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Tank Irrigation in Crosscultural Perspective

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ABSTRACT

Irrigation tanks, or small reservoirs, are localized systems organizationally quite distinct from regionally integrated canal networks. Comparative examination of the organization of irrigation in three societies in which localized systems were traditionally operated shows that most organizational functions were carried out efficiently on a village or local residential group basis, without active intervention from outside. Analysis suggests that this was possible because very high proportions of the local populations were involved, and that in such cases government, and government officers from outside the local area, need not play particularly active roles. The findings suggest that for localized irrigation systems participation is at least as important as authoritarianism, and that this hypothesis might be applied in planning the development of localized systems and in analyzing societies based on them.

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TANK IRRIGATION IN CROSSCULTURAL PERSPECTIVE

Victor S. Doherty*

INTRODUCTION

Irrigation from tanks, which are small reservoirs usually fed by runoff water, is a common technique in geologically and climatically suitable portions of India (von Oppen and Subba Rao 1980). Such reservoirs are built in a variety of sizes, and they command varying areas for irrigation depending upon the different possibilities which are presented by terrain and rainfall. Areas irrigated range from as little as three or four hectares (ha) up to one hundred or more ha, usually but not exclusively paddy land. Most tanks fall in the smaller size range. For example, Ludden (1978a: 349) notes that in Tirunelveli district of southern Tamil Nadu State in India, 80% of the some 2,500 tanks command under 40 ha. The latter figure is close to the average command area per tank in Tamil Nadu as a whole. It is with such common, smaller sized tanks that we are especially concerned here.

Because irrigated land is usually more productive than rainfed land, and since in India irrigated agriculture traditionally has been taxable at higher rates, there was an incentive for rulers of the past, and their agents or feudatories, to organize and oversee the building and operation of tanks. Today as well, nations in South Asia and in many other parts of the developing world are investing in the creation and improvement of irrigation facilities, including tank irrigation. Tanks present special problems and special possibilities, and seem to be particularly complex in terms of human organization. It is the purpose of this paper to attempt to reach hypotheses regarding main elements in the organization of tank irrigation.

TANK IRRIGATION IN INDIA

One easily forms an impression that in India, before land reforms and governmental reorganization following independence from the British in 1947, smaller tanks were in effect the private property of powerful individuals, while larger tanks were under direct government administration. From a multitude of pieces of partial information, including statements by farmers, and oblique or incomplete references in histories and gazetteers, a rather hazy picture is built up, from which it seems

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that tanks having command areas of up to perhaps 40 ha were under the direct, local control of individual large landowners, semi-independent chieftains, and local headmen. Such individuals seem to have been able to command labor for construction and for regular repair work, and also to have been able to support by force, if necessary, the rules governing allotment of water and the authority of appointees such as tank watchmen. Under such circumstances, one is led to assume, there were no insurmountable organizational problems. Rewards for conforming behavior, and punishments for misbehavior, could be administered quickly and locally by a single authority, sanctioned by the force of arms possessed by such locally powerful individuals and backed up when necessary by the arms and arbitrary action of rulers at higher political levels.

There sometimes seems to be an impression as well that abolition of large estates and of the semi-independent, arbitrary powers of large landholders has contributed to the recent organizational decay of small tank irrigation. Many smaller tanks are observed to have fallen into disuse or disorganization, even where government officers at the village level have been charged formally with looking after these. The government has limited administrative resources, and would like village level bodies to oversee the operation of small tanks while government efforts are concentrated on large ones. Villagers, on the other hand, exhibit passive behavior which suggests that they would like the government to take a more active role.

The Indian situation has recently been examined in economic terms, with tests applied to show how some institutional factors may have been important in the growth and decline of tank irrigation (von Oppen and Binswanger 1977, von Oppen and Subba Rao 1980a,b,c). Their analyses have led these authors to emphasize both physical and administrative factors.

Physical conditions emerge as important enabling factors. Thus, an examination of the average density of tank irrigation in different areas of India during the four agricultural years 1968-69 through 1971-72 found no significant correlation between the density of tank irrigation and the presence before 1947 of princely as opposed to British rule (von Oppen and Binswanger, 1977). A significant positive correlation between tank density and princely rule had been hypothesized, on the assumption that arrangements under princely rule would be relatively more supportive of the kind of arbitrary, local power discussed above. The study found, instead, that there were multiple, significant correlations between the density of tank irrigation and the presence of certain physical factors. These included impermeable subsurface layers, which retard water losses from percolation; rainfall concentration in restricted portions of the year, which contributes to efficient filling of tanks; and a climate in which humidity keeps evaporation losses relatively low during the season or seasons of greatest tank use intensity.

The same series of studies (von Oppen and Subba Rao 1980a,b) shows that in physically suitable areas tank irrigation becomes an attractive alternative and is intensified as population reaches and passes a certain density. This point seems to have been about 60 persons/km² in the areas covered by the present Tamil Nadu and Andhra Pradesh states in India.

Looking at secular variations in tank irrigation, von Oppen and Subba Rao found indication of the effects of administrative structure and policy. In the formerly princely-ruled districts of Andhra Pradesh, tank irrigation has decreased in area as population has passed about 220 persons/km²; this has not happened in Tamil Nadu, or in the formerly British-ruled districts of Andhra Pradesh (which have some administrative history in common with Tamil Nadu, having been part of the old Madras Presidency and the post-independence Madras State). It was also found that tank irrigated area in Andhra Pradesh, but not Tamil Nadu, varied with rainfall during the 1960's and early 1970's. As the authors point out (von Oppen and Subba Rao 1980c) these findings suggest that the administrative structure, which provides supporting mechanisms for tank repair, maintenance, and operation does play a role in supporting and stabilizing tank irrigation, and that in recent years more administrative attention may have been given to these functions in Tamil Nadu.

Taken together, this series of studies suggests that the initial possibility for tank irrigation is physically defined, while its continuation requires some level of administrative support from outside the village or village region. These studies do not indicate that arbitrary power is a necessary condition for successful tank irrigation.

It is the thesis of this paper, however, that whether taken separately or together the administrative, geological, and agroclimatic factors cannot by themselves provide a satisfactory explanation of how irrigation from small tanks was organized in the past in India, and how it might at present be improved in India or introduced elsewhere. I suggest that these factors are only three among a larger number, which must be taken together to provide the circumstances which will be both necessary and sufficient for successful tank irrigation.

In what follows the emphasis will be on suggesting what this full set of circumstances might be for small tanks of about 40 ha command area, and for successful local participation in the upkeep and management of such tanks. I suggest that among other requirements for the smooth management of a localized irrigation source such as this, the degree to which all enfranchised individual members of the local community participate in irrigation or its direct benefits plays a key, enabling role. I suggest further that the degree of local participation is at least as important as the degree and type of outside administrative control.

ETHNOGRAPHIC COMPARISON IN THE EXAMINATION OF TANK IRRIGATION

These suggestions will be substantiated by a comparison of data from the ethnographic record. Given the diverse nature of the data, however, there must be agreement about the grounds on which such comparisons can be made.

There is a lack of easily available, detailed, sociological studies of tank irrigation; this lack must be filled by future research. The material to be presented in the following sections is drawn from reports on several societies, having different degrees of technoenvironmental complexity, with different cultures and different types of political system. Of the three cases presented, only one is of tank irrigation. The other two instances involve irrigation from springs and streams in one case, and locally initiated and controlled irrigation from river sources in the other. The comparison to be undertaken will be valid and the results can be applied to questions about the organization of tank irrigation only if we are given certain assumptions. These assumptions are detailed below. Although qualified, and although a detailed exposition of differences and similarities in theoretical implications will not be attempted here, these assumptions are in essential agreement with major portions of the cultural materialist research strategy developed by Harris (1968, 1975, 1979) on the basis of work by earlier scholars including Steward (1972). Statement 2) paraphrases several statements by Harris, besides suggesting that under some circumstances regularity will be found across types of technoenvironmental and social complexity.

1. The unity of the human species means that comparison is valid across societies and cultures, and across different types of technoenvironmental system.
2. Other things being equal (in the examples here, if encompassing, state systems do not exercise active managerial authority at the local level) similar social organizational problems arising from technological requirements will be solved in similar fashion, whatever the overall levels of social or technoenvironmental complexity of the different societies.
3. At the levels and for the types of organization considered in **this paper**, cultural traits and principles will not be limiting in the long run, and will not affect the abstract form of organization required by the task at hand.

The points above focus attention on organizational problems presented by the physical nature of the irrigation task. From such a perspective it is proper to compare the organization of irrigation from streams, rivers, and tanks if in all cases the organizational tasks are similar to those involved in tank irrigation. In all the cases reported below, this similarity exists: the task in question is action by a local group of people to invest in, maintain, and distribute water from an irrigation system which is localized and which is effectively independent of other such systems in the area.

Nevertheless, we might have queries about crosscultural comparison of societies representing different levels of technoenvironmental and organizational complexity. How can it be valid, for example, to compare hunting-gathering societies with state level societies? A nomadic, hunting-

gathering group is integrated at only a few social organizational levels (Steward 1972) and is unlikely to be able to harness the labor of its members as can a state society: in complex ways persisting over the long term and contributing to large-scale investment. In answer, we grant the truth of such observations as far as they go, while maintaining that they do not express the entire state of affairs. People living in state-level societies are often confronted with situations requiring patterns of organization which are common in societies of different complexity, even though the indirect functions and the ultimate consequences of such organization may differ greatly for the two types of society. For example, there are indications that a crossculturally optimal size for face-to-face, short term task groups may be between five and nine persons whether we are speaking of task groups among hunter-gatherers or in peasant society (Doherty 1980). If we suspect that such regularities in human organizational patterns exist, it is worthwhile to analyze data on such a score and also to look for more evidence. Given the problem under review in this paper, we may feel it particularly significant if we find that problems of the control of localized irrigation systems are solved in similar ways by societies which differ greatly in overall technoenvironmental and political terms.

Points 1) and 2) above justify crosscultural comparison among societies at the same or different levels of technoenvironmental and organizational complexity. Point 3), however, raises a different subject: the possibility of cultural as opposed to technoenvironmental determination of a society's selection among possible social organizational forms. As implied by point 3), I suggest that tank irrigation presents a type of organizational problem which, if it is to be solved by any local-level society, will be solved by all such societies by means of the same set of general organizational principles.

A number of cultural responses to the situation is possible. Culturally specific patterns of organization may operate as enabling or supporting mechanisms for irrigation organization. Change may lead to the development of appropriate, new cultural traits supporting such irrigation. Cultural traits which prove limiting to the potential success of such irrigation might disappear or be modified. Such traits could also be displaced, shifting from limiting to nonlimiting functions.

It is also possible that a society might not solve the organizational problems and thus might not irrigate. Assuming that no political, demographic, or economic compulsion is in operation, such an event could be due to culturally based aversion to the types of social organizational form required by localized irrigation. Again assuming no compulsion, which means that we do assume the group in question has sufficient power and resources to enable it to exercise preference, a society could simply choose to follow a particular way of life which happened not to include localized irrigation as part of its appropriate production base. Such cases of culturally motivated selection among

possible adaptations are well known from the North American ethnographic record through the work of Bennett (1970) on immigrants to the Canadian plains.

Logically, none of the possibilities of preadaptation, change, avoidance, or alternative choice listed above affects the proposition that if a certain type of organizational problem is to be solved it will be solved in the same way by human beings everywhere.

THE SONJO CASE

In 1955 the Sonjo (Gray 1963) had an estimated population of 4500 divided among six villages located in what is now northern Tanzania, along the border with Kenya. Sonjo villages were effectively independent political entities; the ethnic group as a whole, however, shared language and religion and the members of Sonjo villages intermarried. The economic base of the society was agricultural; the staples were sweet potatoes, along with sorghum and pearl millet. Sweet potatoes were planted in fields perennially irrigated by springs and streams, while sorghum and pearl millet were also common crops in these same irrigated fields. An additional class of field, usually planted to sorghum and pearl millet, received irrigation water on a lower priority, as extra water was available and when rainfall was low. Gray reports that at the time of his field work rainfall records had been recorded for eight years at a British government rain gauge located near one of the villages lying in the middle of the Sonjo territory. The yearly rainfall during this eight year period averaged 476 mm, with a high of more than 750 mm and a low of 305 mm (Gray 1963: 27). Gray also states that rainfall was concentrated in a rainy season from January-February through May, that it was quite unpredictable from year to year, and that agriculture in this area was not practical without irrigation. Given these rainfall figures, certainly grain agriculture would not be practical without dependence on the most drought resistant (and thus, presumably, low yielding) varieties of sorghum and pearl millet. Moreover, as Sonjo territory was completely circumscribed by territories of the Masai, with whom the Sonjo were on hostile terms, their potential flexibility to crop different types of soil or to expand their grazing areas was presumably limited.

Gray reports that all six Sonjo villages practiced irrigation, with some variation in actual layout depending upon topography, and upon the locally varying yields of the springs and streams on which the system depended. The division of agricultural labor was that men were in charge of clearing fields of bushes and of the preceding season's stubble, while women tilled the fields with digging sticks, and planted and cared for the crops. The men, however, were in charge of irrigating the fields. All the men of a village participated in the process of apportioning irrigation rights and bargaining for the use of irrigation water. All males were also required to participate in repair work. Rights to water were assigned in six-hour portions, with the 24 hours of the day being divided into four such portions. Assignment was on a fourteen day cycle, so that an individual's turn to irrigate came, in principle, every

fourteen days. A group of elders¹ with inherited rights to priority in irrigation allotted the first turns among themselves; another group of elders exercised inherited, second priority turns; and third priority turns were allotted to a third group of elders, who obtained their rights by payments of goats to the first group. In the village Gray chose as his example, all the men of these three groups together accounted for only half the men of the elders' age group in the village as a whole; the rest, in Gray's term, were "clients" of individual elders who sold them subsidiary water rights for certain periods. Such purchase rights were available only during periods of sufficient availability of water. Thievery of water was possible and evidently common, by opening the sides of an irrigation ditch at night, while water was being conveyed past one's field.

Organizationally there are a number of striking characteristics of this system:

1. Use and upkeep: All adult males of a village used irrigation water and were required to contribute to the upkeep of the system.
2. Local responsibility: Irrigation was organized on a village-by-village basis, although the principles followed by the Sonjo as a whole were the same. Authority for irrigation rules was therefore cultural, sanctioned ultimately by custom among the ethnic Sonjo as a whole, and not by the rules of an individual village alone.
3. Administration: Elders with inherited priority rights to water formed a kind of de facto, central committee at the village level for decision on irrigation questions and for control of the system.
4. Types of water right: There were four clearly recognizable, graded classes of access to irrigation. Although the lowest two groups obtained water only on a contingency basis and sometimes by theft, all adult males of a village must be regarded as having had a direct interest in the irrigation system.

As reported by Gray, the system as a whole functioned in a predictable fashion, allowing an individual elder to compare his knowledge of crop water requirements with the development of the agricultural year so far, and on this basis to allocate water to himself and others. There was ample room for political and economic entrepreneurship. Although there were rigid rules, the system was capable of coping with both scarcity and individual ambition.

THE EL SHABANA CASE

The El Shabana are an Arab ashira (chieftaincy group) of southern Iraq, whose members traditionally submitted their disputes to a single shaykh for arbitration. According to the author of the study (Fernea 1970) from which the data examined here are taken, agriculture in the area occupied by the El Shabana and related ashiras "cannot be sustained by the rainfall alone" and "all summer and most winter cultivation is

1. The term refers not to chronological age but to age grade status. An elder in this sense had full adult political status, above that of the members of the junior males' age grades. The latter grades comprised groups of young men who served as warriors.

dependent on water taken from the Twin Rivers." (Fernea 1970:7). Summers are hot and rainless while winters are cool with undependable rains. The World Atlas of Agriculture (IAAE 1973:268) reports that yearly rainfall averages 200 mm in this area.

Irrigation has been practiced for centuries in this region. It has not always depended upon centralized control, whether by the proto-historic states of early Mesopotamia, or by the Ottomans, or by twentieth century rulers. Fernea (1970: 25 ff.) concludes, on what seems to be good evidence, that after the fall of Abbasid Baghdad to the Mongols in 1258 the people of the various ashiras in this area maintained irrigation agriculture with little outside help or interference. He reports that during this period the inhabitants, who still include both farmers and pastoralists, also responded spontaneously to higher export prices for agricultural products by "increased sedenarization and expanded cultivation" (Fernea 1970:30).

The system of irrigation which is institutionalized in this area has at present been consolidated and mapped, while state investments in barrages and related works are made on a continuing basis. Land rights are recorded in writing and the records kept in offices; water delivery and dispute settlement are becoming or have become primarily the responsibilities of government. Previously, however, the system was not consolidated, while investments were limited and at times impermanent. Land tenure was a matter for strength of arms. Disputes were settled by arbitration and mediation before elders in the local settlement; or by the mediation of religious personages; or, most importantly, by mediation in the presence of the shaykh and the men of the ashira. Irrigation as a whole was decentralized. As described below, an individual ashira or ashira subgroup would build and maintain canals leading from the Euphrates or one of its branches into its own territory. Water was shared within the ashira or the ashira subgroup but not outside it.

The members of El Shabana society traditionally depended for mobilization and reference upon a system of ramifying, territorially based lineages and lineage clusters (Fernea 1970: 82ff). The basic principle was recognition of patrilineal descent from a real or assumed common ancestor, traceable by genealogical experts. There was recognition that shared descent entailed the possibility of common action by the entire group or by sections of the group of males claiming such descent. Action was particularly for irrigation, for festivals, or for war and raiding. There was also recognition of the responsibility to submit internal disputes for arbitration and mediation by and in the presence of ashira shaykhs. Ashiras comprised several recognized shabbas, or local residential groups. Shaykhly lineages, which functioned at the ashira level, were liable to replacement by force of arms during periods of internal dissidence.

Before government regularization of land tenure, the members of a shabba and of each of its constituent groups were usually resident in the same area and farmed contiguous fields; in the main they moved from

place to place only as they might force their way into a new area or be forced to move. Irrigation proceeded in the following manner in the El Shabana case. At the start of the cultivation season, temporary dams were erected on the Daghara branch of the Euphrates and water was diverted directly from the river to the fields. As population grew, canals and channels would grow in length and complexity as well, informally, with individuals or groups of individuals, evidently of several shabbas, combining to extend small offtakes from the river itself. In the El Shabana case, as population grew even larger, tension arose from such use of a single canal.² The shaykh, whose position was threatened by such tension, then found it in his own interest as well as in the interest of the ashira to organize the construction of an additional canal (Fernea 1970:119-121).

Most of Fernea's data on system maintenance (1970:121 ff) relate to the present day, but the maintenance system at its lower levels seems to have incorporated previous custom to a large extent. Fernea reports that at the time he did his fieldwork maintenance was controlled in an outwardly informal fashion but operated on the basis of well-known rules nevertheless. Men of the same shabba were normally in close touch with one another, since they lived in the same or adjoining settlements and farmed the same area. Each man was responsible for cleaning a known portion of the offtake canal he used; this work was carried out individually and at one's leisure but during specified general periods, and one who did not carry it out would be denied water that season, by his shabba fellows. Cleaning the offtake canal used by the shaykh was done by members of the ashira as a whole, who assembled especially for this purpose. The government organized maintenance of the main canals and oversaw a rotating system of allotment of water periods to the offtakes used by different groups of farmers (Fernea 1970:124 ff).

Traditionally, and to a large extent at the time of Fernea's study, all of the locally resident members of the El Shabana were farmers, and thus all had an interest in the canal. Most farmed for themselves. In this and in other ashiras it was possible for individuals to employ tenant sharecroppers. In such cases, from Fernea's account, it seems likely that individual employers would have been responsible for their sharecroppers' compliance with the irrigation rules; and that employers, again, would have been expected to settle disputes among their own sharecroppers. Such tenants could in principle be members of the same ashira, though Fernea reports a case in which a section of an ashira returned to pastoralism rather than submit to tenant status.

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2. Von Oppen and Subba Rao (1980c) suggest that in India tank irrigation systems not bureaucratically supported are likely to experience a fall in efficiency when population in the region rises above a certain density, putting increased pressure on the system.

Adoption of groups of outsiders into an ashira was possible; presumably such adoption was decided on practical political grounds and was usually a result of expansion of the ashira into a new territory. Ashira membership was necessary both to landholding and to irrigation:"... until 1922 [when government supervision began] members of the tribe [ashira] were able to block the stream and take water as they wished as long as they were strong enough to prevent downstream tribal groups from breaking up their dams" (Fernea 1970:120). The existence of the ashira itself, in active as opposed to latent or scattered form, seems to have depended on the existence of a common resource such as an irrigation system; Fernea (1970:120-121; note 4, p. 207) notes that severe and prolonged shortage of water could lead to ashira breakup or to changes of shaykhly lineage.

Summarizing the data for El Shabana as for the Sonjo, and concentrating on the traditional system, the following points emerge:

1. Use and upkeep: In the traditional system all ashira members were farmer-irrigators or (more rarely) in charge of sharecroppers who also used irrigation water. All ashira members were required to participate in dam building and in maintenance duties, or to direct their sharecroppers in such work.
2. Local responsibility: The shabba, or maximal local lineage group of 20-50 adult males, seems to have been the de facto territorial group, among the members of which action was arranged both formally and informally, according to customary rules. These rules seem to have been essentially the same from ashira to ashira.
3. Administration: The shaykh of the ashira, which comprised several shabba groups, traditionally had the right to assign land among individuals and to adjudicate disputes among them.
4. Types of water right: Although landholdings were not equal even in the traditional system, one had the right to a proportionally equal amount of water for one's land. Disputes were liable to arise when head vs. tail end location of various persons' land meant that rough equality was not maintained. These disputes were adjudicated by the Shaykh, or settled by migration, or resolved by force.

In the next section we turn to a case of tank irrigation.

THE PUL ELIYA CASE

Edmund Leach's (1971) study Pul Eliya focuses on a Sri Lankan Dry Zone village of that name. It provides a detailed and highly circumstantial account of social organization and land tenure, as these affect the use of paddy land irrigated by the largest and most important of several tanks located in the area. This main tank, and the land it irrigates, form the main basis of the villagers' livelihood. Although they also

engage in rainfed, shifting cultivation of kurakkan (finger millet) and of sesame and mustard as cash crops, rice and the land it is grown on provide the main economic focus. The tank is filled by runoff from rainfall, which averages between 1200 and 2000 mm annually over most of the Sri Lankan Dry Zone (IAAE 1973:66).

In earlier days in Sri Lanka, many tanks seem to have been built (or repaired in the case of abandoned tanks) by colonizing groups of households, whose home village areas had reached a point of population stress upon the agricultural base which made it more attractive to move than to remain.³ Such settlement was carried out according to rules whose sanction seems to have lain ultimately in the hands of regional and subregional feudal rulers. All of the founders of the new settlement would be assigned shares in the tank's paddy land. This land itself would be divided into at least two and perhaps three areas or bāga, with a landholder being assigned equal proportions of land in each bāga. Thus each villager in the new settlement would hold land both in the head (most easily irrigated) and tail (least easily irrigated) areas. In Pul Eliya, down to 1954 when Leach carried out his field work, it was still the case that someone holding land under the main tank held equal proportions in each of the tank's two irrigation bāga (Leach 1971: 159). This meant that water access was of the same type for all participating villagers, even though equality of size of shares owned was not enforced and may not have been sought even at the founding of such a shared tank. Leach maintains that what was shared by such a system was not land rights, but rather water rights. The system was obviously well adapted to adjusting area irrigated according to the amount of rainfall received in a given season of a given year.

Under the Kandyan kingdom, each bāga irrigated by a tank was put under the control of a locally determined officer, the gamrāla, who in the event usually held his position on a hereditary basis. The gamrāla would receive extra portions within the bāga he shared with other cultivators. In return he assumed extra duties in arranging for crops to be watched and in organizing irrigation work and decisions. A gamrāla's authority was sanctioned ultimately by the local, feudal ruler although most decisions seem to have been handled locally. The British during their period of rule appointed irrigation headmen, or vel vidāne; in Pul Eliya the vel vidāne was a member of one of the earlier gamrāla families.

At the time of Leach's visit, maintenance for the tank in Pul Eliya was locally organized. In addition to maintenance work on the dam, the annual work included related duties: repair of channels used by a shareholder, maintenance of fencing around the fields, and crop guarding duties. Those who did not perform their required tasks would be denied

3. This circumstance again recalls von Oppen and Subba Rao's (1980c) work on population density and tanks in southern India. It would be interesting to see such work expanded, on a cross-regional and cross-cultural basis.

water. Timing for some of the work at least was flexible, and could be done according to an individual's time available. Decisions regarding when to begin irrigation and which fields to irrigate were enunciated by the *vel vidāne* following a village meeting and his own assessment of the situation.

Two types of land were irrigated by the Pul Eliya main tank in 1954: land cultivated in the "old field" (Leach's term) according to the original system of shares; and land which was added onto the irrigated area at a later date, according to laws enacted during the British period. The latter type of land was not in balanced shares.

Leach explains that there were three major criteria according to which full village membership could be claimed by an individual in Pul Eliya. The first of these criteria was *variga* or endogamous group membership. The inhabitants of Pul Eliya thought of themselves ideally as members of a single *variga*, and marriages were arranged within the village or with persons outside the village who were recognized as *variga* members. The second criterion of full membership in the village was possession of a house site in a compound (or its sub-division) recognized as one of the village's original compounds. The third criterion was ownership of shares in the main tank's old field, or access to such land.

Examination of Leach's figures (1971:184, 321-331) for 1954 shows that at that time of his investigation 79% of the old field land under the main tank was held by Pul Eliya *variga* group members who were also resident in the village. Each of the 13 original compounds or subdivisions of original compounds which Leach delineates (1971:55-58) contained at least one male family head with shares in the old field. Many compounds had more than one such owner. Leach reports in very full detail on both the ideal and de facto rules governing land tenancy, land mortgage, and household cooperation and interdependence in Pul Eliya. The operation of these rules assured a situation in which almost all non-owners who were nevertheless *variga* fellows and residents of the village participated in cultivation of the old field and in its benefits.

As a system, the set of rules and circumstances outlined here seems to have operated fairly smoothly to promote local control. It seems to have been important for the operation of the system that it operated in the same way for all (cf. Doherty and Jodha 1979). Thus cultivation of the tank bed itself, although practiced in the past under circumstances which Leach does not detail, had been forbidden later on for government tanks such as Pul Eliya's, since the possibility of such cultivation constituted too much of a temptation to individuals to breach the dam in order to hasten the time when planting in the tank bed could occur. There were other problems; the addition of irrigated land outside the old field but depending on the main tank seems to have reduced returns to old field holders, however much it might have helped the individual owners of the newly-irrigated areas. Thus, old field land was irrigated

for paddy only once a year in 1954, whereas earlier it had been irrigated twice a year, with water from each of the Dry Zone's two rainy seasons. As Hunt and Hunt (1976) remark, the addition of this land outside the old field seems to have been to the main benefit of the locally powerful, and to have subverted somewhat the operation of the traditional system. Nevertheless, the system as a whole seems to have been in good shape in 1954, and to have been operated by the villagers themselves with minimal recourse to outside help. It was necessary to make yearly reports including tax reports to government officials, and the possibility of appeal to higher authorities when in need was presumably an effective stabilizing influence. We may summarize the Pul Eliya case as follows:

1. Use and upkeep: Participation was effectively village-wide. Members of 13 out of 14 residential compounds in the village participated under one or another arrangement in use of the main tank and the old field. Maintenance was a local responsibility, locally organized; some government subsidy for repair was available from time to time for major repairs and construction.
2. Local responsibility: Irrigation was locally organized, both informally and by means of a government-appointed officer in the village who acted on the basis of his own knowledge, his perception of consensus, and the recommendations of village meetings.
3. Administration: The local officer was backed up by the possibility of appeal to higher, regional officials.
4. Types of water right: Size of share in the old field varied but not quality of share. Sharecropping agreements were often concluded, and water was not necessarily used directly or exclusively by those having ownership rights to irrigated land.

In the following sections we compare these three cases and draw cross-cultural conclusions for the institution or improvement of tank irrigation.

TANK IRRIGATION, GROUP SIZE, AND GROUP FUNCTION

A summary of main social organizational aspects of the three societies from which these cases are drawn is given in Table I in the Appendix. Although we see from Table I that these societies are quite different from one another, Table II shows that nevertheless they show important similarities in their organization of localized irrigation. These organizational similarities are as follows:

1. All or almost all households in the local residential area or village use the irrigation facility;
2. Adherence to the rules governing use of the system is sanctioned ultimately by an outside force (religion for the Sonjo, the ashira shaykh for the El Shabana, the government for Pul Eliya), from which there is no appeal;

3. There is provision for the use and possession of irrigation rights to circulate among members of the local society, both within a given season and over much longer periods of time; and
4. Season-to-season and day-to-day aspects of management are in the hands of villagers themselves, acting in the context of local institutions.

Such a degree of regularity seems to call very strongly for explanation.

In two earlier papers (Doherty and Jodha 1979, Doherty 1980) I have analyzed differences in human group size and function. These analyses have been tested in part in a later paper (Doherty et al. 1981). The three papers build especially upon work by Birdsell (1968, 1973), which comprised primarily analyses of hunter-gatherer groups and which was focused on demographic questions. Birdsell himself has suggested (1973) that his work can have wider application in understanding the interrelations of demography and society in more complex situations than among hunter-gatherers. In the earlier papers cited, and in the present paper as well, I have made the attempt to work with such an expanded focus. Birdsell's demonstration of demographic constants for local groups and for dialect (basic linguistic-cultural) groups among hunter-gatherers across different environments suggests the possibility that there may be deep-seated, human differences in the appropriate functions of local groups and cultural groups. Moreover, if modal group size is independent of environment among hunter-gatherers, and if characteristic, generalized functions also exist for certain types of group, then these general functions may at the very least be independent of environment and also may be independent of the type of society involved. In the next paragraphs we explore these ideas, and then apply the results of our exploration to the practical problem which faces us: understanding tank irrigation in crosscultural perspective.

As Birdsell has shown in the two articles cited, hunter-gatherer local bands possess a crossculturally modal population size of 25 individuals. Such groups are usually also territorial or corporate in the sense of occupying a particular, definable geographic area or holding priority rights to localized, identifiable resources. In these senses, territoriality exists for local groups whatever the specific nature of the rights controlled, whatever the specific definition of "area", and whatever the nature of a particular group's modus vivendi with neighboring groups. Although Birdsell does not dwell on the point, other authors have reported that the membership of hunter-gatherer bands is quite labile, with individuals or domestic groups moving from one band to another by utilizing social relationships which permit affiliation. The members of such bands also adjust to varying circumstances by spreading out or concentrating themselves territorially according to season, and thus according to the changing availability of resources. Where seasonal abundance of food and water permits, many bands comprising all or most of the members of a single dialect group (with its own crossculturally modal size of 500 persons) may meet for relatively brief periods at a single place.

At this point we may introduce consideration of function. Among hunter-gatherers, local groups all of whose members exploit the same economic resources, and which have a modal population size of 25, provide for the possibility of continually forming and re-forming small task groups of males and of females. A band of 25 persons in modal size also comprises a psychologically easily handled small group of approximately 5 separate, economic interest groups or domestic units (Doherty 1980). A continually varying play of individual endowment and interest stimulates continual changes in the membership of such task groups, and contributes to the variation in band membership as well. One function of the local group seems to be to provide a framework in which such change can take place and in which subgroups of an appropriate size, in human organizational terms, can form and re-form easily for the tasks at hand and within a given territory.

This is only part of the functional story, however. The complement to such within-band and within-group variation is the continuity which we observe both in the local territory and in the larger, dialect or cultural group. Persons may move from band to band but they do not, except in rare cases, move out of their cultural group. Moreover, the cultural tenets which must be accepted by all individuals, by reason of their membership in the cultural unit, place clear restraints on individual action no matter with which local group they may be affiliated at a particular time. These restraints operate without exception; they are the more binding because although one may quarrel with one's neighbors in a particular band, and move to another, one cannot move away from cultural rules. Moreover, individuals or courts of elders in a local unit may enforce or interpret such rules but they do not sanction them in the end; the wider, cultural unit as a whole sanctions them by virtue of the fact that all local groups of the same culture subscribe to and enforce basically the same set of rules.

Bearing in mind this continual interplay in hunter-gatherer society between individual and custom, local group and cultural group, task group and institutional context, one finds that similar dichotomies and divisions of function appear in technologically and socially more complex societies, including agricultural societies.⁴ To take a single example: if one examines those agricultural societies in which "communal tenure" of land is said to prevail, one usually finds that whatever

4. I would like to emphasize that in what follows the concentration is on function; and that demography enters the picture only in a comparative sense, in that local groups are smaller subunits of larger societies. Thus Goodenough (1969) presents data which show that the mean size of a local community varies rather widely according to the economy (fishing, pastoral nomadism) of the society. Birdsell (1973) has also addressed this subject. It seems possible nevertheless to isolate functions and processes which seem to be associated characteristically with the local group, or local community, whatever the type of economy. Similarly, there are other functions and processes characteristically associated with the encompassing or cultural group.

the geographical location of such a society, farming itself is based ultimately on the individual or on the domestic group. "Communal" aspects of tenure are limited to enforcement of rules assuring that persons of roughly equal status have roughly equal chances of access to the use of land and similar resources, while the chances themselves are usually confined to members of the ethnic group in question. One also finds that in such societies the amount of land actually held by any one individual or domestic group is continually changing due to variations in economic situation arising from the influence of individual qualities, family and household growth and re-formation, and seasonal and yearly variation in agricultural conditions. Various means mediate such change, including inheritance, courts of "land chiefs" (in parts of West Africa) and so on.

We also find that in such agricultural societies, just as in hunter-gatherer societies, there are restraints on individual freedom which act to assure that although individual situations vary and individual needs are responded to, no one is allowed to set himself economically outside the system enclosing and supporting the group as a whole. In both types of society, also, local groups inhabit definite if not definitely bounded territories, within which individual and domestic groups pursue their own activities and their changing local alliances. In both types of society we find that restraints on individual action are sanctioned culturally, which is to say from outside the local residential group, even though the demographic size of local groups may vary considerably according to the complexity of the society involved.

There are strong overall similarities between these observations on group function in human societies, and the common features which we observed in the organization of localized irrigation among the Sonjo, among the El Shabana, and in Pul Eliya. In all of these societies one finds the local residential unit in possession of a functional equivalent of a territory: a localized irrigation source. In all cases there is local management but outside, cultural sanction of the rules supporting this.⁵ In all cases, as we have noted, most of the local population participates in use of the irrigation resource, while at the same time there is considerable circulation of rights from individual to individual or from household to household. In all these cases, too, management is effectively in local hands and is organized by local not outside institutions.

CONCLUSIONS AND HYPOTHESES

I suggest that the similarities which we observe among systems for the successful local management of localized irrigation, and systems for exploitation of other types of community resource by local human groups,

5. Acceptance by Pul Eliya villagers of government authority to set rules may be considered fully as cultural as the religious and age-grade rules of the Sonjo, or the patrilineal principles of solidarity among the El Shabana.

are due to the operation of common, human organizational principles governing major functions of different types of group. As was brought out in the preceding discussion, these major organizational principles seem to be valid crossculturally. Although broad, they can help us to understand how societies and their institutions work, and they promise to help us in solving practical problems. They may be summarized as follows:

1. Local residential groups are groups in which small units for tasks form and re-form, and in which individuals and households seek their interests by means of shifting alliances.⁶
2. Such local groups have continuity in a corporate sense, independent of their individual members. Persons, committees, or the local groups as a whole are able to act to enforce limits and directions in the behavior of individuals. Both this corporate nature and the power to enforce rules seem to depend importantly on the right of individuals in the local group to exploit a common territory or similar economic resource.
3. Ultimately, it is the larger society or cultural group, comprising a number of local residential groups, which holds the key to such enforcement of rules, because it is in the larger group that cultural rules specific to the larger society and the type of its economic base are held.

Regarding the third point, it is important to note that while cultural rules are used by persons and groups as problem-solving devices, so that a certain amount of local variation in actual custom is always observed, cultural sanction means that it is relatively difficult to change the basic nature of the rules involved. Where the rules are well-adapted to human organizational and local economic needs, this situation means that it is all the easier for them to exert influence in an essentially passive or latent fashion.

These three suggested organizational principles can be seen as first attempts at an understanding of authority, cooperation, and related phenomena in human society, by means of a model which describes the bases of generation and survival of cultural rules in various societies. If substantiated by further research, such principles could be of considerable help in practical tasks, such as the task of designing improved systems for tank irrigation, or introducing such systems where economy and population pressure warrant. These suggested organizational principles should be tested as their application might make possible a reduction

6. In an earlier paper (Doherty et al. 1981) special conditions were described for the long term persistence of small groups under the application of strict rules. Such rules were shown to minimize interaction among the members of persisting, small groups, which is a point in agreement with the conclusions here.

of government administrative expenditures, and might increase the effectiveness of whatever government effort is made. As a preliminary to such tests, I hypothesize as follows:

Village level institutions will be relatively more efficient in managing tank irrigation as the following conditions are met in addition to the condition of economic profit to such irrigation:

- 1) dependence on tank irrigation for a significant portion of their income, by all enfranchised members of a local community;
- 2) land ownership and rental arrangements which assure the possibility of adjustment to individual situations;
- 3) outside, extra-village sanctions of a passive type, supporting village institutions to which active management roles are assigned.
- 4) relatively high regional density of the system;
- 5) relative uniformity in the basic organizational rules followed by each local community.

Each condition mentioned must be met in such a way as to avoid its contradiction of any other condition. Thus land ownership and rental must establish the possibility of easy adjustment to household variation in such resources as managerial ability, draft power, and labor; but they must not contribute to the concentration of large proportions of the irrigated area in a few hands. This would defeat the possibility of community interest and support for local management institutions. Such concentration also would seem likely to reduce returns to irrigation and to be detrimental to the health of the system in the long run, by reducing the number of persons in the local community who have a direct interest in the agricultural efficiency of the tank. Similarly, if local institutions are to manage the irrigation system they must be free to do so: extra-village or governmental contributions should be limited to such relatively passive activities as providing guarantees for a realistic set of laws which can be applied strictly and firmly at the local level, and to provision of extraordinary investment or repair costs.

The fourth and fifth conditions above are important for the smooth functioning of locally run tank systems or of any other localized and locally run system for resource use. All of the conditions suggested here for successful local control of such systems have been justified by analogy with conditions which seem to support the generation and institutionalization of cultural traits and patterns. Neither cultural traits in general nor irrigation rules in particular can be expected to persist unless a certain density of local groups, whose members interact with each other from time to time and who follow the same rules, is achieved. More on this subject is contained in Birdsell (1973). Measures of the density required for different types of systems are needed and should be established by research. As a rule of thumb, however, one probably cannot expect to institute a locally run (as opposed

to centrally, bureaucratically run) irrigation system or any other locally run resource use system which is not replicable over a rather wide area. Historically, tank irrigation systems, with similar rules for management, were established throughout wide regions of southern India, evidently involving most of the agricultural members of some entire ethnic groups. The same seems to have been true for Sri Lanka and we have seen below that in eastern Africa, Sonjo society as a whole was an irrigation society. There is an important functional difference between a pilot project or an isolated installation, and a widely replicated system whose rules and technology have a chance to become part of the life of a regional population.

DISCUSSION AND SUGGESTIONS FOR FURTHER RESEARCH

If investigation were to bear out the hypothesis that efficiency of local management of tank irrigation depends on the three conditions above when economic and physical factors are held constant, this would strongly affect our view of localized irrigation systems. In particular, a pre-occupation with control rather than with participation would be avoided, and analysis of the organization of localized systems such as tanks would be separated from analysis of regionally integrated systems such as one finds with canals.⁷ A prevailing tendency in anthropological analysis (Hunt and Hunt 1976, e.g.) to emphasize correlations of irrigation with the development of authoritarian patterns in society might be modified. One would be allied with Fernea (1976) therefore, who cautions against the uncritical acceptance of such an emphasis. There is historical support from studies of South India for the view that participation is a key to the success of localized irrigation. Ludden (1978a,b) describes how, in the southern Tamil country during the Pandyan period, kings and chiefs were important figures for the foundation and preservation of tanks, validating their authority and their rights to taxes by investing in tank building and repair. Ludden's reports suggest, however, that these same tanks were managed on a year-to-year and day-to-day basis by rules which were adhered to by village groups of landholders, and that most if not all landholders of such villages were involved. While outside support may be needed, particularly at points when heavy investment is necessary, it seems that such outside support need not be particularly active and need not be too closely involved in management if widespread participation in use of the local system by the local population is achieved.

In India, where a very widespread pattern of agricultural organization has been based on a roughly interethnic (that is, intercaste) stratification, it is easy to be led to too great an emphasis on authoritarianism in one's analysis. Thus, only dominant caste members would have counted

7. The work of Wade and Chambers (1980) suggests that in regionally integrated canal systems the extra-local, canal bureaucracy is in effect a key part of the technology. In its regionally integrated nature, much canal irrigation differs radically in social organizational nature from the systems we have considered here, despite the fact that there is evidence (Wade 1979) which suggests that for canals, as well, participation in irrigation by large portions of local communities can help to improve the operation of the system.

for very much politically in the past, as they would have been the only ones permitted to own land. Lower caste groups and craftsmen would have been dependent, their interests effectively merged with the interests of their employers' and patrons' families. If the analysis in this paper is correct, however, it seems likely that tanks in the old days in India would not have been well managed unless all of the households or household groups of the dominant caste or castes in a given village had tank irrigated land. In this case, seen as a local group in themselves, the dominant caste households in a village would functionally have paralleled the El Shabana, who ran their traditional system on principles of inclusion and egalitarianism.

Again with special reference to India, the hypothesis that a high degree of local participation is necessary for local management to be successful would help to explain post-independence deterioration in management, such as von Oppen and Subba Rao (1980) noted for Andhra Pradesh. Following 1947, the formerly untouchable, or laboring, castes were emancipated. Although their members' condition is still very poor in many areas they nevertheless can and now often do hold land, and they form a voting bloc of importance in many local and regional as well as national elections. They probably do not, however, participate on an effectively equal basis with the members of the formerly land-controlling castes, when it comes to relative proportion of tank-irrigated land. Even if there is little extra-village employment and even if the poor remain as wet-land tenants of the former land-controlling groups, they are no longer politically subordinate; they may well have more interest in their own economic and political networks and the small amount of dry land they do own, than in the productivity of wet land which they may cultivate on unfavorable terms, and do not own.

If supported by further research, the conditions which are suggested here as appropriate for effective, locally managed tank irrigation would be useful in designing institutional structures for the introduction of tank irrigation into new areas, such as Africa. They could be useful as well in organizing the renovation of tank irrigation in those parts of India and Sri Lanka where it has declined in efficiency and where village participation in its improvement and management is desired. They could be applied to the introduction of tanks for irrigation in regions such as the semi-arid areas of Thailand, where under earlier conditions of less population pressure tanks were used primarily for domestic water supply.

If one were to test the conditions proposed here on the basis of Indian data, two sorts of analysis (among others) could be carried out. The broad outlines of such investigations might be as follows. In the first type of investigation, utilizing an agreed upon criterion of efficiency, such as per hectare production per unit of water stored, interviews in a sample of villages in a specified tank irrigation region could indicate the proportion of agricultural households owning tank

irrigated land; these proportions could then be compared with the indicated physical efficiency of particular tanks or tank systems. It would be important to find analytic means to separate the effects of such factors as variation in market demand from organizational factors.

If the suggested criteria are valid, they should hold true whatever the particular technical details: whether, for example, a tank is used for rice or for supplementary irrigation of dryland crops. Thus analyses should be carried out in different regions, where tanks are used in different ways.

The second type of investigation would be historical in focus. Preferably these studies would be for the same sample of villages, in the same regions where present-day interviews would be made. Where available, land revenue settlement records and maps from earlier years, along with census and similar records, could form a basis for historical investigations. A key goal would be to define and to measure the degree of participation of dominant caste members in irrigation. In areas where both rainfall records and revenue records are available and cover the same areas, one might also be able to obtain an estimate of tank efficiency. To the degree possible, such an investigation should also be crosscultural, and should include investigations in regions of South and Southeast Asia where tank irrigation has been important in the past and is still regularly practiced.

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Appendix Table I. Social organizational comparison of the cases.

Society	Cultural and geographical area	Level of indigenous cultural integration	Wider political context
Sonjo	Bantu-speaking, sedentary farmers of East Africa (northern Tanzania)	Village within its endogamous/ethnic region of like villages	Possible earlier regional chiefdoms, followed by colonial control, and independence in 1961
El Shabana	Sedentary/nomadic, Arab Middle East (southern Iraq)	Consensus-based chiefdom/confederacy of local residential groups claiming common, patrilineal descent	Successively: feudal empire; colonial empire; independent state from 1932
Pul Eliya	Indo-Dravidian South Asia (Dry Zone of north central Sri Lanka)	Village population of single endogamous group, within region of like villages, within regional, feudal kingdom	Successively: feudal kingdom; colonial empire; independent state from 1948

Appendix Table II. Local irrigation in the three case societies.

Society	Persons using water	Gradation and bases of rights	Reallotment of primary rights	Managing Authority	Sanctioning Authority
Sonjo	All village households	Primary and secondary rights heritable; tertiary and quaternary rights by purchase; ethnic Sonjo	Inheritance and purchase, within village	Individuals; village elder males	Kin- and age-based authority principles; religion
El Shabana	All households in the same agricultural settlement area	Equal water rights per ha to landholding members of chieftaincy group; tenants dependent	Inheritance and force of arms within and across settlement areas	Individuals; group of all local adult males of chieftaincy group from time to time	Chieftaincy <u>shaykh</u> ; ideals of brotherhood and equality within chieftaincy group
Pul Eliya	Most village households	Equal rights per ha to landholding descendants and later buyers; tenants dependent; ideal limitation of ownership to endogamous group	Inheritance or purchase; subletting system reallots to local persons the use of plots purchased by outsiders	Individuals; appointed water controller; village adult consensus, informally and at whole village meetings	Government rules; solidarity and internal pressure for equality within endogamous group