

# Canal Irrigation and Local Social Organization<sup>1</sup>

by Robert C. Hunt and Eva Hunt

## INTRODUCTION

For a few scholars in social anthropology, irrigation has been of great theoretical importance (see especially Wittfogel 1957 and Steward 1955; cf. Leach 1961, Childe 1954, Wolf and Palerm 1955, and Sanders and Price 1968). Most anthropologists, however, have ignored it, even when it was a major technique of cultivation in the society they studied, or mentioned it only briefly in passing (Béteille 1965). We believe that irrigated agriculture is a very unusual social resource, that it almost certainly has systematic relationships to other features of social organization, and that these relationships need to be pursued in a systematic way.

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The present paper, submitted in final form 8 1 76, was sent for comment to 50 scholars. The responses are printed below and are followed by a reply by the authors.

Resource control systems (e.g., land tenure, trade, production) loom very large in most macrotheories about socioeconomic organization. There would seem to be, historically, three major (and cumulative) ways of intensifying plant food production: domestication of plants, irrigated agriculture, and industrialized farming. It is widely assumed that the yields from agriculture with irrigation are far higher than without it. Irrigated agriculture would thus seem to be an unusually rich addition to man's repertoire for exploiting his environment and consequently a resource of unusual social power. The intensification due to irrigation has been proposed, under some circumstances, to have had enormous effects, including the urban revolution and the origin of pristine states. It is therefore worth determining what its characteristics are and whether it has any systematic corollaries.

Of the limited number of general propositions concerning the relationship of irrigation and social structure, some focus primarily on the surplus generated by irrigation and others on labor inputs and their control. Both sets hold that there are functional, and even causal, relationships between irrigation and political structure. There has been virtually no discussion of the role of irrigation's surplus since Childe. Discussion has focused instead on the control of labor input, which is prominent in Wittfogel's Oriental-despotism hypothesis (1957; cf. Bennett 1974:44-47). We shall focus on the labor-control aspect here.<sup>2</sup>

Wittfogel's theory has four main elements: (a) a particular form of resource (arid land, large water source, potential for large irrigated agriculture works); (b) for preindustrial regimes, a sociological imperative for its exploitation (massive, centrally organized and controlled labor demands); and, as a conse-

GS-3000, to Eva Hunt, is supporting the gathering and analysis of materials on Tehuacán in the colonial period.

The materials on contemporary Tehuacán come in part from the work of our graduate students in the summer of 1970, most of which is not yet published. The work of Kjell Enge (cf. Enge 1973), Paula Sabloff, and Gordon Drever was most helpful in providing new ethnographic information.

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This is a greatly expanded version of a paper entitled "Irrigation and Local Social Structure" which we presented at the 1973 annual meeting of the American Anthropological Association.

<sup>2</sup> The surplus argument is at least as interesting, especially for local social organization, and we plan to investigate it in another paper.

quence of this, (c) a particular kind of state system (managerial) with (d) a particular distribution of power (despotism). There are two main thrusts to the theory: one concerns the role of irrigation in the evolution of the state, and the other is a synchronic functional (systemic) model of how certain kinds of states are structured. There has been a large amount of discussion of the first of these (cf. Adams 1966, Price 1971, Mitchell 1973, Bennett 1974), but relatively little of the second (cf. Millon 1962) except for its type-case, China (cf. Eberhard 1965). We shall concentrate on this second dimension.

The direction in which we wish to move here is one that is a precondition of hypothesis testing in a diachronic frame and involves the synchronic analysis of the system's parameters (Godelier 1970). Canvassing a portion of the literature within a synchronic frame may sharpen some distinctions and suggest some hypotheses. We intend to explore some sociocultural responses to irrigated agriculture at the local level, paying special attention to (1) the local organization of the tasks pursuant to irrigation, (2) the linkages between the local level and higher levels of the system, and (3) the relationship between roles in the irrigation system and other roles in the local social organization. We will be able to suggest a few hypotheses along the way, some of them referring to covariation within a sample of irrigated communities and some to irrigation as a special phenomenon. The latter can only be tested with a different sample that includes communities without irrigation as a control group. None of the hypotheses can be tested with the present sample; it is too small, it has been used to suggest the hypotheses, and it cannot be adequately measured.<sup>3</sup>

Furthermore, Wittfogel's general propositions are concerned with water control in its relationship to whole societies. Water control means not only irrigated agriculture, but also, and perhaps more important for the general hypothesis, flood control and drainage systems and canals as a means of communication and transport. As Price (1971) has pointed out, the larger problem of land and water management is complex and composed of multiple subsystems. Despite this, the literature in social anthropology which has been considered relevant to his propositions is almost exclusively based on detailed case studies of small localities, usually communities, which depend upon canal irrigation for a significant part of their production (cf. Millon 1962). These case studies cover less than the total society and tend to be synchronic and contemporary (cf. Kaplan and Manners [1972:97-98] for a discussion of the problem in terms of Wittfogel's and Sahlins's work). In consequence, there is a logical gap between the general hypotheses and the case studies which purport to test them. Three significant shifts in level of analysis have been made: from whole societies to communities, from water control to local irrigated agriculture, and from a diachronic to a synchronic frame.

A number of anthropological field studies have taken place in localities with irrigated agriculture. Almost none of these, however, represents Oriental-despotism conditions, so most are irrelevant to Wittfogel's thesis. Wittfogel, for example, has consistently maintained that the classic "hydraulic society" occurs in an "arid" environment. As Conklin (1973) has remarked, critics of his thesis rarely pay attention to this. Another variable is "scale," which may be taken to mean the scale of the physical works associated with water control, the population served, the acreage irrigated, the length of canals, and so on. Measurement of these in the available studies is generally no better than

<sup>3</sup> Ultimately, we would like to ask whether there are sociological or sociocultural forms of organization which are specific to irrigated agriculture as a resource. This is inherent in Wittfogel's work and in Marx's theories of the Asiatic society (cf. Wittfogel 1957). The research design for this demands a comparison of various systems, some with irrigated agriculture and some without. It is uncertain if such a job of research could be done with the published literature. Our guess is that it could not, at least not without some additional archival work.

an intuitive ordinal scale. Leach (1961) gives a picture of the old canal system leading from one of the tanks in Pul Eliya, and we presented as much information on the San Juan physical system as we had, including measures of atmospheric moisture conditions, scale of canals and irrigated lands, and at least some folk views of amounts of silting, etc. (Hunt and Hunt 1974). Geertz (1973) gives a general account of climatic conditions and describes the general layout of the canal system, but gives no physical measures (size, amount of water, length, technical devices). All of the phenomena of interest can be measured physically with current technology, and most such measurements are within the competence of the fieldworker with little training. Until such data are generally available, a test of Wittfogel's hypothesis from anthropological field studies is out of the question.

We shall focus on canal irrigation alone because there is as yet no evidence in the literature of community-level flood control or canals as means of transportation. In any case, canal irrigation is a significant aspect of local production and social organization and is worth understanding in its own right.

There is at least one good reason for concentrating on the local level of integration: there are major difficulties with concept formation and measurement in the more general propositions. Such concepts as centralization, despotism, water control creating other kinds of social power, etc., are all extremely difficult to work with in an empirical case study (see Hunt and Hunt 1974). These conceptual and measurement problems can best be dealt with by establishing feedback loops between detailed case studies and generalizing comparative efforts. The case studies can most efficiently be conducted on small localized populations, where the analyst has some reason to be optimistic about being able to control the values of parameters in sufficient detail. (In this regard, we follow Goodenough 1970.)

In addition, general propositions all contain, at the very least, implications for local structure. Although centralization, despotism, stratification, and agromanagerial bureaucracy refer to phenomena at the center of the society, they should manifest themselves in some way at the most local level, since they refer to linkages between vertically arranged units in a society and especially to the distribution of power within these linkages. Most general discussions of these phenomena tend to be distressingly abstract. A highly desirable step, therefore, will be to measure these phenomena at the local level.

Our discussion will largely be based on a few high-quality monographs on local irrigation systems: Gray (1963) on the Sonjo of Tanganyika (now Tanzania), Leach (1961) on Pul Eliya, Ceylon, Fernea (1970) on the El Shabana of Iraq, Glick (1970) on medieval Valencia, and our own materials on a region of rural Mexico (E. Hunt 1972, Hunt and Hunt 1974). We also refer to work done in Bali (Geertz 1959, 1973) and Japan (Eyre 1951, Beardsley, Hall, and Ward 1959). The sample is thus heavily weighted at the extremes of the political scale, there being large states at one end and a small tribe at the other.<sup>4</sup> We also have used other studies which, although they do not contain information on all variables, exemplify special problems (e.g., Bacdayan 1974).

## LOCAL ORGANIZATION OF TASKS

Every society with irrigated agriculture has several tasks peculiar to irrigation to accomplish. The physical system must be constructed and maintained. Relationships among those who would use the water present other tasks, including allocation of water to the users, conflict resolution, and organization

<sup>4</sup> We originally attempted to utilize a larger cross-cultural sample based on the "Ethnographic Atlas." Unfortunately, the data and coding are simply not sufficient to discriminate with precision in terms of our needs.

of ritual. The social organization of these tasks is our interest here.

In our Mexican case study, we distinguished between frequent or daily decisions and intermittent or infrequent ones. The construction of a physical system, for example, is a rare event; the allocation of water to users is very frequent (daily or hourly). In general, frequent events include allocation, maintenance, and, in some cases, resolution of internal conflict; infrequent ones include construction, repair, and, in some cases, resolution of major internal as well as external conflict. We suggested in the context of the Mexican case that the different levels of social structure (household, village, municipio, district, state) are differentially responsible for these different kinds of tasks. In general, there is a strong association between infrequent decisions and higher levels and between frequent decisions and lower levels.

The social system(s) is(are) a collectivity (collectivities) of roles and institutions in one way or another connected with the physical system(s). A major stimulus for the distinction between social and physical systems is that physical systems differ in size. A difference between states that is crucial for political organization above the local level is the presence or absence of physical systems which cut across local community boundaries.

All societies with irrigation that we have so far studied have an institutional locus which is primarily responsible for the maintenance, repair, allocation, and minor-dispute resolution functions (cf. Beardsley 1963; Glick 1970:31). This organization is based upon a clearly bounded physical irrigation system, such as a feeder canal, a stream, or a tank. Its personnel is headed by some named, specially designated role or role set. (These roles may be embedded in other roles—village headman, local community officials, and so on.) A body of norms, rules, or customary law regulates the decisions and behaviors of both management role holders and water users. The local unit is small in relation to the whole society; although in some cases larger than a community, it is the smallest unit concerned with collective water management and is capable of managing most of its own internal affairs. It usually has no more than a few hundred members. Recruitment is always connected to water rights, land rights, or both. This local group cannot resolve disputes with equivalent groups except by mediated negotiation, submission, or violence. If it takes water from a larger artificial system, it has little to do with the decisions made at the level of the larger system.

The relationship of this local irrigation unit to politically defined territorial units (such as villages, cantons, municipios, districts, prefectures, etc.) is highly variable. On occasion they may exactly coincide (e.g., Sonjo), but where larger state systems exist territorial and irrigation units often crosscut one another. The irrigation associations in the Tehuacán Valley in Mexico cut across municipios. In San Juan, they are smaller than the municipio, located at the village and hamlet level. Both areas, however, are under the management of a single water district which cuts across three states. Irrigation units cut across several territorial units in Bali (Geertz 1959) and so do water cooperatives in Japan (Eyre 1955) and medieval Valencia (Glick 1970).

There appears to be considerable variation in the degree to which political units occupy hydrological units. When political units crosscut ecological ones, there has to be some kind of superordinate unit to manage the water system. This can be one which deals specifically with water, such as the *qanat* societies in the Tehuacán Valley in Mexico or the cooperative water societies in Bali. At times these units, at least in the 20th century, may occupy the whole of a watershed (e.g., the Tennessee Valley Authority and the various agencies around the world which more or less reproduce it, such as the Papaloapan Commission in Mexico). The 12-village cooperative is a unit occupying parts of the watersheds of two rivers in southern Japan.

Some of the specialized bodies are creations of the central polity, and some are local in origin and authority. It would seem that many of the pre-Hispanic settlements (*cacicazgos*) in parts of Mexico were organized in terms of hydrological boundaries, and indeed some of the disputes between them concerned precisely the issue of one basin-political unit attempting to expand its influence into the basin of another unit (cf. E. Hunt 1972 for an extended discussion). On occasion, the larger unit may be a preexisting unit of the central polity (or of some intermediate level) which is given, or takes, responsibility for overall coordination of the irrigation system. This can be seen in contemporary Iraq, where the administrative district is also treated as an irrigation district, a decision which seems arbitrary from a hydrological point of view (Fernea 1970).

Glick (1970:230) has identified two alternative principles governing the allocation of rights to irrigation water within a system. One, the Syrian, is associated with large rivers, treats water rights as inseparable from land rights, and allocates water proportionally. Planting schedules may be staggered. The other, the Yemenite, is based on small sources of supply (often oases, very small or impermanent streams, or water tanks), treats water rights as separable from land rights and as capable of being sold, and uses fixed time measurement units. The primary difference between the two is clearest when there is a serious reduction in the amount of water available. In the Syrian model, there is a proportional reduction in allocation of the water, and everyone suffers equally. In the Yemenite model, some individuals or communities have primary rights to the water, and they are the last to suffer.

Water rights can sometimes be held independently of all rights in land. In that event, the discussion can largely ignore land (although there are other complications, such as that political clientship subsystems may then become dominant). In most communities in our sample, however, water rights are said to be permanently and inalienably connected with land rights, and allocation of water is a function of rules of land allocation.

While we think that the different water allocation principles are real and sociologically important, we doubt that they correlate very strongly with size of water source. It is also debatable whether proportionality of distribution is necessarily linked with size of water source, or with whether or not water rights are separate from land rights. For example, both Pul Eliya (Old Tank) and the 12-village cooperative in Japan have a proportional-distribution model, but the former's is based on a small village (143 persons) and a very small tank (Leach 1961) and the latter's on a large river, with over 5,300 ha. of irrigated fields (Beardsley, Hall, and Ward 1959). In neither case, at the moment, can water rights be separated from land rights. This coding of community studies according to both the allocation principle for water and the size of the water system reveals that there is little if any relationship between the two. There may be, however, a relation between allocation principles and scarcity of water at crucial times in the growth cycle of a crop (cf. Downing 1974).

San Juan is in practice a case of mixture of the two principles of allocation. San Juan has a moderately large river and two small streams which join it, both permanent. There are three communal physical systems, two of which use all the water from two streams and one of which takes water from the river. In addition, there are private canal systems which take water from the river or buy it from one of the communal systems. Mexican law is very definite about rights to water, and it is the Syrian model which it proposes. In San Juan, if there is sufficient water in the communal systems, then distribution is legal, according to the Syrian model. If there is a shortage, however, the center of the communal system, where the lands of more powerful people are located, gets more than its share. This is,

in effect, the Yemenite form of allocation. The private canals are clearly run according to the Yemenite model.

Three different kinds of conceptual models are available to the social anthropologist. First, there is a local folk model, which Lévi-Strauss (1953) calls the homemade model. This model has been the one most likely to be resorted to by the analyst for an understanding of the irrigation system. This has had harmful results. If a larger social entity exists, there is likely to be a folk model, often phrased as a legal code, explaining irrigation at that level as well. In the Mexican case, each of these levels has two separate components, a normative one (e.g., a native view of how the system "ought to work") and a descriptive one (e.g., a native view of how the system "really works"). As Lévi-Strauss argues, however, the primary purpose of these folk models is to manage the system, to permit continuity of the status quo, not to explain it. Considerable ignorance or misinterpretation of ethnographic reality may be built into these models, as Netting (1974a) has shown. Our job as analysts is to construct a scientific model which will explain not only the way the irrigation system works, but also the folk models—how they relate to the social reality. We agree with Flannery (1972) that information processing is an integral part of any ecological study, but we would add that in many irrigation systems, not only is water unevenly allocated, but information crucial for an understanding of how the system really works is unevenly controlled.

The folk models of San Juan do not assign the allocation principles just described to two different systems, but consider them to be good and bad variants of the same system. The average water user perceives the Yemenite system simply as a faulty version of the Syrian one. From the national legal point of view, this version is corrupt and punishable by law. From the point of view of those favored by the system, however, it is the only rational way of coping with water shortage. Thus analysis cannot be based purely on folk models without serious distortion.<sup>5</sup>

A major feature of water control systems is the possibility of a shortage or excess of water. Water scarcity is not a fixed condition of any place, but rather a particular relationship between supply and demand for water at a given point in time. If demand is greater than supply, then there is scarcity. It is widely presumed that arid and semiarid environments are automatically characterized by shortages, but this is not always the case. For example, San Juan in the late Post-Classic and most of the colonial period (when population was greatly reduced because of other factors such as epidemics) had no shortage of water for traditional agriculture (E. Hunt 1972). In the Tehuacán Valley, which is also arid, however, early in the colonial period, water shortages and conflict developed between villages planting traditional crops and haciendas planting sugar as a cash crop, because haciendas took more than their "legal" share of communal waters. This cropping pattern introduced scarcity because of the high water demands of sugar vis-à-vis traditional crops (e.g., corn, beans). Where meteorological information for 30 or more years is available, it becomes clear that most agricultural systems are subject to very considerable variation in the amount of environmental moisture available. First, there are droughts, floods, and more or less normal years in between.

<sup>5</sup> The ability to understand the workings of a local system of irrigated agriculture is totally dependent upon detailed information of high quality and degree of completeness. Such basic questions as how a person acquires rights to land and water are often very hard to answer from the ethnographic record. Beardsley, Hall, and Ward are among the few who specify, and they say that water is absolutely a function of access to land but do not demonstrate how they know this. Furthermore, as we have pointed out, there is a danger in taking the folk model as a model of actual behavior. The only way to know what distribution practices are is to study a goodly number of actual cases. There are precious few of these cases reported in the literature, and yet statements about distribution abound.

Second, there are cases of environmental degradation (e.g., steady lowering of the water table in the Tehuacán Valley).

Social systems can, to a point, increase the supply of water. This has happened slowly in many different societies (China, Japan, medieval Valencia, Pul Eliya, San Juan). In modern times, it sometimes happens very rapidly (Lees 1973). One strategy is to utilize present technology to expand supply, and another is to search for new technology. Both of these are represented in most of the studies we have consulted. Still another strategy is to locate a new source. Bacdayan (1974) has described such a solution. In this case, individuals slowly added terraces to the system until, at some point, the fact that demand was significantly greater than supply was recognized. The first public response was to accuse the authorities of mismanagement. Next the community decided that deforestation was the cause of the "drop" in supply, tightened up rules for exploiting, and searched the forest for a new source. They were able to tap one, and now supply is back up above demand.

Another strategy a society may use in balancing supply and demand is to place limits on demand. If there is a well-balanced traditional agricultural system, the major means of limiting demand is to resist new uses (new canals, new terraces, new fields, new crops, etc.). Glick (1970) shows how and why irrigators in medieval Valencia fought new construction. Since Valencia used a proportional-allocation principle, everyone suffered equally in the case of drought. If the demand expanded so as to exhaust the water in a normal year, it would be insufficient when the supply was less, so there was great resistance to the expansion of the cultivated area without a corresponding increase in total supply.

Other responses to a shortage of water may be individual emigration (e.g., Iraq, Mexico) or a shift in the allocation principles towards water monopolization such that some social segments must suffer more than others. This latter response is documented at least for one of our cases (colonial Tehuacán). If land is in short supply, cropping can be intensified to the point of involution, providing the water supply is adequate (Geertz 1963).

The conditions under which each alternative is chosen is a subject worthy of research. It is likely that accessibility to outside markets (labor as well as commodity) and the system of social (e.g., class, ethnic) stratification in the larger social system will affect such choices.

## LINKAGES

Wittfogel's general propositions about the relationships between irrigation and social organization are concerned primarily with the relationship between a political center and the subordinate local systems. The presence or absence of a centralized, specialized bureaucracy which deals with irrigation has been a prominent part of the discussion. Most social anthropologists who have tried to respond to this hypothesis have concluded that centralization is not a constant, or a necessary, concomitant of irrigation (e.g., Gray 1963, Fernea 1970). The original hypothesis is a complex structure of variables designed to apply in its entirety to a few situations. A more useful model would be one concerned with sources of power, the organization and use of power, and the relationships between levels of organization in a social system. Building such a model is beyond the scope of this article. What we shall do instead is consider the two comparative studies to date which have concentrated on the issue of centralization and then present some findings on the linkages between local and nonlocal systems of roles in the context of irrigation.

Kappel (1974) has argued that as population size and density increase, so do political centralization and the size of the irrigation system. Using Murdock's *Outline of World Cultures*, he ex-

amines 17 societies for which he finds sufficient evidence on size and density of population, size of irrigation facilities, and degree of centralization of decision making. None of the cases in his sample is a classical field study of irrigation. As he points out, there are difficulties in the measurement of his variables. The most important difficulty is with political centralization. He states (p. 370) that he wishes to measure "decision-making groups which manage irrigation," but his data seem to refer to the highest levels of integration of the political unit. It cannot automatically be assumed that the highest level of sovereignty is also the highest level of control of irrigation. Until the relationship between these levels has been analyzed, his conclusions are doubtful.

The major attempt at a comparative empirical investigation of the relationship between irrigation and centralization is by Millon (1962). He uses materials from seven case studies to investigate the relationship between size of the irrigation system (defined in terms of both acreage and population) and centralization of authority over the allocation of water. He finds that for Pul Eliya, Bali, Japan, and the Nahid (in Arabia), allocation is strongly or partly decentralized, while for Teotihuacán, the Sonjo, and the El Shabana allocation is centralized. He goes on to conclude (p. 80) that "centralized authority and the practice of irrigation are not necessarily related." Further, he states (pp. 86-87):

The studies of relatively small irrigation systems . . . illustrate that there is no necessary relationship between the practice of irrigation as such and centralized authority, and that social responses to the practice of irrigation agriculture are as varied as the social and ecological settings of the people who practice irrigation. . . . One conclusion strongly suggested by the evidence examined here is that centralization of authority is an exceptional response to the problems of irrigation agriculture.

Millon's conclusions have been mentioned more or less favorably by Lees (1973) and have been accepted by Wolf (1966), Price (1971), and Mitchell (1973). His work is therefore worth examining in some detail.

First, the narrow scope of Millon's paper must be emphasized. Millon is interested only in the *allocation* of water, not in other tasks. (Wittfogel, it should be noted, was interested as much in construction and maintenance as in allocation.) Of the five tasks or functions that we have concentrated on, Millon chooses only one. It is perfectly legitimate for him to do so, but the reader must be careful not to generalize too much from so narrowly defined a study (cf. discussion in R. Hunt 1973). Secondly, while centralization in most discussions is closely connected with the idea of despotism and total control of a society, in this case centralization is concerned *only* with allocation. There is no strong a priori reason to suspect that centralization of allocation would have any systematic relationship to centralization of other functions in the society. In the long run, broad comparative studies will be able to examine this matter closely. For the moment, however, we must confine our interpretation of Millon's study to the range of his assumptions.

A major difficulty with Millon's study is that size of the irrigation system is inconsistently measured. For some of the cases in the sample, it is easy enough to take a measure directly from the ethnography (e.g., Japan, Pul Eliya), but for at least two others Millon's measures are almost certainly wide of the mark. In the case of the El Shabana, he gives the apparent area commanded by the tribe in 1918 rather than the area commanded at the time of the fieldwork, or, more important, either the area served by the local irrigation district or the area irrigated from the Daghara main canal. In the case of Bali, the figures he gives are for a virtually unique small princely state, and in the article in which this unit is discussed Geertz does not say anything about the relationship between it and any irrigation society. In fact, we have so far been unable to find any population figures for irrigation societies at any level higher than

the minimal one. Moreover, while the acreage of the Japanese case is clearly given in the ethnography, there is no stable population figure for the whole of the cooperative. In some cases, then, Millon uses the figures for population and acreage which are dependent upon a given head work. In other cases, he uses a unit which, as far as can be determined, has nothing to do with irrigation. In still others, he chooses units which are not all dependent upon a head work in the same sense as the others. It is our conclusion, therefore, that his measure of size of the irrigation system is not stable enough to warrant even the table he presents.

Furthermore, Millon's centralization variable is not clearly defined. In one "centralized" case, the Sonjo, the top officers of the village deal with allocation; in the other two, the El Shabana and Teotihuacán (both parts of states), national-level bureaucrats make allocation decisions. In the "decentralized" cases, Bali, Pul Eliya, and Japan (also parts of states), allocation is not handled by national-level officers, and there are what Millon (p. 80) calls "strongly traditionalized" rules for the allocation of water. It is not at all clear what he means by traditionalization, but apparently it is that customary rules about the distribution of water cannot be contravened by some authority. The linkage here of "decentralized" and "traditionalized" seems not very useful. In all systems which have been in operation for any length of time, there are customary rules about rights to water and procedures to be used, regardless of the amount of control a centralized authority structure may have. There is evidence for this in Millon's account of Teotihuacán, where one village had special rights to water based on documentary proof of pre-hacienda rights. He also states (p. 79) that on the village level "water was allocated to individuals on the basis of traditional agreements." Millon's point is that the allocation rules for the basin as a whole have not been institutionalized, but within corporate units they have been so for a long time. The federal government has become involved in the intervillage levels and lately in the villages themselves. We therefore feel that the addition of "traditionalized" does not contribute to the analysis.

Millon's (implied) definition of centralization seems to be that allocation decisions are handled by an office of the highest level of government that exists in the society. If this is accepted, we agree with Millon's findings in the cases of the Sonjo, Teotihuacán, and the El Shabana. We also agree with his findings with respect to allocation in Japan (although, as we shall demonstrate in another paper, this does not hold for other tasks in that case). We are unable to evaluate his assessment of the Nahid, because the data have not yet been published. That leaves two cases, Pul Eliya and Bali, and here we disagree.

Millon concludes that Pul Eliya is strongly decentralized with respect to water allocation. Netting (1974b) also argues that there is no centralized control of irrigation in Pul Eliya. Leach's book (1961) contains sufficient evidence to demonstrate, however, that the irrigation system is embedded in a hierarchically arranged, unified state political system.

Pul Eliya irrigates from two reservoirs, village and temple. Only the village tank is large and in good repair. Its water is channelled to fields by canals. One or two tanks appear to be typical of some villages in the provinces of north-central Ceylon, but many villages in the area share tanks which are under the direct control of the national central government. All tanks are said to belong to the Crown, and this is how village corvée labor to repair the tank, called "Crown's work," is legally enforced (pp. 17, 43, 45, 46).

The tank of Pul Eliya was built in the 11th century under the authority of a classical Sinhalese kingdom which Leach (p. 16) describes as a "striking and characteristic example of what Wittfogel has called 'hydraulic civilization.'" Before the arrival

of the British, Pul Eliya was part of the lowest level of a large feudal system. This system was controlled from a capital outside Pul Eliya and had more than three levels, with named officials, who dealt with water issues above the village. "The administrative categories of the British Colonial Period were a systemization of the . . . feudal system" (p. 28).

At the village level, land was controlled by aristocratic land-grant holders, who were tenants of a district feudal lord and managed the services of the villagers, collected taxes, entertained government officials, and maintained the irrigation tank in good working order. Such obligations continued for quite a while under the British system, after the abolition of feudalism (pp. 153–54). In exchange, the local aristocracy had clear prerogatives in ritual and in the use of both land and water according to the traditional old-field tenure system (pp. 155, 166, 103–4, 124, 153). The British in part froze the local political and economic structures (e.g., p. 156), but at the same time they created new offices connected with land and the control of irrigation. Of these the most important, from the point of view of Pul Eliya, was the village irrigation headman. The headman is what Leach calls a "dictatorial office" (p. 154). Millon believes, however, that the Pul Eliya system is effectively decentralized and that "no single individual or group of individuals exercise *any real authority* over its operation" (Millon 1962:64, emphasis ours).

Leach is explicit on the authority of both headman and central government. In the old system, he tells us, until about 1838, "all effective authority was in the hands of . . . the Ratēmahatmayā" (the head of the top regional unit). Now all effective authority at the village level is in the hands of the irrigation headman; below him are the heads of kin groupings. A person holds the headman's job for life, and until 1926 he had to be an aristocrat. He ratifies land titles. He has the exclusive prerogative of operating the village tank's sluice. He keeps the village land and tax records. "His first responsibility is to see that government regulations regarding the fair distribution of water are fully adhered to." His "authority is mainly economic," but "he can, if he so chooses, exercise wide and autocratic powers." He settles disputes, including those over water. Besides being responsible for water distribution, he has accumulated great economic and political power by manipulating orthodox custom to his advantage.

Indeed, the headman managed, in the 1940s, to change the distribution of rights to water, a fact noticed neither by Leach nor by Millon. Prior to the late 1930s, irrigation had apparently been confined to a small area known as the Old Field. There was normally enough water to cultivate this plot twice a year. In the 1940s, under the stimulus of a central-government campaign to increase rice production (due to supply difficulties in World War II), the headman and his associates brought a large amount of new land under irrigation, still using the same old source of supply. The new land was then cultivated in one season, the Old Field in the other. As a consequence, the new lands have taken half the water away from its traditional recipients—all those who have rights in the Old Field.

Moreover, although Pul Eliya is today far from being part of a feudal arrangement, and the local land-grant holders exist in name only, the caste system, the marriage system, and land and water distribution have kept aristocratic titles in only a few families, who happen to be the wealthy of the community and who, not by accident, hold the traditional power offices (pp. 20, 28, 47, 64, 160, 198, 154, 204, 227, 232).

Thus, in Pul Eliya irrigation is the most significant factor in social organization, in the recognition of kinship, in the formation of marriage alliances, in the distribution of political power, and in relationships with the outside world. Historically as well as at present, the Pul Eliya system is not a local invention, purely locally maintained, nor is it free from impingement from the larger social and political world. The central government of Ceylon provides aid in times of famine (p. 32), forces the villages

to keep records (pp. 28, 47), gives financial assistance in irrigation (p. 46), legitimizes the types of land tenure possible and therefore water allocation (p. 20 et passim), and subsidizes major repairs on the irrigation tanks (pp. 45–46). Therefore, we conclude that the Pul Eliya allocation system should not be described as decentralized.

In Bali, water and land are managed by a corporate unit called the *seka subak*. This unit is entirely separate from the village and has both sacred and secular activities. It tends to be small (Geertz and Geertz [1975] mention two, one of which has 70 ha. of land and 197 members and the other 159 ha. and 439 members). It has authority over water sources (dams or take-offs from major canals), canals, and all matters having to do with the management of the physical system, including the work necessary to maintain it and the allocation of water. Each such society has an elected chief (Geertz 1959:996).

A reading of some additional sources reveals that there are conflicting sets of evidence on the question of authority. All agree that land and water are managed by a subak, that the subak is quite separate from other kinds of associations, and that there is a complex customary law which applies to subak matters (Grader 1960, Geertz 1959, Geertz and Geertz 1975). What is not clear is the relationship of each subak to a superordinate political hierarchy. Geertz (1959:995–96) says that subaks are groups, such that an entire watershed is a single, albeit loose, organization, connected by means of an office with the princely household:

. . . the lords played an important role in coordinating activities between irrigation societies and settling interlocal disputes, granting rights to clear new land, build new dams and form new societies, and so on. Usually, a member of the royal house was appointed general overseer of irrigation for the whole region and each noble house had one or two irrigation officials of its own.

Grader, a Dutchman doing administrative surveys for the colonial government in the 1930s, reported that the heads of the subaks were appointed by the government and that a principal job of the entire hierarchy was to oversee and manage water allocation (Grader 1960:270, 287). The clear conclusion from this material is that allocation in Bali is centralized. On the other hand, Geertz and Geertz (1975:19–20) unequivocally state that each irrigation society is egalitarian and autonomous. Either choice seems arbitrary under these circumstances.

Because of the smallness of the sample and the extreme difficulty with the measures, it seems to us that Millon's conclusions are premature and doubtful. What does emerge from this material is a quite consistent picture of a strong relationship between irrigation and power. Very often, higher levels of authority than the local are strongly involved in local affairs, and not as distant or passive agents.<sup>6</sup> Direct evidence for this can be organized in terms of the types of tasks we have outlined above: construction, maintenance, allocation, conflict resolution, and the organization of ritual.

1. New construction which is greater in scale than previous works is usually imposed by an outside agency. Centrally organized construction is surely not infrequent and has occurred in all sample cases except Sonjo. For Japan, Mexico, and Iraq, there are several accounts of construction by central agencies, and in all cases locals were largely unable to resist them. In medieval Valencia, there were deep divisions of opinion at all levels of the society about new construction, so it is difficult if not impossible to say that locals were or were not able to resist external decisions. In the case of Pul Eliya, there is no instance in Leach's account of a centrally imposed construction decision. Murphey (1957), however, does mention early historic construction schemes under central direction which had the effect

<sup>6</sup> In another work now in preparation, we are exploring these relationships systematically with a larger sample than we have been able to use here.

of tying the dry-zone tanks into a centralized canal system. Yalman (1967:37, 248-49) mentions that the government built a new system and that one village built its own tank.

The new works centrally imposed may well be detrimental to the local society or the local ecology. This has been documented for Iraq (Gibson 1974) and for the Valley of Oaxaca (Lees 1972). One function of having members of the local community occupy roles which involve extra-local power may be to protect the locale against the damaging policies of higher-level institutions. This is clearly what was tried by the San Juan elite when a central bureaucracy dealing with water, the Papaloapan Commission, proposed a new canal that might threaten their economic power.

There is a second, minor, kind of construction which is within the means of most participants in an irrigation system: the extension and enlargement of a physical system. Canals can be widened and deepened little by little, and new ditches can be added on to the end in a piecemeal fashion (Geertz 1963). This does not seem to involve extensive executive organization or a tie-in to decision-making centers. It is uncertain how this part of the construction effort is accomplished, for there is virtually no information on it.

In Tehuacán, qanats and associated canals are financed by cooperative groups of peasant men, while the work is actually directed by a single local expert, a man with technical experience who is hired for such jobs. The completion of a qanat can take, often, up to 50 years, although water from it can be used before the total length is reached. Although the initiative is local, the federal government has to give permission.

2. Routine maintenance of a physical system at the local level is apparently always in the hands of the local social organization. While the central part of a canal system is the responsibility of an extra-local collectivity, the maintenance of the peripheral parts of the system is under local control. We would not be surprised to discover, however, that, where there is industrial agriculture based on highly capitalized canal irrigation, some extra-local unit is taking a strong interest in at least monitoring local maintenance conditions. This seems to be the case on the new canal system of our Japan example, where the modern section of canals (Ashimori) and the new facilities of the old canals are maintained directly by the prefecture, bypassing the cooperatives in the system (Eyre 1955).

3. The allocation of water to local branches of a large artificial system is usually done above the local level, and there is little that the local unit can do to alter the state of affairs (e.g., Iraq, Japan). Allocation within the local physical system is apparently almost always the responsibility of the local social organization, and within this is managed by minor executive roles (e.g., gate guards). Allocation and maintenance roles may or may not be combined in the same personnel. In the communal system in San Juan, daily allocation is in the hands of water policemen, but maintenance is determined by the water committee. Private canal owners in San Juan make both sets of decisions. In Pul Eliya, both decisions are made by the same personnel. In village Japan, where water rights are firmly associated with land rights and the Syrian allocation principle is dominant, there is apparently little need for obvious central organization and decision making about allocation. (It is probably this situation which leads Millon [1962] to conclude that these represent only "traditional" forms of organization.) That such systems seem to run themselves over the short run, however, is insufficient reason to conclude that no formal decision-making procedure is available. As Beardsley, Hall, and Ward (1959) show, new decisions must often be made because of unusual events (such as a flash flood in the river).

4. The resolution of conflict over allocation has two dimensions. One has to do with conflicts that are internal to the local unit but cannot be resolved locally. It is a universal feature of state systems that conflict not resolved at the local level will be taken to higher levels (e.g., through the courts). In the

Mexican case, this is often the course followed. Since 1940, this has also been the case in our Japanese example. As far as we can see, internal conflict resolution is always connected ultimately with higher-ranked political roles in the society, which may or may not be directly linked with the social organization of the physical system. Sometimes specialized roles (such as the water judges in Valencia) are created to deal with this special set of problems.

The other dimension of conflict resolution is defense. Conflict between two local organizations over irrigation water has a high violence potential. This issue is mentioned for our Valencia, Mexico, Japan, and Iraq cases and may well be universal. The central authority can *impose* decisions because it can resort to force or punitive measures or the threat of them. This seems to be a major factor in the maintenance of a working system over time. In the case of the Nahid cited by Millon (1962), it appears that the collapse of the central political system led to paralyzing conflict at lower system levels.

The other side of this coin is that, from the local point of view, the issue is one of defense or expansion of one's own territory. As far as we can determine, the central authority's role is to see that disputes are resolved by peaceful means with least cost to the larger social system. This may normally mean a court procedure or the imposition of some form of supervision to maintain peace and keep production levels up, but it may also involve preferential treatment of localities in water allocation. The degree to which the final decision can be imposed by the court is not clear for all cases. In many cases of hacienda-village conflict in colonial Tehuacán, the court was largely the servant of the more powerful of the two contenders (the hacienda) and was in effect rubber-stamping a decision made by one of the local parties. Ultimately, this can be attributed to the fact that it was to the advantage of the colonial elite that cash-crop landlords be favored over subsistence peasants. The villagers, on the other hand, often boycotted court decisions and took their claims to a different agency, sometimes prolonging a case in one court or another for several generations. In the colonial period and during the "hacienda boom" in the 19th century in Mexico, absentee landlords had a virtual monopoly over allocation, construction, and changes in the system, not only for their haciendas, but also for the villages which had the misfortune of sharing the watershed or water sources with them. Even when the courts occasionally favored the villages, the hacendados continued to impose their will without major conflict because of their other sources of power.

In the Tehuacán Valley, for example, because of the shift from subsistence agriculture to sugar cash-cropping in the 16th century, the haciendas had illegally reduced the allocation of water to local communities. When such cases were taken to court, the local communities invariably lost their traditional rights, and a new allocation system favoring the haciendas was imposed from above. The hacendados as a group were able to control the court system because of their extra-local links with the government apparatus, because of their ability to convert their wealth into power over the judiciary personnel at the regional level, and because, ultimately, their role as water managers was legitimized by the other bureaucratic roles they had cornered for themselves within the regional political and economic structure. Furthermore, these changes led to monopolization of local power by making many of the local peasants, who could no longer plant because of insufficient water supply, into hacienda peons. (This, it needs to be remarked, occurred not because the peasants became landless, but because they became waterless.)

The lengthy court cases in the archives on Tehuacán are ample evidence that procedures to convert illegal water allocations into new legal codes for water distribution favoring haciendas and mills were highly standardized. They involved,

among other things, the recurrent bribing of witnesses, the stealing of wooden water-measuring templates, the control of lawyers in the capital, local military harassment, and threats of economic sanctions against the villages (e.g., Archivo General de la Nación, Ramo de Tierras 1673–1745, 1689–1801, 1690, 1711–35, 1769). In order to understand more fully how and why these decisions are made, we need detailed case studies with a full social context. Since this legal context involves the central government, and especially its court system, it is clear that anthropologists need new skills and strategies to deal with it. One point which needs investigating is the impact of colonial systems on the management of irrigation facilities. Both Chernyak (1968) and Frank (1970) have argued that Western social scientists have ignored this problem because of their ideological biases on the issue of colonialism.

5. Beyond these linkages with larger political units, there may also be linkages to ritual organizations and religious institutions. There is in the literature very little on this topic, and in most of the modern states the phenomenon can hardly be said to exist. Linkages of this kind were, however, significant in Japan and Indonesia in the past, and in the Mexican region we studied the ritual cycle and roles are involved in complex ways with the irrigation system in the Indian villages. Here well cleaning, communal repair, and construction, from the point of view of the local culture, necessitate the active participation of workers in ritual and the delegation of power to ritual specialists. These are now local-level roles, but it is possible that in the past, when the Roman Catholic Church was the major landowner in the area, the Church controlled access to water by the local community through ritual scheduling. This was true in Tehuacán, because several haciendas were owned by religious corporations (monasteries and convents) which were absentee landlords.

Some generalizations from these data are possible: Massive construction and conflict resolution are closely linked with extra-local organization, while maintenance and daily allocation matters are in local hands. With large artificial systems, allocation of water to the local segments is a matter of central policy and management. If there are any demands of a small local irrigation system which encourage centralization, they are the social problems between homologous units rather than the technical ones. This may well not be the case where flood control and large-scale canals are the issue, or where a very large (in both extent and volume) artificial water supply system is in operation. Here again, the limitations of the community study must be noted. No community study can throw light on the problems of the organization of the large artificial supply systems. Community studies cannot therefore bear upon questions involving such a higher-level system. Community studies can show, however, how local organizations are linked or related to such a larger system, as we have tried to show, tentatively, here.

## ROLE EMBEDDEDNESS

The relationship between roles which manage the irrigation system and other roles, especially powerful ones, in the local social organization has received less theoretical discussion than the linkages just described, but more data on it are available. Social stratification is an integral part of the problem; in terms of the case studies we have examined, there can be no doubt that where there is irrigated agriculture there is social stratification and that the stratification is importantly linked to differential decision-making power over the tasks of the irrigation system.

A major concern with most of the general propositions is the existence of a specialized organization for coping with the tasks of the physical system. (Wittfogel's agromanagement bureaucracy is one form.) In our sample, where there is a small physical sys-

tem and no large artificial supply system, and where the local irrigation system is nearly isomorphic territorially with the governmental unit, there is a high degree of embeddedness of irrigation-system roles in other powerful roles in the local society. Furthermore, water tasks may be controlled by agencies which have other political tasks, for example, a municipal board or a village government. In San Juan, for example, while there are some specialized personnel (e.g., water policemen) and three special water committees, almost all the authority roles which deal with the problems of the irrigation system are embedded in other role systems of the local elite (economic, political, and, in the past, religious), and many are not formally part of the water committees at all (e.g., the sugar-mill manager controls one whole physical system, ignoring the committee officially over him). The same is true for Pul Eliya, with its headman embedded in the state political structure, and for the Sonjo and their chiefs.

Degree of role embeddedness at the local level seems to be related to the degree of internal stratification. If there is low internal stratification, authority differences of water-management roles may be minimized, while the real authority lies outside the locality. In Pul Eliya, the irrigation headman is the bottom rung of a long ladder of government offices and local elite roles, and he is integrated into the state power structure. His role is also embedded in a number of other roles involving kinship groups, control of taxation, judicial functions, and executive tasks. In southern Iraq, the central government has been trying to cut back the power of the shaykhs for many decades. At the time of Fernea's study, the local irrigation officer of the central government, whose functions were formally technical, was responding to local pressure to make decisions about allocation in the fashion of a local political leader. We have, then, apparently, some structural pressure to coalesce the roles of technical decision maker about the physical system and decision maker about allocation. That the technical aspect of his role comes first, however, may have more to do with the reduction in power of the traditional shaykh than with its being connected with a central bureaucracy, and factors of historical priority may be related to exogenous variables.

Normally, the management of the basic functions of an irrigation system is assigned to a highly specific set of ranked roles. These roles per se, however, may not carry much political weight. The set of roles which is usually associated with the management of local social affairs is a mixed category, including local governmental roles, dominant economic interests, high-prestige persons, and perhaps others. It is rarely the case, apparently, that these roles form a single or consistent system (cf. Bell and Newby 1972:186–249). We are therefore, in referring to it as a system, papering over considerable difficulties and ambiguities. This is not the place to try to solve these problems, which in any case we are in no position to do. We simply wish to start from the position that there are (a) ranked local roles associated with social affairs and (b) ranked local roles associated with the management of the irrigation system and to have a preliminary look at how these two sets relate to each other.

Since an irrigation system is onerous to run, the incentives leading individuals to seek executive positions are of interest. If there is relatively high actual or potential demand for water, management skills are crucial for daily operations, but the occupants of management roles, more often than not, find their lot to be harassment and even grief. For example, in San Juan, during the period of water shortage, water policemen carry rifles simply to protect their lives from possible attacks by angry farmers with dry fields. From the studies in our sample with sufficient information on identity of officeholders and identity of landowners (Pul Eliya, Sonjo, San Juan, Japan), a pattern emerges. The chiefs of the Sonjo have executive tasks and clearly gain in terms of the local stratification system

through connection with the irrigation system. The irrigation headman in Pul Eliya has clear executive responsibility for the whole system and has been able to use his position to develop a separate physical system mainly for himself and his clients. In San Juan, the "owners" of the private canals clearly manage them and gain personally from such management (from water sales, rights to buy crops of water clients, etc.). The communal system, on the other hand, confers little gain on the executives, and it is said to be hard to get people to serve on the water committee. Informants often call it "a waste of time." Water policemen are poorer townsmen said to be "contented with small bribes." Glick (1970) mentions the same phenomenon for medieval Valencia, but we have no information on land-holding or on other positions for the executives. In the Japanese case, most hamlet members prefer not to take the post of headman, and it is a role which is difficult to fill; the hours are long, the work prodigious, and the personal gain apparently near zero (Beardsley, Hall, and Ward 1959). We therefore propose the hypothesis that the incentive for a person to assume executive responsibility for a local irrigation system lies in the possibility of differential control of the deployable surpluses of the system.

It would also seem to be the case in our sample that the higher roles in the local stratification system are linked with instrumental decisions in irrigation, whether or not the individual occupies a water-management role. Again, water-management roles are actually power roles only when control of water is associated with control of the flow of production or distribution.

The degree of local stratification seems to be greater where there is some means for converting deployable agricultural surpluses in some extra-local economic system. The most prevalent such means is the market. This appears of particular importance in systems where irrigation is utilized to raise cash crops, but redistributive systems may operate in the same fashion at lower levels of efficiency in terms of increased differentiation. Therefore, there is a strong case to be made for a linkage between control over water resources and control over other decisions in the local unit. We have no doubt that this is the case for the few closely studied local systems that we have (Pul Eliya, San Juan, Sonjo, and El Shabana). Therefore, water control is not the only source of power, but one of a complex set of production variables linked to economic flow in the society and to other factors which determine the distribution of political power.

A major question raised by Wittfogel is the directionality of the relationships between power over water and power over other valued social resources. Wittfogel's position is that water power dominates. The study of local stratification, its relationship to irrigation, and the directionality of that relationship demands considerable detailed information about power and other differences between roles and between particular individuals, both at the local level and above. Some of our case studies provide this information and some do not. Some studies give only a general overall view of the local communities (Geertz, Glick, Lees); others give at least some detail on the relevant variables of one case (Leach, Beardsley, Hall, and Ward, Hunt and Hunt, Fernea, Gray). In San Juan, we have argued, there is complex mutual influence (feedback) between variables. In Pul Eliya, the headman was able to gain control over a new source of irrigation water after he became headman for the original source. For the Sonjo, there is no clear indication of which comes first, power over water or power over people; Gray discusses both, but in his materials on recruitment to the office there is sufficient ambiguity that we can make no decision. There are, in a given village, several sets of roles, arranged hierarchically, each of which has some sort of rights over water, and one set is the primary executive and judicial body of the village. Positions in these sets are inherited patrilineally, but they can also be bought and sold (Gray 1963:146). When a person is recruited to the position, a large

initiation fee of goats must be paid. It is not possible from Gray's account to separate these payments of goats and lineage positions from differential control of water, although Gray himself feels that water control has priority.

Assessment of the relationship between these two sets of phenomena demands, first of all, adequate frameworks for measurement. Rights of access to land, labor, capital, other monopolized resources (such as salt in the Chinese case or permits to mill sugar and distill alcohol in Mexico), markets, judicial and ritual roles which control distribution of surpluses, etc., must be analytically distinguished. All too often these rights are merged in the accounts, perhaps because the roles are frequently merged in small local systems and the folk model is presented as an ethnographic mechanical model (in Lévi-Strauss's sense) of how the system works. Further documentation of statistical models may be needed to answer many of the unanswered questions.

Furthermore, these different phenomena must be anchored in carefully measured time. The major empirical technique for inferring cause and effect is temporal sequence, and it must therefore be a prominent part of any research design. The ordinary synchronic community study is perhaps least likely to be able to address itself to the directionality issue. As Adams (1973) and others have pointed out, the time span of observation is much too short. It would be desirable to have measures on all the interesting variables extending over a long enough time period to cover several changes of leadership. In this way, changes in relationships to property, political office, and irrigation roles could be correlated. This might give at least some measure of elite circulation as it relates to the irrigation system. With documents, the time span can be extended considerably (see, e.g., Adams 1965, Adams and Nissen 1972), but anthropologists who are both capable of and interested in doing both participant observation and extensive historical documentary research have been rare. Probably both teamwork and long-term commitment to research on a particular area are needed (cf. R. Hunt 1973: 90-92). It is a curious fact of the intellectual history of our discipline that the Radcliffe-Brownian structural-functional studies which have dominated the field and which supposedly emphasize "holistic systemics" have so often ignored time depth as a variable, or dealt with it as mythology (Leach 1954), or simply projected the synchronic structure into the past, assuming cyclicity, homeostasis, or a steady-state system.

Finally, the research design will have to allow for the possibility of feedback loops between power over water and power over other resources, for it seems intuitively unlikely that simple linear causality is involved. Clearly, a systems-analysis approach, with a sufficient time span to permit multidirectional correlations, is indicated. We are obviously dealing with very complicated phenomena which can even now be measured by a large number of variables. At this stage in the evolution of the analysis, we should adopt research strategies which will reflect and manage that complexity.

## SUMMARY AND CONCLUSIONS

First, it should be clear that future studies of irrigation systems should include information on the physical system and the relevant environment. As Netting (1974*b*) and Conklin (1973), to mention only two, have pointed out, the environment is crucial for understanding the local irrigation situation. Meteorological and climatic information covering a long period of time is necessary in order to assess the contemporary situation. Physical measurements are necessary for the investigation of differences in ecological system from one locale to another.

Second, it is important to specify the role system connected with the management of the local physical system and the role

system which manages the local political institutions and to clarify the relationship between them. This will demand information on land tenure, water rights, office holding, the functioning of territorial political units, etc.

Third, the external (extra-local) social environment must be specified, including political (governmental), economic, and religious dimensions. The specification of connections between the national and regional political and economic structures and the local role system is crucial. Similarly, relationships to outside markets, transportation systems, credit systems, etc., need to be investigated because of their direct impact on the local system. The same applies to the ritual organizations (if any) involved in the system. Ultimately, what we are calling for is a shift of focus from the traditional community study. We think it now self-evident that important questions about irrigation as a social system cannot be answered by confining analysis to a year or two and to a single "isolated" locale. We are in fundamental agreement with Netting (1974b:34) on the above points.

Irrigation is clearly a resource of unusual fecundity. It occurs with differentiation of power in the total society, and the power is frequently, if not universally, associated with the management of the irrigation system itself. It is therefore connected with stratification systems based in part on differential control of means of production. We have argued that local communities embedded in state systems are linked in complex ways, especially with higher levels of organization of water management, and that these higher levels of organization are significant variables in at least some crucial aspects of local process which concern irrigation. We have shown that the management roles for the local irrigation system are closely linked with systems of roles belonging to higher levels of integration, if such exist. In many cases, the local unit is incapable of resisting for any length of time many of the decisions made at higher levels of integration.

Irrigation agriculture thus clearly is a resource of great structural potential; it is systematically linked with major features of the social organization, closely linked with differential power, and embedded in the local-national linkages of states. It may therefore be associated with distinct forms of social organization which require further study. There is little ethnographic information that is useful for the testing of hypotheses. We can choose between different views only on the strength of our convictions. What we need, instead, is to return to the field with a more clearly specified set of questions. We have tried to outline a few in this paper.

## Comments

by G. MUNIR AHMED

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This article is well documented, summarizes a voluminous literature, and admirably contributes to research as a review. It falls short, however, of the significance claimed in the title for local social organization. Notwithstanding some remarks, one wonders if the particular factors and elements of social organization discussed can be construed to constitute a portrayal of social organization per se. Furthermore, the value of the review is limited by the authors' choice of literature. Though this is justifiable in its own terms, they could profitably have included one of the most extensive canal irrigation systems in the world, in South Asia, not to mention others. Had they done so, their critique of the literature and the preconditions for testing hypotheses would have been conceptually more functional and regionally more balanced. The sampling technique adopted in the presentation could have been a little more flexible. Addi-

tional literature to render it more representative could have been accommodated by shortening the somewhat too long discussion of Wittfogel, Millon, Lees, et al., of slight or doubtful relevance to the article's title. The conclusions sum up all of the research: its scope and limitations. A plea is, however, made that we return to the field with a "clearly specified set of questions" for further study. In this lies hope of unfolding the secrets of environmental and other sociocultural covariations that bind irrigation and social organization.

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We should be grateful to the Hunts for this interesting contribution to the slender comparative literature in anthropology. For many years secondary analysis has been a ticket to professional oblivion, and I had hoped that my recent paper on water-resources writings in anthropology (Bennett 1974) would stimulate a certain amount of interest in comparative work.

The Hunts are justifiably skeptical about the value of community studies—especially community studies done without adequate reference to the larger systems in which they are located—for deriving general theory. Nevertheless, they attempt to use community studies to find regularities ("systemic correlates") in the relationship of water-resource development to social organization. I think they should be congratulated for taking on a job which was almost sure to produce meager results. Only in this way will the shortcomings of classical ethnographic community study be revealed.

Their paper demonstrates the dearth of theory in the study of the relationship of resource development to social behavior. A description of an irrigation system does not substitute for an attempt to explain the behavior of people in varying contexts of that system. Only a theoretical approach to the problem, featuring adaptational concepts which ask what people want and how they get it, in different systems and at different times in the same system, can do the job.

In two places the Hunts note the tendency for local systems to devolve toward illegal or inequitable states: (1) in the discussion of the San Juan schemes and the "good" and "bad" distinction between water rights assigned on watercourses on the basis of land-tenure rights (which, following Glick, they call the Syrian) and water rights assigned on the basis of ownership of source of water, making them saleable (which Glick calls the Yemenite); and (2) in the discussion of stratification, especially with reference to a search for power on the part of local persons who see water resources as a vehicle.

A variety of models is available in the literature on water management for the analysis of these very common situations. The distinction between the two kinds of water rights is basic in all studies and texts in this field. The Syrian system is equivalent to the "doctrine of prior appropriation," which is the foundation of modern western North American water laws. The Yemenite is similar to the classic riparian-rights system, prevailing in eastern North America, and formerly in the West. The two approaches have displayed an institutional progression because the underlying problem is a physical and instrumental one—the fluid nature of and absolute need for water. Hence, increasing population plus increasing rational control of resources in order to maintain equity of allocation of water in this population means that systems tend to evolve from the Yemenite toward the Syrian—that is, as long as land tenure remains in private hands. This happened in western North America as population and water use increased in arid and semiarid lands. When land tenure and use move toward collective solutions, however, the prior-appropriation (Syrian) system may be modified or abrogated by the state or other body supervising collective use or control and replaced by collective-use schemes or related methods of allocation. This three-or-more-

stage progression is basic in North America and elsewhere, and while institutional variations between societies can influence it, there is an underlying uniformity introduced by the amount of available water, the need for it, and the size of the population using it.<sup>1</sup>

With regard to the tendency to view one or the other allocation system as illegal or corrupt, the Hunts might have profited from my model (Bennett 1967) showing how in North America systems of resource allocation tend to move from universalistic (i.e., equal or fair allocation for all) to particularistic (i.e., unequal and covert allocation to the few), usually with the collusion of government bureaus that become involved in local affairs and with wealthy or highly productive operators as a result of their decision-making functions, adjudication procedures, etc. This evolutionary progression also seems to have occurred in the Neolithic–Bronze Age transition. As the Hunts noticed, people tend to use irrigation as a means for collecting power because water is a necessity and the accumulation of power is a universal behavioral tendency.

Still another progression which I have published on in brief<sup>2</sup> concerns the interaction between external bureaucratic control agencies and the local population with respect to the allocation of water and operating arrangements of the irrigation scheme. In many nations, local, technologically simple, and inefficient private schemes are replaced by government-constructed community schemes which are costly and must be operated by a professional water master lest the “corrupt” particularism alluded to above develop and a general free-for-all emerge. In most cases this situation will last for some time, until government decides it can no longer afford wages and salaries for personnel to settle quarrels, set allocations, open and shut gates, etc. Then government attempts to give the responsibility for these functions to the local water users, who are required or persuaded to organize their own users’ association and establish procedures. This is usually resisted because it costs money, which must be collected by a tax on the users or by raising water fees. The cycle may continue if and when the local users’ association falls into disorder, the scheme begins to break down, the government steps back in, and so on.

At several points the Hunts’ paper could have benefited greatly from the use of economic models or at least elementary economic perspective. About halfway through the paper they come to two conclusions: (1) that “new construction . . . greater in scale than previous works is usually imposed by an outside agency” and (2) that “routine maintenance of a physical system at the local level is apparently always in the hands of the local social organization.” Well, of course. There are a number of reasons for both of these, but one overriding one: cost. Local systems are usually—in tribal, peasant, and entrepreneurial societies—relatively simple because they are largely labor-intensive: few local agrarian communities at *any* level of development can generate enough capital to afford elaborate schemes, which in water management are very expensive, not only for construction, but also for engineering expertise and maintenance. Hence, if the system is to be enlarged or improved, someone else has to pay for it. I am talking not only about money,

<sup>1</sup> For histories and analysis of water rights and water-management practices in North America and elsewhere, the following make a useful start: Dobkins (1959), especially good for the history of water rights and the interplay between the cooperative and private elements in Western water law; Green (1973), an excellent study of the spread of irrigation in the Texas plains and the dynamics of resource abuse; White (1969), a basic essay on the nature of American water management and development and how it has been influenced by social structure; White, Bradley, and White (1972), an approach to East African water use, but with references to our own society and its systems of water use; and Smith and Castle (1966), a basic “reader” on water management, economics, and law.

<sup>2</sup> See Bennett (1976:290–92); the material there has since been expanded to chapter length and will appear in a book on the anthropology of resource and agricultural management.

but also about knowledge, skill, techniques of social mobilization, and so on. These are all monopolies which are assembled in state bureaus or the like; the local community simply cannot be expected to have them. Moreover, the costs of improvements or high-level maintenance can be so great that local communities hesitate to embark on them even when they might be able to manage the operation fairly well. As the Hunts remark, irrigation is “onerous.” This explains a great deal.

In other words, some of the Wittfogelian propositions boil down to simple economic truisms: e.g., as increasing efficiency is desired in water-control systems in local communities, there is need for a supra-authority of some kind to pay the bills—not to mention political aggrandizement, etc. You don’t have to go to ancient Egypt to find this, either—it has happened in the Tennessee Valley Authority and practically every other enlarged and rationalized irrigation system in western North America, India, Pakistan, and elsewhere.

There is another factor here: George Zipf’s “least-effort” principle in action. When the people of a local community have become accustomed to having someone on the outside pay the bills, or can perceive an opportunity for getting someone to do so, they rarely pass it up, local autonomy or no. If they can get water more cheaply, they tend to put this first and worry about losing their freedom later. Here again, we don’t have “culture,” but simply the structural channelling of behavior, and in all these strongly instrumental systems we will find such channelling. Obviously one cannot always predict the course of change precisely, and of course humans act perversely from time to time, but at key levels the outcomes are remarkably similar in these water-management situations if you know where to look or what questions to ask. Since the community studies the Hunts survey did not ask such questions, one can hardly expect them to furnish the answers.

I am not overwhelmed by the Hunts’ finding concerning the “embeddedness of irrigation-system roles in other powerful roles in the local society,” since everyone dealing with resource management in a practical sense has been aware of it. Resource management aside, it is a fundamental principle of rural social organization, as Frankenberg (1966) and many others have pointed out. When the local society is composed of neighbors and relatives, there is a tendency for any one individual to play a number of overlapping roles; there is no alternative, really, and it is almost a simple matter of numbers—more roles than people. Further, since water control is a major concern in an agrarian community, it is automatically, as the Hunts have indicated, a source of power. The specific details of “embeddedness” will of course vary from case to case, since at this level specific institutional features come into play.

This leads to a concluding thought: The basic problem in all inquiries into the relationship of resource management to social organization and ideas is the interplay between a number of physically and instrumentally determinable behavior sequences, on the one hand, and local institutional methods of allocation, plus the external institutional imperatives (bureaus, taxes, etc.), on the other. This is a complex three-way interaction which is perfectly susceptible of empirical research, and even case-study research, providing that the dimensions of the problem are clearly formulated and the research sites chosen with care. The extent to which physical (the nature of water and the amount needed) and instrumental (human wants, power drives, costs) can prevail over institutional variants and external pressures is a measure of the extent to which the system is guided by instrumental rather than symbolic concerns. The germ of truth in Marvin Harris’s “cultural materialism” lies here. The potential errors in his position appear if he assumes that instrumental considerations always prevail, or that they always so prevail in domains of human experience other than the instrumental. This is why models and theories pertaining to human behavior

have to be founded on empirical generalization and not universal theorems.

Some factors, of course, are well known with respect to their regularity or variability. The Hunts mention some: all societies have an "institutional locus" (I take it they mean *responsible authority*) for maintaining the works, and all irrigation systems are "regulated" by bodies of norms or laws (and nearly all are also characterized by constant violation of same!). Then the Hunts note that the relationship of the responsible authority to political and territorial units is a variable, and indeed it is. This is so for the simple reason that you can do the job as long as someone gives you the authority and the proper orders, and it doesn't matter much where they come from—a proper case of definition of the level of institutional variation. The Hunts also note that there is "variation in the degree to which political units occupy hydrological units." Of course, since the boundaries depend on the nature of the land survey, land tenure, and settlement history—all variables. It would seem that one could determine these levels of regularity and variability without having to look into a specific literature (irrigation). But then anthropology is "preparadigmatic": it lacks a central core of principles, hence we have to recapture the essence for each case. Another zone of ambiguity lies in the bias in cultural anthropology toward diversity: the assumption that cultures always differ, a belief which reinforces the tendency to do community studies without adequate reference to the larger systems. Hence anthropological literature is slanted away from regularities, even though it frequently seeks them. The Hunts comment on the "logical gap" between the grand-scale teleological generalizing, on the one hand, and the microcommunal studies, on the other (as I also observe, in Bennett 1976:25, 30, 212, 271). It is just the kind of theorizing the Hunts wish to do that gets lost in the "gap."

Anthropologists could move ahead faster if they did a little reading in the technical and historical literature on the subjects they wish to research. Although this literature often mistakes cultural variables for constants, it nevertheless contains information on the very generalizations anthropologists seek and draws its data from familiar societies.

by RICHARD K. CLEEK

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The Hunt and Hunt article extends recent efforts to model the irrigation-society relationship. The reformulation and refinement of the subhypotheses of the Steward-Wittfogel theory initiated by Mitchell (1973) and the 1972 Symposium of the Southwestern Anthropological Association on "Irrigation's Impact on Society" (Downing and Gibson 1974) form the basis for this excellent effort.

The Steward-Wittfogel theory founded on a lack of definition of the terms of the theory, the scale of irrigation and centralization in social organization. Hunt and Hunt's attempt to refine these terms within a three-part framework focusing on labor control seems a viable approach, but several aspects of the discussion require elaboration.

The authors reject Glick's (1970) two alternative models of water allocation, Yemenite and Syrian, partly because there exist some "small" water sources (Pul Eliya) with proportional allocation instead of the expected time-unit allocation and partly because examination of their sample indicated no relationship between allocation principle and "size" of the water system. This rejection seems premature, inasmuch as Glick (1970:215-16) also proposes a developmental hypothesis in which time distribution is succeeded by proportional distribution as demand or scarcity increases. It could well be that "small" systems with proportional allocation underwent some pressure forcing the succession of the proportional principle. Alternatively, given the existence of proportional distribution systems in the wider society, it would not be surprising to find

"small" systems with proportional allocation as a diffused element.

The preceding discussion presents two problems but lightly touched upon by the authors. One is the concept of scale of irrigation, which most recent writers, including Hunt and Hunt, agree needs better measurement. Some typology of irrigation based on scale is critical to most hypotheses relating irrigation to social organization. Spooner's (1974) work well illustrates that the relationships between scale and social complexity involve not only physical scale, but the scale of the irrigation system measured in social and economic terms. In Spooner's Iranian cases, scale measured in terms of economic investment proved a key explanatory variable. Until our concepts of scale have been refined, rejection of hypotheses relating vague notions of irrigation scale (usually physical) to other phenomena seems unwise.

The second problem has been noted by the authors: that there is a logical gap between most irrigation hypotheses, which deal with whole societies, and irrigation case studies, which deal with communities. This seems a critical problem in any proposed cross-cultural analysis, although the second aspect of the authors' analytic framework, exploring "the linkages between the local level and higher levels of the system," may alleviate the problem if the second major term of the Steward-Wittfogel theory, "centralization in social organization," is operationally defined. The authors' discussion of the "centralization" concept is to the point, but without a more rigorous typology of social organization, which obviously has strong functional relations to centralization, the discussion remains ambiguous.

by P. E. B. COY

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The Hunts have to be congratulated upon bringing forward a topic long neglected. I am not sure, however, that a cross-cultural comparison such as they have attempted is so much satisfactory as tantalizing. Where, for example, are the references to the significant contributions of the French human-geographers such as Brunhes (1908) and Sorre (1934)? Where is a consideration of the different styles of water allocation down the southeastern coast of Spain from Alicante through Elche and Murcia to Lorca? Can one pass over the whole gamut of local control over water resources, as represented by the different sorts of tribunals and their different powers over transgressors, with two ambiguous sentences about "specialized roles . . . [being] created to deal with this special set of problems"? What are the arguments for and against water auctions? Is enough made of the different impact upon a local irrigation system when there is a local manufacturing industry competing for the water? What are the consequences of kinship links between irrigators on the same distribution channel? Finally, I would question the implication that, in colonial Mexican courts, local communities "invariably" lost their traditional rights to water and wood (see Coy 1968).

by THOMAS F. GLICK

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I wish to address myself to the nature of proportionality as an organizing principle in allocation of water. Both Syrian and Yemenite systems have proportionality-based rationales, but they require different measurement techniques which in turn are dictated by the degree of pressure on the water supply: the greater the pressure, the greater is the need for precision in measurement. Therefore I do think there is a broad correlation between supply relative to demand for water and the tendency

toward one or the other modal type. Where demand is high, more social control is needed, as is tighter technical control in the form of more accurate measures. The Syrian model becomes increasingly inflexible as pressure for water grows; this sometimes sets in motion a shift toward the Yemenite model whereby water once public becomes private and greater efficiency in allocation is attained through the establishment of a market in water or water rights. Thus, the two types are frequently linked sequentially in the same region, with the direction of change always from Syrian toward Yemenite. As demand for water rises (as the result of a climatic shift, increasing density of settlement, etc.), there is a marked tendency to move to a more patrimonialized, privatized system. This can be observed in many places in eastern Spain, where there is a distinction between "old rights," assigned on a Syrian principle, and "new" ones, on a Yemenite principle. When such a change occurs, those affected perceive a loss in justice and in equity (see Glick 1972:166 n.105), and the Yemenite version is seen as a faulty version of the Syrian one.

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As I am more familiar with general ecological theory than with the specifics of irrigated agriculture, I shall attempt to place Hunt and Hunt's stimulating article in a broader ecological framework. If I am not mistaken, the following is the multi-variable proposition offered as a tentative explanation for the relationship between agricultural irrigation and social organization: An irrigated agricultural system leads to an increase in energy supply and an increase in the ability of certain roles (or role sets) to exert control (power) over the social system.

Although Hunt and Hunt's synthesis of the relationship between irrigation and power is important, I am disappointed that they do not explicitly relate their findings to a significant body of literature dealing with the relationship between energy and social organization (see, esp., Adams 1975; Hanks 1972; Margalef 1968; Odum 1971; Rappaport 1968, 1971; and White 1943). This literature would suggest that their hypothesis regarding "a linkage between control over water resources and control over other decisions in the local unit" could be altered by substituting "energy flow" for "water resources." Another point emphasized by Hunt and Hunt is that "not only is water unevenly allocated, but information crucial for an understanding of how the system really works is unevenly controlled." This is an important point, but the uneven allocation of water must be preceded by the uneven access to information regarding the system. I see this relationship as follows: An increase in information leads to an increase in power for certain roles, or role sets, via control over energy flow, only when said information is monopolized by said roles. Obviously, there is some differentiation of power in all societies, because even when all information is public, individuals will differ in their perceptions of the same information and their abilities to apply it.

I would agree with the need to utilize a methodology such as the systems approach, which would allow the testing of multidirectional correlations and many variables. The relationships between such concepts as information, energy flow, mass-energy, resource base, power, role sets, and economics are indeed much too complex to accept a "simple linear causality." However, the measurement of variables related to irrigation and other energy sources is not nearly as simple as the authors state (see Hanks 1972:62 and Lewis 1976).

The points regarding the necessity of more detailed ethnographic data to allow for the testing of hypotheses related to irrigation and power (or energy and power) are excellent. Hunt and Hunt's analysis should indeed stimulate ethnographers "to return to the field with a more clearly specified set of questions."

by BRUCE B. MACLACHLAN

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Allotted space permits only bald comments without explanation:

1. The Hunts have identified in irrigation farming institutions an empirical arena of research of potentially great theoretical significance. They have indicated apparent gaps in well-documented published sources, and they offer a program.

2. In view of the concern with the linkage of irrigation systems to subsystems or levels of a complex social system, I believe that they will find allocation of water more significant generally than construction or maintenance. The systemic locus of allocation will largely depend upon the conception. Therefore I suggest explicit and systematic development of the concept of allocation, specializing the term to a meaning appropriate for their purposes and discriminating other possible meanings, e.g., by grouping them under other, similarly specialized terms. A concept well-designed for the Hunts' purposes may be a linchpin in the realization of their program; an unconsidered concept may mire the enterprise in a conceptual slough.

3. Although available literature forces them to narrow the scope of this paper to irrigation, I suspect they will have to broaden their gathering of material to such uses of a canal system as drainage, fishing, transport, and source of toll revenues. For the involvement of more elaborate centralized control, some of these may rank with irrigation in significance.

4. Since the paper introduces a tangential aside on intellectual history, I shall insert my own: It is a curious fact of the intellectual history of our discipline, as the Hunts put it, that it is a well-practiced custom for an anthropologist to "set an extreme (and fictitious) picture of his predecessors' and contemporaries' work to lend virtue to his own" (Hoebel 1954:183, speaking specifically of Malinowski). The virtue of the Hunts' topic lies in the reasons they, and others cited by them, have adduced; the significance of their program lies in its appositeness, internal logic, and feasibility—not in its novelty or its superiority to other programs designed at other times, in other circumstances, for other purposes.

5. Aside from theoretical significance, the social organization of space and resources has practical advantages as an object of study. For example, well-chosen geographic (e.g., hydrologic) features will have meaning to anthropologist and native; problems of intersubjective reliability between anthropologists and between anthropologist and native will be minimal (though present).

6. One attractive possibility is systematically conceived and coordinated collaboration among a group of ethnographers and archaeologists. One skill more common among archaeologists than among ethnographers is that of eliciting and interpreting geological, physical, chemical, biological, and meteorological information of the sort supporting the Hunts' program. More generally, I would eschew unilateral intellectual imperialism in favor of exhaustive consultation with colleagues in a wide spectrum of disciplines. "A social or human scientist may profit by studying disciplines other than his own. It is dangerous to practise them without training and appropriate skills" (Devon and Gluckman 1964:261).

by WILLIAM P. MITCHELL

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One of the problems I have encountered in utilizing Wittfogel's hypothesis has been in trying to determine the conditions under which it would prove true or false. The mere presence of irrigation in centralized and stratified polities is not sufficient to establish the validity of the hypothesis. To this end it seems to

me that a combination of synchronic and diachronic studies is necessary. In the synchronic study, as the Hunts suggest, we need to test a "sample that includes communities without irrigation as a control group." To do so, it is crucial (1) to operationalize the relevant variables of the hypothesis and (2) to test these variables on a sample of societies both with and without irrigation. The Hunts' paper is a valuable step in the first procedure. In addition, they are correct in urging increased use of diachronic data in assessing the hypothesis. I would emphasize the utility of archeological as well as ethnohistoric and ethnographic research on the problem. The hypothesis requires analysis with as great a time depth as possible.

In addition to the specific variables mentioned by the Hunts, I would emphasize the importance of analyzing the functions of irrigation in the local ecosystem. Not all irrigation systems utilize water in the same way. I have found, for example, that in the Peruvian Andes water is used differently depending on altitude (Mitchell 1976). The different functions of irrigation, of course, will have a direct effect on the size of the irrigation system and the amount of water needed by the community.

by WILLIAM L. PARTRIDGE

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While Hunt and Hunt are mainly concerned with origins, the analytical distinction among tasks associated with irrigation agriculture is important to other theoretical problems such as development. It leads to an analysis of arenas of interaction both within communities and between communities and to the recognition that a system of stratification important in one arena may have little significance in others. In a *municipio* in Colombia where I have worked, this is a useful distinction. The irrigation network is the product of the United Fruit Company and Colombian government alliance from 1896 to 1964. The local (regional) elite had no role in this. When the Company left this region in 1964, the irrigation canals, together with the railroad, land, and physical plant, were turned over to the national government. Since then the government has recognized old contracts with the Company as legal use-right title to irrigated land. Former banana growers switched to cattle ranching of the colonial-period type, which does not use irrigated pasture. The Agrarian Reform Law of 1961 calls for expropriation of land that is underutilized. Consequently, the regional elite dominance is now threatened by squatters who invade the cattle estates and by national government support of squatters in the form of legal services, credit, technical assistance, and other services needed to form peasant cooperatives devoted to mechanized rice agriculture.

The regional elite, while powerful in many arenas of local life, has no role to play in irrigation. Construction, maintenance, and allocation are all government functions. The regional stratification system comes into the dispute settlement process, in which regional elites find themselves in the position of defendant, but decision-making power rests with the national government representatives.

Neither the national nor the regional stratification system came into being as a result of irrigation (which is probably the case in most states), and probably more attention should be paid to the manipulation of human and nonhuman resources of all kinds rather than merely water. Nevertheless, in Colombia the irrigation system of the north coast appears to be one element in the rise of a new system of stratification which is emerging to compete with the older one. Hunt and Hunt's distinction between tasks and arenas of interaction can be usefully employed in such a case.

by BARBARA J. PRICE

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Because evolution is a diachronic process, any theory of cultural evolution must be formulated diachronically. Yet postu-

lated links between human behavior and its materially expressed consequences can be documented only in the present, i.e., synchronically, where both sides of the equation are directly observable. When a series of observations can be closely and systematically linked to one stated set of phenomena and only partially, tenuously, or indirectly linked to others, it is the former linkage that has the greater explanatory power. This is the significance of the Hunts' treatment of the relation of irrigation agriculture and sociopolitical organization.

Particularly salutary is their disposal of a number of fallacies that have attached themselves to the hydraulic hypothesis over the years. Among the most important of these is that centralization implies the constant meddling of a bureaucracy in the details of everyday operation. Their point that such intervention is most probable in terms of decisions or actions which, while only occasional, affect the broadest levels of energy allocation and the largest numbers of people is well taken. With the Hunts, I lament the absence of the cross-cultural data against which to test this proposition. Their use of essentially role-theory criteria of centralization suits the problem and generates additional propositions that may ultimately be tested, such as the probability that water-control roles and other social-control roles will tend to be largely isomorphic in smaller, simpler systems. While the limitations of data preclude systematic verification or falsification, this proposition tests well upward through a broader network of more inclusive theory (cf. Adam Smith on market size and degree of specialization and Wittfogel's own statements concerning hydraulic density). The transition from egalitarian to ranked society can also be viewed from this standpoint.

The Hunts' observation relating lack of development of internal stratification at the local level with the structural position at the bottom of an existing hierarchy centered elsewhere is a breath of fresh air—the statement of a point taken into account by too few who deal with peasant societies. As is quite correct, this accords to the interrelation of hierarchic strata the status of a fact. It is deducible directly from their stricture concerning the epistemological illegitimacy of inferring developmentally simple or early phenomena from the observation of the local, peasant sector of a complex, stratified system. The link between behavior and its consequences will have very different material expression in these two types of case.

As does Wittfogel himself, the Hunts emphasize labor and its organization rather more than the intimately related factors of productivity—energy flow at the expense of energy capture. Labor organization can, however, be analyzed as a function of scale of size and energy content of the system—in sum, as underwritten by productivity. Here my own emphasis departs somewhat from Wittfogel's. The relationship between labor and productivity is more than implicitly recognized, however, as executive roles are regarded as relatively more attractive the greater the opportunity they offer for differential access, direct or indirect, to the production of the system. Unlike any other form of paleotechnic monumental construction, irrigation works represent the investment of energy to produce more energy. The result is a mode of production with unusual potential for intensification, with production increasing as a function of labor input and with increase in carrying capacity until some new limiting factor is reached. Since the increased carrying capacity is based on artificial means, the entire positive feedback system is also peculiarly vulnerable both to natural catastrophe and to the application of political sanctions. Obviously the labor and productivity parameters are closely related; quantified data on this relationship would be desirable, even where, in pragmatic terms, I tend to share the Hunts' pessimism.

by WOLF RODER

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The Hunts appear to stretch the management of quite varying systems of canal irrigation on a bed of Procrustes in order to arrive at generalizations about socioeconomic patterns of power and control. Layouts and mechanics of canal irrigation systems differ from place to place, usually in response to topography and sources of water. Some demand a high degree of disciplined use and control of water resources, especially in the face of limited supply. Others are capable of leaving individual cultivators, or communities, rather independent of central authority, although such control may be superimposed for reasons having little connection to the needs of carrying on irrigation. The first order of business for the field researcher may be a careful assessment of the level of management or control required by the particular conditions under which irrigation is carried on in his study area.

I do applaud the Hunts' call for investigation of irrigation agriculture systems in historical depth and in terms of their connection to social structures of the larger society. It is probably rare that entire large societies depend on irrigation exclusively, hence societal controls may be transferred from other segments of the society to irrigation. This may be particularly the case where irrigation is a late technological development diffused from adjacent cultures.

Among one community of the Shona in eastern Rhodesia, irrigation technology diffused in the early years of this century from European settlers. The absence of a tradition of customary concepts of water allocation and of community cooperation in maintaining canals hampered the development of this form of agriculture. As is so often the case, diffusion of technological innovation outran the ability of the social traditions to adjust. There are indications that irrigation did strengthen the established social structure of chiefly control (Roder 1965:93-102).

The irrigation projects which eventually evolved under government authority were in fact closely controlled by central organs of government. The layout of several, but by no means all, of these does require a measure of supervision for the allocation of water, but by no stretch of the imagination could these requirements explain the almost dictatorial role of government. Rather, the administration of the projects is a subsystem of the Rhodesian authority structure. Since the Rhodesian government considers it necessary to keep close control over Africans in many respects, its power over irrigation projects and development is merely one consistent aspect of the overall system (Roder 1965). The danger to be avoided is the ascription of features of centralized control to the necessities of irrigation when these may well derive from other sources. A clear concept and definition of central control is needed. As a research strategy I would recommend comparison of political and social structure between communities that practice irrigation and those in the same larger society that do not. Quite similar hierarchies of political and social control may be observable. The fact that local irrigation units tend frequently to crosscut other politically defined territorial units seems to argue for other sources of social stratification and administrative control than irrigation.

The involvement of national or regional government authorities in local irrigation projects tends to derive from needs for capital. Next to under-glass agriculture, irrigation is the most capital-intensive method of farm production. It carries high risk, long lead-times, and slow payout. To the extent that farmers can maintain their own irrigation system, they tend to remain free of central control. Where they cannot, private or public capital tends to bring central direction. That money controls resources, and resources imply power, is not unique to land or water.

Hunt and Hunt: IRRIGATION AND SOCIAL ORGANIZATION

by AXEL STEENBERG

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It is a well-known fact that the less one knows about a matter the easier it is to raise hypotheses and construct convincing models of it. It is always confusing to know too much. This is the way scholars of the humanities are compelled to move, however, and it is perhaps more striking in our branches of knowledge than in the natural sciences that every problem solved raises unpredictable masses of new questions. We have to reckon with too many variables. For this reason I think Wittfogel's theory is already out of date, and so are many others of the same kind. Every attempt forces other scholars to re-think the problems, however, and therefore the paper presented by Hunt and Hunt is welcome. It would have simplified the case if they had confined the question to the political control and allocation of water resources and the social organisations involved; but, bravely enough, they take a step forward, seeking the technical basis, documented with relevant descriptions, measurements, and figures. What a challenge!

It is beyond my qualifications to contribute to the theoretical discussion. I might contribute to the discussion, however, by emphasising knowledge which was not included in the authors' prerequisites because the relevant literature was not available or was written in languages which are normally not familiar to American scholars. My remarks fall into three categories—technical, historical, and geographical—and for practical reasons I will start in the arid zones and finish in the temperate and subarctic regions of Europe, Greenland, and Asia. In some regions the problem is to balance irrigation with drainage; in others the problem is not only to provide water, but also to get rid of the immense quantities of salt left when water evaporates.

From al-Tabari, an Arab historian of the Middle Ages, the Soviet scientist Andrianov (1969) records that thousands of black Zinj slaves had to remove the surface layer of salts and to carry the waste material away from the irrigated plots. After the Zinj revolted in A.D. 869, 50,000 hectares of irrigated land were abandoned and ultimately became salt marshes (see UNESCO *Courier* 2[1972]). Andrianov is secretary of the Soviet Academy's committee on the practical uses of historical data in the national economy, and in his book he has drawn upon his broad knowledge of the development of irrigation from the middle of the 2d millennium B.C. to the Mongolian invasion, when the Amu- and Sir-Darja region was destroyed. He suggests that with irrigation the yield rises by four- or fivefold. In his survey, general trends of the development of irrigation in the Middle East and India are included.

Concerning the irrigation of Mesopotamia from ca. 4000 B.C. to Roman times, Salonen (1968) presents materials from contemporary sources as well as the literature. In Ugarit in the 14th-13th centuries B.C., the land belonged to the temple, to the palace, and to such persons as the ruler entrusted it to. The members of the village community were jointly responsible for the work to be done in the fields. In a chapter on irrigation, Salonen gives technical terms and details of the irrigation projects as well as their social relations, the allocation of water, the number of workers, lifting devices, water reservoirs, etc. Elsewhere, he deals with the organisation of labor.

Another rich source of information is Schiöler's (1973) book, *Roman and Islamic Water-lifting Wheels*. It is interesting that the *noria* or *saqiya*, probably invented in Hellenistic Egypt, which lifts water in a continuous chain of small containers, approximates in efficiency the machine-driven pump. A Coptic papyrus mentions a man who hired a potgarland wheel with 40 plugs for the period of irrigation, June 25 to the harvest on July 24; he paid 19 measures of wheat and guaranteed the loan by 27

keration in case it should be stolen or he should not be able to return it to the proper place in the same condition as he received it. This is only an example of the exact information in sources available from antiquity.

A description of the cultivation of a modern Indian paddy-system is given by Claus and Lintner (1975), including relevant details on population, distribution of labor input, labor demand throughout the agricultural year, agricultural land-use divisions, cultivation systems, and equipment.

Hunt and Hunt refer to the use of subterranean canals, *qanats* or *karezes*, in the Tehuacán Valley, a late derivative of the more than 2,000-year-old practice of the Iranian plateau. Humlum (1965) has published a general survey of their distribution throughout the world, illustrated with maps and photographs and with an English summary. Relevant details of construction, distribution, and use are given, but unfortunately very little is said about their social significance. Most of the subterranean canals were paid for and maintained by the big landowners, who allocated the water to their tenants and sold it to private holders of gardens and shops. Consequently their social implications were quite different from those of allocation systems regulated by the society, the small landowners, or the tenants themselves.

It is not always the water itself, but the minerals and silt or the manure it contains, that makes the land fertile. This is well known from Egypt and Mesopotamia as well as from the mountainous regions of Europe. In tropical New Guinea, people dig canals in which silt is allowed to settle, and the silt is then scooped up and distributed over the banks, fertilizing taro and other crops (Heider 1970). This practice could well be as old as cultivation in the New Guinea Highlands—which, according to Jack Golson, is likely to be about 9,000 years.

In Europe, irrigation has been practised since antiquity, not only for grain crops and legumes, orchards, and vineyards, but also for pastures. Columella recommended tilling of the meadows for three years with root and grain crops and finally sowing grass mixed with vetch. After the first scything, the meadow would be irrigated. In his book on Roman farming, White (1970) has a whole section on irrigation and organisation of water supply as well as drainage in Italy. This corresponds well with Scheuermeier's (1943) detailed descriptions of the techniques of irrigation and water-lifting devices, illustrated with maps, drawings, and photographs, especially from Lombardy, but also from Sicily. This work is of immense significance for the understanding of what the classical authors describe. Since it is written in one of the internationally well-known languages, I shall not relate its contents even in summary.

The language difficulty is greater with the Icelandic sagas. Irrigation of meadows is known from *Egil's Saga*; Skallagrím of Borg tells in chapter 80 that when the ice breaks up at the meadow Stakksmyra, the grazing for cattle on this irrigated pasture becomes quite as good as that on manured meadows. The same practice is described in *Havard Isfjording's Saga*, *Landnámabók*, and *Grágás*.

In Greenland, Krogh (1974) recently investigated and mapped an irrigation system which made it possible for the bishop of Gardar to keep about 100 head of cattle; the last bishop died in 1377 or 1378. In Norway, too, irrigation of grassland must have been practised since Viking times, because the Atlantic islands were populated from that country. In a decision from 1303, a type of ardplough (*Vassarder*) is mentioned which, according to Hasund (1932), was used for making water channels for irrigation.

Hatt (1915) once wrote an article about irrigation of grassland in Norway. More recently, Michelsen has published a comprehensive study on irrigation in the Nordic countries (1953) and an excellent small study on irrigation of grassland in Ötztal, in the Austrian Tyrol (1955). Nowhere did the peasants use water-lifting gear, but they often channelled the water across

valleys in wooden gutters supported by poles and beams and scooped it out and spread it from small reservoirs or dammed canals with a special shovel. In Gudbrandsdalen, situated in the shadow of the western mountains, the climate is dry, as it also is in many deep valleys on the west side of the ridge. For this reason the corn fields are also irrigated before the spring ploughing, and the use of drill sowing machines as early as the 1770s must probably be understood as a means of preventing evaporation. Indeed, a kind of dry farming was practised in which, after sowing, sheep and goats were driven across the field to trample the soil and coincidentally loosen the upper centimetres with their hooves. In a dry summer, irrigation with wooden scoops was practised as often as ten times during the season. This would always be done in the morning or in the evening, never in the middle of the day, and not during the night, when it might cause erosion which could only be noticed too late. A grass field, however, could be irrigated during the night.

Often, several farms were irrigated from the same stream, and each spring an official was elected to allocate the water. The share of a single farm could be calculated from its irrigated area or from its duties to the state. Irrigation is recorded from legal disputes from the late 16th century, and fines for damages are codified in the 1687 *Christian V's Norske Lov*.

The quality of the water was not always the same. We know from arid zones that subterranean water from *qanats* was preferred because it was cold and would not evaporate as rapidly as surface water and leave soluble salts on the top layer. In temperate zones near mountain glaciers, the water could be too cold, and therefore water from bigger streams was preferred to water which came direct from the melting ice. On the other hand, in northern Sweden and in subarctic areas it was the practice to dam the rivers in order that the meadows could be covered with ice during the winter. This restricted the growth of mosses and shrubs, and in spring, when the water was released, the grass would flourish and produce a rich hay-harvest.

In the Alpine regions, irrigation is recorded from the 13th century. It was practised in Wallis in Switzerland and in Ötztal (mentioned above) from at least 1313; in the Rhône Valley it is recorded from the Middle Ages. Probably the technique of irrigation came to Denmark from Germany as late as the 18th century, together with the improved husbandry, but in some parts of Germany (e.g., Siegen) it was a common practice from time immemorial. In Norway as well as in other regions, the meadows could be manured, the dung being dissolved in the irrigation water. In Stephens's (1855) *The Book of the Farm*, manuring in that way is recorded from Sir George Montgomery's sheep farm in Scotland. He simply collected the water from the surrounding sheep-drains and irrigated five acres of meadow with it. In this book, different methods of irrigation are described from private properties, and it is well known that irrigation is an old practice in many shires, as it is also in England.

As my comments may have shown, irrigation is not always planned by a society, though the society may play its part by making laws for the regulation of rivers, streams, and canals. Furthermore, I doubt that a single model can collect all these variations under one hat, and I fear that models in modern anthropology often produce a false understanding because they build upon limited knowledge. This is not intended as a criticism of the authors specifically, but as a general warning against taking models in the human sciences too seriously.

by ROBERT WADE

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“What we need . . . is to return to the field with a more clearly specified set of questions.” Our questions depend on what problems we wish to address. The Hunts' questions and con-

cepts may be useful for addressing problems pertaining to theories of social evolution and local social organization. If, however, as seems likely, anthropologists become more concerned to make their work relevant to matters of policy, we must also ask whether the kind of approach used by the Hunts is likely to be helpful in the design and operation of irrigation systems.

It seems quite clear that social science analyses can potentially make an important contribution to irrigation policy, and it is equally clear that this potential has not been realized. India, with the second-largest irrigated acreage in the world, is currently undertaking a major rethinking of irrigation matters, in response to the generally poor performance of existing irrigation facilities (especially canals). Yet the prescriptions for improvement are almost entirely of an engineering or narrowly economic nature: modernize the canal structures, improve the layout of irrigated fields, set water prices right, and put in better marketing structures; these are the limits of the suggestions made. Some attention is also being given to the formation of water-users' associations, but virtually no attention is being directed at the irrigation bureaucracy and the other bureaucracies directly involved with irrigation and irrigated agriculture. I suspect (on the basis of preliminary field research) that characteristics of the way irrigation is organized, especially characteristics of the irrigation bureaucracy, are critical influences on the performance of irrigated agriculture, and that many of these characteristics are changeable by government action.

Has anthropology any legitimate business in this field? In the design and improvement of water-users' associations, certainly. One has to be cautious, however, about assuming that roles and procedures which work effectively in small-scale systems, with water users fully responsible for administration, can be transferred to large-scale systems in which responsibility is split between government and users. At least in the Indian context, the fact of government involvement seems to make so big a difference to the behavior of farmers that one can learn fewer lessons from the study of autonomous systems than one might think at first sight.

In terms of relevance to policies for improvement, however, the local level is surely not the level to focus on, not, at least, in the context of Indian canals (which tend to be larger than those found in Southeast and East Asia or in Africa). The Hunts recognize that one cannot learn much about the larger system from the study of local systems within it, but their paper—and most other anthropological studies of irrigation, apart from the macro studies of Steward and others—is about local systems, and looks at larger systems only from the bottom upwards. It would be a pity if anthropologists confined themselves to this level, for they can contribute to our understanding of the structure and operation of irrigation bureaucracies in a way that other social scientists cannot or will not, particularly by direct observation of irrigation engineers (and other officials connected with irrigation) in their native habitat, going about their usual business at the office, on the canals, at home. Space limitations preclude an attempt to specify how this kind of understanding can contribute to improvement in the performance of irrigated agriculture; here I can only assert that it will. To reach this kind of understanding, however, requires that some anthropologists, some of the time, take their problems not from theories of social organization and social evolution but from the concerns of the bulk of mankind—problems of food production, productivity, income distribution, and employment—and work backwards into their discipline from there.

by **IMRE WELLMANN**

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Hunt and Hunt seem to oversimplify historical evolution by stating "three major (and cumulative) ways of intensifying

plant food production" and identifying irrigated agriculture as the second. In fact, industrialized farming, mentioned last by the authors, had partly been preceded, in Flanders and England, by the agricultural revolution of modern times, which laid the foundation of modern crop production. Further, without the development of science—trophology, genetics, plant pathology, etc.—industrialization could have had only a limited effect on agricultural progress. As regards irrigation, it cannot be considered a generally prevailing stage of development in the history of agriculture.

Irrigation, along with the social organization associated with it, nonetheless had great significance: it not only facilitated the increase of crop yields, but also rendered possible the establishment of agriculture in arid zones. Hunt and Hunt mention rice and sugar production, but it would be worthwhile extending research to all kinds of irrigation, among others meadow irrigation, which played an important role in the development of animal husbandry. This is important because the demand for water and its periodicity, as well as the techniques of irrigation, vary from one type of crop to another, and this affects the social structure.

The demand that research be extended to other fields as well only underlines the statement of Hunt and Hunt about the inadequacy of the research conducted so far. There really is a gap between general hypotheses and detailed case studies of small localities, and this is why the authors have limited themselves essentially to raising problems and setting a course for further research—valuable local monographs being so few and far between. I fully agree with them that, besides fieldwork, more attention should be paid to historical documentation, which allows historical development to be traced over longer periods of time, always with an eye to the changes that have occurred in climate, methods of production, population, market relations, possession rights, and social and political conditions.

It is also right to demand that research not be limited to narrow local units—especially, of course, if one is dealing with artificial irrigation systems including several local communities. This, however, does not mean that community studies are no longer necessary. Hunt and Hunt themselves indicate that even where local irrigated agriculture is embedded in a wider power structure, technical problems and maintenance, the everyday tasks of allocation, and matters of gradual development were usually regulated within the community. So were internal disputes: the authors rightly point out that the central power was happier if conflicts could be settled peacefully and as cheaply as possible. The autonomy of communities is even greater where small local irrigation systems have been established through the efforts of the peasant community. As long as none of the higher powers intervenes in local matters and cash-crop production does not intensify social differences, such irrigation systems are governed to a great extent by local customs, community norms, rites, beliefs, and religious concerns. In this context, it would not be expedient to leave folk models out of one's investigations.

## Reply

by **ROBERT C. HUNT** and **EVA HUNT**

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Some 30 different points have been made in the comments. They seem to fall into three more or less distinct categories, which can be (roughly) labelled "Comparative-Study Research Design," "Results," and "Future Field Research."

*Comparative-study research design.* Bennett and Lewis have point-

ed out that both energy and resource utilization are larger contexts for our study and have taken us to task for not highlighting this. It was not our purpose to elaborate on all the paradigms which would be relevant for this study. We agree that a general theory of resource allocation is highly desirable, that a general theory of energy flow in human society is necessary, and that the two would probably largely overlap, but it was not our intention to produce a major theory in this article. Furthermore, we are not persuaded that, given the limited purposes of this paper, they would have been served by the addition of the larger contexts suggested. When Hevelius set out to describe the craters of the moon, he could hardly be made responsible for not incorporating a theory which also explained the red spot of Jupiter.

Roder has stated that our paper is set in a Procrustean bed. One of our purposes was to sharpen categorical thinking about the subject (which has been muddily treated) by being very careful with scientific concepts and distinctions. It is unclear to us how Roder distinguishes between clear thinking and beds of Procrustes and why he thinks our analysis has been inhibited. Once he has presented his evidence clearly, we will be happy to respond further.

Ahmed seems to find our discussion of Wittfogel and Millon irrelevant for a discussion of local social organization. He has failed to understand what we have done. We have presented a justification for transferring general theoretical attention from whole societies to communities. The major set of conclusions about local social organization is that of Millon. Need we say more?

MacLachlan has suggested that problems of cross-cultural validity (the relativity, or equivalence, problem) are more easily solved in studies of space and resources. We are not sure about the general terms of his suggestion, but will agree with him that for the study of irrigation, and probably waterworks in general, problems of cross-cultural conceptual validity are much less severe than for virtually any other endeavor. Clearly the concepts involved in allocation will be the most problematic, but there is no indication yet that, once they have been adequately studied, they will not yield to cross-cultural conceptualization.

Some of the details of our research design have also been commented upon. One of our purposes was to distinguish several tasks attendant upon canal irrigation. We are gratified that nobody has attacked either the purpose or the results and that Lewis and Partridge approve.

Ahmed has in effect complained that our sample is too small, because we "could profitably have included one of the most extensive canal irrigation systems in the world, in South Asia, not to mention others." We suspect he is referring to the Punjab irrigation systems, but since he provides no references we are not certain as to which are the published sources we have neglected. We will be happy to receive any references to detailed empirical studies of canal irrigation systems which cover even a part of the range of information involved in our studies. Most anthropologists do not do field studies where there is irrigation. Those who do often ignore the physical system completely, and the roles (and other phenomena) associated with it are barely mentioned. If they happen to pay some attention to these, the subjects are usually not clearly marked in the table of contents, and sometimes not in the index either. Lastly, it is almost universal that the book reviews published in major anthropology journals in the U.S.A., Canada, and Europe do not mention the presence, or importance, of irrigation in the work under review. Kinship and other traditional problems are much more likely to receive specific attention. Only a few studies have focused any significant amount of attention on irrigation, and finding them has been a long, hard, and tedious job of swimming through the literature. In writing the paper, we decided to concentrate on a few well-known studies. Since then, one of us (RCH) has embarked on a larger-scale comparative study

of the relationship between canal irrigation and local social structure. More than two dozen additional studies have been turned up, and the forthcoming work will be based on a much larger sample. South Asia still presents a serious problem. India is the country with the second-highest total of irrigated hectares in the world and the country for which good community-level data are hardest to find. We are grateful to Steensberg for the reference to Claus and Lintner (1975). This larger work will deal directly with several aspects of local social organization.

The major doubt about our model is raised by Steensberg, who questions whether a single model of canal irrigation will suffice for all the variations. We agree that probably no model now in existence can do so, although without a serious try such a conclusion is somewhat premature. When we have a sufficiently large collection of well-described cases, covering the range of variation, we can proceed with more effective modeling.

Several scholars have remarked on our call for historical studies. We firmly believe that time-anchored cause-and-effect relationships are worth looking for and that they are likely to be found connected with irrigation. In this paper we deliberately avoided most such statements, largely because the research design for establishing such relationships currently calls for measurements at different time periods, i.e., a diachronic analysis. We are not yet in a position to produce such a comparative study, or even a good complete case study. Incidentally, we disagree with Price's contention that measurements of two or more variables can only occur in the present. We feel that careful historical work, under the right circumstances, has the potential of yielding the appropriate data at the appropriate time periods, thereby permitting questions of cause and effect. In the meantime, it is useful to proceed with correlational studies, and we are doing so.

That we have emphasized the labor input, and not the production output, of irrigation has been mentioned by Price, Wade, and Lewis. As we pointed out, it is not because the additions to production due to irrigation are unimportant, or less important than the organization of labor. In the larger comparative study now in preparation, this issue will be dealt with at some length. Suffice it to say here that there were virtually no data on production in the community studies, so for the moment we concentrated on labor. We agree that studies of production capacity and intensification and more careful thinking about the results of production for social organization are not only desirable, but extremely important.

MacLachlan has pointed out that other waterworks (and the list approaches a dozen) may be important; we said so ourselves, but our purpose here was simply to examine canal irrigation in some detail. The other waterworks may be just as important socially, perhaps in varied ways, but until the data are available we prefer to direct our attention to the better-documented phenomena. Cleek observes that scale of works is in general badly conceived, and he points to the need for a good operational definition of centralization. We agree heartily on both counts.

Following us, Roder and Mitchell have suggested studying matched pairs of communities, one set with irrigation and the other without, to determine the effect of irrigation on social structure. Having spent some time and effort on the parameters of such a research design, we can say that this is not as simple as it sounds. The only studies we are aware of that compare a specific community with irrigation and another specific one without it are two in India (Epstein 1962, Mencher 1966) and a Mexican case (Finkler 1973). All present problems if they are to be used as Roder suggests.

In the Epstein case, the two communities were very near to each other, and the region had very recently received a massive government-provided canal irrigation scheme. The "dry" village was just on the edge of the irrigated area and on a main highway, whereas the "wet" village was in the middle of the

irrigated area and on a secondary road. Many individuals in the "dry" village already owned, or soon bought, "wet" lands in neighboring communities. Is this, then, a true "dry" village in any significant sense? We think not. In Finkler's case, the "wet" village received a deep well from the government, whereas the "dry" village did not. In both cases, the "wet" villages intensified their farming, whereas the "dry" ones turned to more extensive contacts with outside agencies and markets. In both cases, the waterworks were recently introduced by the central polity. Neither of these studies, it seems to us, is relevant for a test involving traditional long-term presence and absence of irrigation works.

Mencher compared nucleation of villages, centralization of kingdoms, and the ecology of waterworks and land transport between Kerala and Madras in South India. She found that highly nucleated villages, highly developed roads, and more highly integrated kingdoms were associated with the area with lower rainfall and larger irrigation works (Madras). Mencher has a strong correlation, but it is clear that irrigation works are not the only difference between the two areas. Assigning causal priority to irrigation is a relatively arbitrary decision.

With respect to controlling variation in comparative studies, there are basically two choices: one can either try to minimize other kinds of variation or to maximize them (cf. Przeworski and Teune 1970: chap. 2). Anthropologists usually choose the Most Similar Systems design. Our instinct is to do so also. This requires us to control everything but the presence or absence of irrigation. It is easy to control level in the political hierarchy, population level, perhaps even the demography of social strata. How, we ask, are we to control the ease of communication with other centers of population? Most important, does the specific structure of the local mode of production have an effect upon the matching procedure? In Mexico, most of the valleys have been irrigated for at least 1,000 years, while mountain regions use rainfall agriculture. Since mountains and valleys are structured socially very differently and have been so for millennia (cf. Sanders and Price 1968, Aguirre Beltrán 1967), it is difficult to imagine finding communities with and without irrigation in which the resource structure is in some way matched. If, however, the point of this design is *not* to match the resource base, how are differences between resource bases other than irrigation to be taken into account? These are serious problems which need a great deal of further thinking.

*Results.* The transition between the Yemenite and Syrian modes of allocation is commented on by Glick and Bennett. In the paper we adopt the same position as Glick (Cleck is wrong), that there is a shift from Syrian to Yemenite. (The empirical work for both of us has been in the Iberian-Mediterranean tradition.) Bennett, on the other hand, proposes that the sequence is reversed, that "systems tend to evolve from the Yemenite toward the Syrian" where there is private property in land and increasing demand for water. He further suggests that as land tenure moves toward collective solutions, the Syrian principle may be modified by the state and replaced by "collective-use schemes or related methods of allocation." We are not now in a position to decide the issue. Rather, two kinds of work are needed. Several components of these allocation principles have been suggested for study, including techniques for measuring the water, land tenure, size of water source, and supply and demand curves. These need to be spelled out and clearly defined. Second, we need empirical studies in which all the components can be measured and a shift is documented to have occurred. It may be the case, as Bennett in effect suggests, that two principles of water allocation are not enough to cover the range of phenomena. It may also be the case that it is possible for a society to shift back and forth cyclically between allocation principles, depending upon demand conditions that we may be able to specify. Certainly no unilineal trend is visible in the literature we have consulted. Thus the potential

development may be (a) Syrian to Yemenite, (b) Yemenite to Syrian, (c) cyclic, or (d) something else, as yet unidentified.

The world has for the past century been undergoing steady population growth. Up until some time in the 19th century, however, most of the irrigated areas had gone through many successive phases of growth and decline of population. The flux of population will affect demand for water and therefore the relationship of supply and demand curves. If it is true that this relationship affects allocation principles, it follows that until the recent population explosion there would have been no *unilineal* and *irreversible* trend in shifts in allocation principles. Rather, they would have shifted back and forth cyclically, depending upon demand. There is some evidence for this cycling in the Middle East (cf. Gibson 1974) and in our Mexican case (E. Hunt 1972, Hunt and Hunt 1964). It may be that under the conditions of the last 100 years such a progression as Bennett suggests has in fact been true in large nation-states. We now need a small number of carefully researched case studies to clarify the conditions under which a shift from one principle to the other occurs. This may simultaneously clarify how many types of allocation principle we are dealing with. Then we can return once more to well-grounded theorizing.

With respect to our observation that political and hydrological boundaries seem not to coincide most of the time, at least today, Roder makes the excellent observation that this would imply that there are "other sources of social stratification and administrative control than irrigation." When we can finally turn our empirical attention to matters of cause and effect, this question will be a primary one to answer. It is not certain that the mismatch of these boundaries is as old as the state. It would seem to be the case in Post-Classic Tehuacán, medieval Valencia, and medieval Japan that hydrological and political boundaries were very close if not isomorphic. If this is true, and if the crazy-quilt distribution of boundaries is a modern (i.e., industrial or colonial) phenomenon, then we have a relatively simple set of circumstances to explain. If, however, the mismatch of boundaries is found much more generally, then Roder's hypothesis becomes a very strong one. We very much need studies of the relationships between various kinds of boundaries in clearly specified historical contexts.

Wade points out that we should, some of the time, try a top-down view, in place of our usual bottom-up one. In one sense, we agree wholeheartedly with this. The anthropology of peasantry, and of complex societies, has been moving in this direction, at least in theoretical terms, for 40 years or more. In our field studies, however, we tend to focus primarily on a single place, and this gives, inevitably, a localocentric bias. Top-down studies of specific water-control systems (rather than of whole bureaucracies) would certainly be very desirable.

Bennett states that he is not overwhelmed by our use of the concept of embeddedness, that it is a fundamental principle of rural social organization. That is true, and beside the point. At stake in our presentation are a number of general issues, including centralization, specialization, bureaucratization, and power which is derived from control of irrigation systems. It was easy for Millon to conclude, in effect, that water and power are not connected if there was no systematic specialization or centralization. We hope to have exposed some of the flaws in this position. The phenomenon of role embeddedness is crucial to this demonstration. We plead (a little) guilty to not having set the concept in its most general framework. The existence of the phenomenon in certain circumstances is not obvious, however, and *it is not simply a function of the relative numbers of roles and people*. San Juan has a population of over 3,000; the total number of official power roles is in the neighborhood of 35-40, and the actual power brokers are about 10. Rather, it seems more likely to be a function of whether the responsibility

for operating the physical system is focused on a locale or on a central government, and this is not simply a matter of the size of the community or of the physical system. The sources of variation are not yet clear to us, but it is certainly more complicated than mere numbers.

Turning to a different set of conclusions, those suggested by the commentators, we find there are some we can support and some we feel should be challenged. Partridge presents some data for a case in Colombia in which the local community apparently never had any significant responsibility for the irrigation system. This is exactly the kind of case that is badly needed in the literature, and we urge Partridge to get these data published. Steensberg's additions are particularly welcome. In general, we find his discussion exciting and opening new areas of thought. One of the benefits of publishing in *CURRENT ANTHROPOLOGY* is the creation of truly international dialogues. One is able to discover important references to works published in languages one doesn't command and to become acquainted with the thinking and work of people it would have been difficult to know about under other circumstances.

Bennett claims that there is a tendency for governments to take over local systems, to run them for a while, to hand control over to the local authorities, and then to take them over again if they become disordered. This is probably universal, and the degree to which local people can and will run a system alone when there is a possibility that an external and superior agency is interested in doing the job, and under what circumstances (of capital investment, etc.) this occurs, badly need study. We have a clear case from San Juan which is the reverse—there was local opposition from all social classes and interest groups to the proposed federal construction of a new dam and canal, all seeing the actions of the state as threatening to their specific interests (Hunt and Hunt 1975). In southern Japan, there is also strong resistance to prefectural and national involvement in local management (Beardsley, Hall, and Ward 1959), even though there have been at least two recent government investments (reclamation of land around Niiike and improvement of the bed of one of the rivers) in this century. In the Ebro Valley and in Iraq, there is a degree of local responsibility, although in both cases this has diminished in the last 50 years (Lison-Tolosana 1966, Fernea 1970). Some other cases are confusing, especially that of Taiwan (cf. Pasternak 1972, VanderMere 1971). Bennett's hypothesis seems sound and reasonable enough, yet the lack of comparative case materials and some apparent contradictions are serious and warrant extreme caution.

Roder suggests that often societal controls can be extended from other institutional realms. When this is true, it nullifies irrigation as the major source of power. There is no doubt that it has sometimes been true. If we understand Adams's (1966) argument correctly, this appears to have happened in the city-states in Mesopotamia, as well as during the industrial-colonial era of modern times. But to find, as surely we will in a general way, that the control of an irrigation system is attractive to roles with other sources of power should in no way deflect the search for regularities in which irrigation (and generally water control) is the primary source of power. Both types of study are important and ideally will yield complementary insights.

Both Roder and Bennett suggest that centralized control is a function of the cost of the system. The more it costs, the more likely that an extra-local agency will have to be involved. He who pays the piper calls the tune. Bennett's proposals are complex. He argues that large construction is imposed from outside and maintenance is locally controlled because of cost factors. State bureaus have a monopoly in money, skill, knowledge, etc. He appeals to Zipf's law and goes on to claim that some Wittfogelian propositions boil down to economic truisms. In essence, Bennett's position seems to be that no elaborate theory is necessary or desirable to explain centralization of

construction or decentralization of maintenance. We have several responses to this.

It is not at all obvious that money, skill, knowledge, etc., are monopolies of state bureaus. This may well be the case in the 20th century, but it may not always have been so. For example, in preindustrial Bali, much construction was local and piecemeal. In Tehuacán, the state must grant permission for qanats, but the technical advisors and capital are from local independent cooperatives, often working against state regulations.

It appears that large construction projects are not handled with local capital and other resources in *today's world*. Part of the reason for this is that most construction of waterworks today (a) takes place in difficult terrain (the "easy" projects have already been built) and (b) is on such a scale that no small social unit could possibly generate the resources necessary.

It is certainly not universally true that local people will choose what is "cheaper" despite the fact that it brings domination from outside. We have already mentioned the case from San Juan, in which the community strongly resisted central government attempts to build a new dam and canal which would have increased the irrigated area by more than 30%. Resistance of domination was certainly the major part of their response.

It is not at all clear, again, that major construction projects are always imposed on the locale by the center. One might be justified in arguing that the Southern California system was imposed on the central government by the local power groups, rather than the other way around. The movie *Chinatown* is probably accurate ethnography of some cases.

With respect to maintenance, as part of the effort to determine the *facts* of the organization of irrigation, it was necessary to be as detailed and systematic as possible. Since the sample used here is so small, few generalizations are to be expected. If it turns out to be true that maintenance is locally controlled, then explaining it is easy, and one of the simple economic propositions suggested by Bennett will probably take care of it. If, however, it is *not* true, then the problem of explanation becomes much more complex. The only way to find out what is true is to search systematically for the cross-cultural facts and present them, however trivial or self-evident they might appear to some of us.

Bennett also argues that "as increasing *efficiency* is desired in water-control systems, there is need for a supra-authority . . . to pay the bills" (italics ours). This is a very different matter, and one which our paper was not addressed to. Efficiency is typically a concern of a central state bureaucracy worried about increasing national production and maintaining it at a high level. This concern is widespread in some industrialized states (Japan, Taiwan, Spain, U.S.A.). Increasing the size of the system (which is found in every case study), however, is very different from increasing the efficiency of use. The first is designed to increase total water and/or land in the system. The second aims at decreasing waste of water or environmental degradation. A new dam and main canal involve only a short time-period of intervention by central authority and require only minimal local cooperation. Increasing efficiency, on the other hand, usually involves long-range activity, trying to change the behavior of every user of water for at least allocation and maintenance, and often for construction. Ironically, central government is most likely to become involved in routine local maintenance precisely when its goal is to increase or maintain efficiency (see Freeman and Lowdermilk 1976 for an example). The fact of state interest in efficiency, however, poses a new and interesting problem for understanding local social organization. Further work is clearly needed in all these directions.

It is not clear to us which "Wittfogelian propositions boil down to simple economic truisms." Some Wittfogelian propositions are clearly wrong (cf. Adams 1966 for a few); all are highly controversial hypotheses. What is needed are not untested

generalizations, but rather careful statements of the general propositions and an equally careful confrontation with the ethnographic evidence. This is a long and tedious process, and we hope we have made some progress in this paper. There is no substitute for the hard work. Up to now, the field has been divided into pro-Wittfogel and anti-Wittfogel parties, and the positions have usually had bases quite removed from empiricism.

We therefore disagree that we could have benefited from the use of other "economic models or at least elementary economic perspective." We have asked economic questions; what we have refused to do is answer them in an elementary fashion or take unsupported positions. The assumption that all systems want growth or that all choose economic variables over other kinds is patently false. A community or small society may refuse economic aid because it entails political domination. One can say that the legendary old lady who sat in the front of her hut in the valley while the TVA flooded her out is a lovely folk example of the conflict between local and national systems.

We completely agree with Bennett that instrumental considerations do not always prevail. This is not because the cultural materialist position is naive, but because a sophisticated cultural materialist position, with which we identify, considers relations of production as part of a complex set of variables which require synchronic and diachronic specification to make sense of evolving sociocultural conditions. The problem with the so-called anthropological Marxist approaches is that they are seldom at the level of ethnographic clarity or theoretical sophistication of Marx's or Engels's own thinking and are often produced by people who have not read Marx and who confuse economic (e.g., money flow) variables with the social aspects of economics (e.g., the flow of services, appropriation of resources, direction of production control, and so on).

Wade argues that the government makes so much difference that the study of autonomous systems is perhaps not very useful. If we accept as a legitimate purpose of our research the attempt to encompass all kinds of experience with irrigation, then clearly the autonomous system is relevant. We would agree, however, that in the case of the very large and centrally managed modern irrigation systems in arid lands, local autonomy is simply not a relevant factor, at least insofar as the thin current data reveal.

MacLachlan argues that allocation is probably more important than the other tasks, contrary to what we merely speculate. In the larger study now under way we hope to be able to approach this question in a productive way. In the meantime, we certainly would welcome theoretical arguments.

*Future field research.* We social anthropologists clearly have much to learn from the archaeologists in terms of interdisciplinary cooperation. Both MacLachlan and Bennett suggest that we should utilize specialists in other disciplines. We could not agree more. A related issue is Lewis's caution that physical measurements may not be simple to get. He is very likely right, and this reinforces the need for cooperation with technical specialists. Presumably such collaboration might make it possible to do what Roder suggests—establish what controls are actually necessary for a system. Cooperation with the relevant specialists would also perhaps help to dilute the localocentrism identified by Wade.

As this reply suggests, and our commentators have remarked, much remains to be done. Let's keep going.

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## Institutions

■ Anthropological research in Finland has been spread over a number of disciplines, and representatives of the different branches of anthropology have had little contact with each other. Culture has been the domain of ethnologists (social and material culture) and folklorists (spiritual and social culture), while social anthropology has been linked with sociology. Physical anthropology has been a focus of interest for a few natural scientists, and research into "primitive" cultures has, since the time of Edward Westermarck, been virtually non-existent except for studies made by a few Finnish scholars probably better known internationally than in Finland. The word "anthropology" itself has frequently been interpreted to mean physical anthropology, while the general study of culture has been referred to as general ethnology.

The need for a forum where anthropologists could meet and discuss their interests has been felt for a number of years. This demand for a concentration of anthropological interests under one roof, so to speak, has been augmented by the need to promote the study of Finnish culture on a wider basis than hitherto and to approach it from viewpoints that cross the traditional boundaries between academic disciplines as well as by Finland's increased participation in aid to the Third World, which has meant that more needs to be known about foreign cultures.

On March 20, 1975, the time was at last ripe for the inclusion of a new Finnish scientific society among the ranks of the existing ones. In setting up and naming the Finnish Anthropological Society, the founders have adopted the Anglo-Saxon concept of anthropology as "the science of man." The Society, SUOMEN ANTHROPOLOGINEN SEURA/ANTROPOLOGISKA SÄLLSKAPET I FINLAND, is bilingual, and its aim, as expressed in the rules approved at the first meeting, is "to further the study of man, of human societies and cultures, by encouraging the anthropological sciences and closely related fields of study and to increase the knowledge and understanding of foreign peoples and different cultures."

The Society will publish a periodical, *Suomen Antropologi/Finlands Antropolog*, to provide a forum for methodological and theoretical articles on anthropological research and to disseminate information about current anthropological events, including recent student papers. Among the activities under consideration is the preparation of a report about anthropological research in Finland.

Matti Sarmela of the University of Helsinki (cultural anthropology) was elected chairman and Björn Kurtén, also of the University of Helsinki (physical anthropology), deputy chairman. The secretary is Henni Ilomäki. The address of the Society is Suomen Antropologinen Seura r.y./Antropologiska Sällskapet i Finland r.f., PL 248, 00171 Helsinki 17, Finland.

■ MANNFRAEDISTOFNUN HÁSKÓLA ÍSLANDS (Institute of Anthropology, University of Iceland) was established in 1975. Its governing body consists of four members chosen by the University Board—Gudjón Axelsson, Gudmundur Eggertsson, Jóhann Axelsson (Chairman), and Sigurjón Björnsson (Secretary); one appointed by the Director-General of Public Health—Ólafur Ólafsson; and one chosen by the Icelandic Anthropological Society—Davíð Davíðsson. The director of the Institute, appointed by the Minister of Education and the University Board, is Jens Pálsson. Its research emphases are the anthropometry of Icelanders, pigmentation of hair and eyes, age changes, secular changes, urbanisation, regional differences, "ethnogenesis," exogamy/endogamy effects, dental morphology, and cardio-pulmonary characteristics in relation to growth and development.

Earlier anthropological institutions in Iceland include ÍSLENZKA MANUFRAEDIFÉLAGID (the Icelandic Anthropological Society), founded in 1969, which has organized many meetings involving lectures and discussion on anthropological topics. Its governing body includes Jens Pálsson, President; Magnús Már Lárusson, Vice-President; Einar Siggeirsson, Secretary; Gudmundur Eggertsson, Helgi Eliasson, Jóhann Axelsson, and Jón Júlíusson. MANNFRAEDINEFND HÁSKÓLA ÍSLANDS (the Anthropological Committee of the University of Iceland) was created in December 1971 to make suggestions about anthropological research in Iceland and cooperation with foreign scientists. Its chairman was Gudmundur Eggertsson, its secretary Jens Pálsson; other members were Davíð Davíðsson, Sigurdur Thorarinnsson, and Ólafur Ólafsson. MANNFRAEDISTOFNUNIN (the Institute of Anthropology) was established in 1972 by the Icelandic Anthropological Society and supported by it and the Parliament of Iceland. Its director was Jens Pálsson and its governing body included Jóhann Axelsson (Chairman), Gudmundur Eggertsson, and Ólafur Ólafsson. It has been replaced by the new Institute.

For further information, please write: Mannfraedistofnun Háskóla Íslands, Ásvallagata 54, Reykjavík, Iceland.