermediate or final outcomes.

(6) Information rules that authorize channels of communication among participants in positions and specify the language and form in which communication will take place.

(7) Payoff rules that prescribe how benefits and costs are to be distributed to participants in positions (E. Ostrom, 1986a: 19).

This classification of rules, for example, can be used to further examine H3 which states, "In order to induce cooperative efforts in managing an irrigation system, greater rights should accompany greater duties." Within each irrigation system, we may identify the specific rights and duties of each irrigator in relationship to the water flow, physical facilities, and collective and constitutional choice mechanisms.

The property rights literature often discusses three broad types of rights: (1) rights to use a good, (2) rights to receive income generated by the use of the good, and (3) rights to transfer the good to others (see De Alessi, 1980: 3). These three types can be used to study the distribution of rights and the associated duties regarding the water delivery facilities and the water flow in an irrigation system. According to the institutional analysis framework, these three broad types of rights can be further refined by reference to the seven types of rules mentioned earlier. For example, in order to specify who has the rights to appropriate water from the water delivery system, we have to delineate the various position and boundary rules in use. The authority and scope rules stipulate the manner in which water may or must be appropriated and used. The right

to receive income is part of the payoff rules. The right to transfer water shares is stipulated by the boundary rules.

The property rights system is an important determinant of the survival and performance of a communal irrigation system. A case in point is H9 which states, "transferable water rights enhance efficient uses of water." However, rules governing property rights relationships are not self-enforcing, and, sometimes, the rules themselves are not sufficiently defined to allow unambiquous interpretation. Therefore, some kinds of collective choice arrangements is usually required. Besides enforcing and interpreting existing property rights relationships, these collective choice arrangements may also be responsible for settling disputes and organizing cultivators to maintain and repair the hydraulic facilities. H4 to H6 deal with constitutional and collective choice arrangements. These three hypotheses can also be further refined and analyzed by reference to the seven types of rules.

In the actual analysis, we will not be able to deal with every possible configuration of rules. We can, instead, try to identify systemic differences and similarities among cases. We can then explain these similarities and differences by reference to factors such as the attributes of the physical system, technology, and community understanding.

The following is a sample of questions I will ask about the attributes of the physical features, technology, and community of an irrigation system: P T C

(PT1) What is the rainfall pattern in the area?

(PT2) What are the major crops irrigated?

(PT3) Is there a great variation of flow of water within a year?

(PT4) How often are major collective efforts required to maintain and/or repair the physical structures of the system?

(PT5) What is the total area of irrigated field?

(PT6) Is there a great variation over space of the flow of water?

(PT7) Are irrigators readily observed by each other?

(C1) Are there large differences in ethnic, clan, racial, caste, and religious identifications among the irrigators that may affect their capacity to communicate effectively?

(C2) How many groups of irrigators are there who have different water rights, different water withdrawal rates, different exposure to variation in water supply, or different levels of dependency on water?

(C3) Have the irrigators engaged in cooperation in regard to other activities besides the management of the irrigation system?

Answers to the above questions may help us estimate the potential benefits and costs individuals may face in relationship to their irrigation organizations. Answers to PT1, PT2, PT3, and PT4 can help us assess individuals' exposure to water scarcity and uncertainty, their exposure to the adverse effects of others' actions, and thus their potential gains of having rules that govern everyone's appropriation activities. By this analysis, we may evaluate the contradictory claims of H1A and H1B. Answers to PT5, PT6, PT7, C1, C2, and C3 can help us estimate the costs involved in making, implementing, and enforcing rules. We may be able to explain the differences and similarities of rules among cases by reference to these costs.

Further, in order to understand the actual effects of different institutional arrangements, I will ask the following questions for each irrigation system:

(P1) Can the average mean flow of water during the irrigation season meet the water demand?

(P2) How extensive are problems of interference between appropriation technologies within the irrigation system?

(P3) Are the water delivery facilities well-maintained?

(P4) Are there any irrigators who have been consistently disadvantaged?

(P5) Have the relatively worse off been cut out of their benefits from the irrigation system?

Answers to these questions would help us to test the inferences made according to our theoretical framework.

The above research strategies will also be applied to study bureaucratic-communal irrigation systems.[7] However, one further complication in regard to this kind of system has to do with the role of government officials. H7 and H8 posit that government officials should refrain from intervening in the internal affairs of irrigation communities, and should act impartially in relation to local partisan interests. The two hypotheses, however, do not deal with the incentive structures that may induce the government officials to do so. The institutional analysis framework can be applied to study the behavior of government officials. By analyzing the goods, the

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[7] Some of the cases include: Bottrall (1981), Coward (1980b), Fernea (1970), Reidinger (1980), VanderMeer (1980), and Wade (1985; 1987).

community, and the rule that government officials face, we can estimate their possible actions and their effects on the appropriation organizations under their influence.

Outline of the Proposed Dissertation

The dissertation will consist of the following chapters:

(1) Introduction.

(2) The Survival and Performance of Irrigation Institutions: A Survey of the Literature.

(3) A Theoretical Framework.

(4) Communal Irrigation Systems (I): Unitary Systems.

(5) Communal Irrigation Systems (II): Federated Systems.

(6) Bureaucratic-Communal Irrigation Systems.

(7) Conclusions and Policy Implications.

Chapters 1, 2, and 3 will be an elaboration and development of the first four sections of this proposal. Chapters 4, 5, and 6 will present the findings of the research done according to the agenda outlined in the section, Research Design, of this proposal. In the concluding chapter, I will summarize the major research findings and their policy implications.

Estimating Equations?
Statistical Techniques?

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