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lar-sectioned tangs and medial stiffeners. The medial rib is often finished to a point (fig. 8; see Vogel n.d.).

A tang probably from a hoe is reported from the 5th-century village near Lusaka (Phillipson 1968:101); otherwise there is no record of hoe blades as early as these.

The Hydraulic Hypothesis: A Reappraisal¹

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The literature on the hydraulic hypothesis of Wittfogel (1955, 1956, 1957) and Steward (1949, 1955*a*, *b*) displays considerable misunderstanding as to the variables involved. This misunderstanding has led to a premature rejection of the hypothesis by some authors. When the relevant causal factors are delineated, many of the criticisms miss their mark. This is not to say that the hypothesis is correct, but that the criticisms of it have been misdirected. Further research will be needed to verify or disprove the hypothesis, but this research must be predicated on a clear understanding of what is important.

Steward and Wittfogel have posited that large-scale irrigation requires centralized coordination and direction of effort, which, in turn, leads to greater political integration. Thus, they have proposed that irrigation is a major "cause" of the emergence of centralized political authority and supracommunity political organizations and, as such, a major "cause" of the development of early states and civilizations. Steward (1949) proposed that the "irrigation civilizations" (Egypt, Mesopotamia, China, Mesoamerica, and the Central Andes) had common basic cultural features and developmental sequences because their adaptation to an arid or semiarid environment required large-scale irrigation.²

¹I am indebted to John Gillin, Keith Otterbein, Thomas Schorr, and Arthur Tuden for their criticisms of earlier drafts of this paper.

²Since 1949, Steward has revised his hypothesis in response to a number of criticisms, some of which will be discussed below. The major thrust of the revisions has been to deemphasize irrigation and add other causal factors. The first modification (Steward 1955*b*:61, 63-64) was to attribute the emergence of Mesoamerican civilization to the centralized control of specialized production and trade, rather than to irrigation. Later, primarily in response to Adams's (1966) criticism, Steward (1968:323) concluded that "irrigation was definitely an unimportant factor in [the

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Wittfogel has emphasized the thesis that large-scale irrigation results in authoritative political patterns (Wittfogel and Goldfrank 1943:20). He posits that in the "hydraulic state" (Wittfogel 1957:239) one finds such authoritative political patterns as an "agromanagerial despotism" (pp. 49-50) and a "monopoly bureaucracy" (pp. 45-46).

The essence of the Wittfogel-Steward argument focuses on the nature of the tasks in large-scale irrigation. Watercourses must be dammed, canals must be dug and periodically cleaned, and the water, since it is a scarce commodity, must be apportioned; cooperative activity of several communities is required, since they will be linked by the same network of ditches and canals. These tasks require certain organizational changes (Wittfogel 1957:18):

If irrigation farming depends on the effective handling of a major supply of water, the distinctive quality of water—its tendency to gather in bulk—becomes institutionally decisive. A large quantity of water can be channeled and kept within bounds only by the use of mass labor; and this mass labor must be coordinated, disciplined, and led. Thus a number of farmers eager to conquer arid lowlands and plains are forced to invoke the organizational devices which—on the basis of a premachine technology—offer the one chance of success: they must work in cooperation with their fellows and subordinate themselves to a directing authority.

Archaeological research has generated both support and negative criticism of the hypothesis. Some of the criticism relates to questions of fact—whether irrigation was present in ancient civilizations and associated with the political system or not. Many of the arguments, however, involve imprecise language and a misstatement of the problem.

development of early state civilizations in Mesopotamia and Mesoamerica] . . . , although its role may have been greater elsewhere." Recently, Steward (1970:200, 212-16, 220) has seen irrigation as only one of a number of possible causative agents.

Some archaeologists criticize the notion that centralized political power in the early states centered around control of irrigation activities. Adams (1960, 1969), for example, has argued that in Mesopotamia and Mesoamerica the centralized state developed prior to large-scale irrigation activities. Indeed, he argues (1960:280) that "the introduction of great irrigation networks [in Mesopotamia] was more a 'consequence' than a 'cause' of the appearance of dynastic state organization—however much the requirements of large-scale irrigation subsequently may have influenced the development of bureaucratic elites charged with administering them." Other scholars have reached similar conclusions for Mesopotamia (Hole 1966) and Mesoamerica (Steward 1955*a*, Wolf and Palerm 1955). For Peru, Rowe (1963:20) has found that in Ica "large cities appear first and major irrigation canals were only built later. It would be difficult to argue that there was any relationship between irrigation and the development of cities in the area, unless it was that the growth of cities produced a pressure on the land which was met by irrigation projects on an unprecedented scale." Mason (1968:39) and Lanning (1967:181-82) also argue that centralized government preceded extensive irrigation systems. Thus, Lanning concludes (p. 181) that "we cannot, therefore, say that irrigation led to the centralization of authority but rather that, once authority was centralized, it became possible to build and maintain irrigation systems. Irrigation was thus a product of civilization, not a cause of it."

Other archaeologists have reached very different conclusions, particularly for Mesoamerica. MacNeish (1967:326), for example, states that "we must now examine Mesoamerican cultural developments, particularly the rise of cities, in a new light, for we have indisputable evidence that irrigation played a major role in the rise of Mesoamerican civilization." Sanders and Price (1968:125, 149-50, 178-88) and Sanders and Marino (1970:104-5)

argue that hydraulic agriculture was a major factor in the evolution of states in Mesoamerica and the Central Andes. Indeed, Sanders and Price (1968:183–86) use Adams's own data, as well as that of others, to argue that irrigation was important in the development of Mesopotamian society as well. And, although the evidence is still inconclusive, MacNeish (1969:44–45) seems to have found early indications of a water-control system in the Ayacucho basin of Peru.

Archaeologists and others have reached very different conclusions, even when interpreting the very same data, at least in part because of ambiguities in the way the causal problem is stated. There are two interrelated ways in which the problem has been misunderstood. The first is the assumption that large-scale irrigation must be found prior to centralized states. The second is the assumption that irrigation requires centralized coordination.

A number of scholars (e.g., Carneiro 1970; Adams 1960, 1966:67–69) have assumed that large-scale irrigation must be found prior to the centralized state in order for the irrigation hypothesis to be verified; the finding of small-scale irrigation preceding the centralized state and large-scale irrigation only later is considered negative evidence. This assumption raises a false issue. According to the hypothesis, one would expect irrigation and political control to develop together, interacting with each other in a synergistic fashion, somewhat as automobiles and paved highways developed in the United States (Braidwood 1967:141–42). The causal issue is stated very well by Murphy (1967:29):

When pursuing historical causality, we often end by chasing our own tails. Does the political requirement of irrigation beget the state, or is a state a necessary precondition for irrigation? Actually, it probably works both ways. The irrigation hypothesis never required us to believe that communities undertook projects beyond their political means and then caught up institutionally to their accomplishments. Of course large-scale irrigation works were built by large-scale polities, but both had antecedents in small communities and small irrigation projects. It would be surprising indeed if significant temporal priorities were to be found, for the two variables probably emerged together. Perhaps our real problem is a mechanistic model of causality that leads us to seek for the cause at a point in time distinctly before the effect.

Second, it is often assumed that large-scale irrigation *requires* some sort of centralized coordination or direction. Steward, for example, states that "political controls *become necessary* to manage irrigation and other commu-

nal projects (1949a:22, italics mine) and that "when several villages cooperated in the construction of irrigation canals, supra-village authority patterns *became necessary*" (1955a:2, italics mine). He suggests (1955b:71) "the very general and provisional hypothesis that informal intercommunity cooperation is feasible in systems having only small dams and a few miles of canals, but that expansion of these systems increases the need for a labor force and augments the 'managerial density' until *corvée* labor supplants volunteer workers and a permanent, state-appointed bureaucracy supersedes temporary supervisors." Wittfogel argues that "a large quantity of water can be channeled and kept within bounds only by the use of mass labor; and this mass labor *must be* coordinated, disciplined, and led" (1957:18, italics mine): again, "To have many persons cooperate periodically and effectively, there *had to be* planning, record-keeping, communication, and supervision. There *had to be* organization in depth. And above the tribal level this involved permanent offices and officials to man them—bureaucrats" (1956:156, italics mine). Goldfrank (1952:75, italics mine) writes that "large-scale water control, which *demand*s co-operative effort, *requires* a directing center outside the family and usually outside the local community."

This assumption has been criticized by Beals (1955:54) as perhaps "culture-bound." Millon (1962:56), in a comparative study of seven "relatively small-scale" irrigation systems, has demonstrated that "there is no clear relationship between degree of centralization of authority and the size of the irrigation system or the number of persons it supports." The same might be said of large-scale irrigation systems. Steward (1955b:71–72), for example, cites the Hohokam as a society which would require some central managerial authority, since "a single irrigation system might comprise several hundred miles of large canals serving many widely separated communities." No central managerial authority, however, has been substantiated by archaeological investigation. There is no evidence of a ruling class (Haury 1962:128; Woodbury 1961:556). The canals were probably not built by a central coordinating authority. Informants state that between 1860 and 1880 "canals were built on the initiative of individuals, men of prominence but not necessarily village headmen, who could secure the necessary cooperation of others" (Woodbury 1961:556–57).

The assumption that irrigation requires centralized direction has created

some confusion in the literature. If a large-scale irrigation system is found without centralized control, it is taken to be negative evidence with respect to the hydraulic hypothesis. This is the crux of Millon's comparative study, and it is this conception of the problem which underlies Leach's (1959) criticism. Leach argues that Wittfogel's thesis is not supported by the data on ancient Ceylon—that although there were large irrigation works, there is no evidence that such irrigation works produced the hydraulic bureaucracy required by Wittfogel's thesis. Leach suggests (p. 23) that we cannot infer from large-scale irrigation works "the existence of a large labour force under central government control; nor can we make inferences about the size of the population that was fed by the irrigation system. Still less can we make inferences about the nature of political authority in the ancient state." Although the irrigation works represent a colossal investment of labor, "their construction was haphazard and discontinuous and spread over many centuries." Moreover, the whole irrigation system was probably never intact at any one time.

Leach's point here is well taken. Large-scale irrigation does not always require or produce centralized direction or coordination of effort. It is mistaken to view irrigation by itself as the independent variable. Any society may or may not direct its irrigation activities centrally; such direction is not necessary. In fact, a society may view cooperation on irrigation activities as disadvantageous. For example, among the Swat Pathans, cooperative activity on irrigation works "is inevitably difficult to arrange, since land owners profit to different extents from any one irrigation channel, so that new works affect the balance of power between established factions. As a result even necessary repairs may be neglected, and land fall into disuse . . . because of political complications" (Barth 1959:117).

These criticisms of the hypothesis can be obviated by reformulating it: it is not irrigation itself, but the centralized coordination of irrigation activities that has important social consequences. It is the synergistic action of irrigation and its centralized coordination that results in greater political integration. The development of such centralized direction gives the political system a vital economic sanction (Childe 1954:70): individuals can be denied access to irrigation water. Moreover, centralized direction permits expansion of irrigation activity, which in turn results in expansion of political activity. Thus, a feedback situ-

ation develops. Ecological and cultural factors set the limits to such a development. For example, although the Owens Valley Paiute had centralized direction of irrigation (Steward 1933:247), authoritative political leadership did not develop. Since these people were hunters and gatherers, irrigation could be useful to a limited extent only.

In sum, Steward and Wittfogel have isolated important social consequences not of large-scale irrigation itself, but of an irrigation system that is regulated by some central political authority. Their hydraulic hypothesis should be

reformulated to state that if there is centralized direction of irrigation activities in an arid or semiarid environment, then there will be a corresponding increase in centralized political power in other areas of social life. The extent of political power will vary directly with the extent of the irrigation system and its importance to the total economy.

It would be of interest to isolate the factors that predispose certain societies to develop centralized direction of hydraulic works. It is also important to consider other possible explanations

for the origins of the state, among them centralized coordination of trade or other vital economic activities, as well as dense populations, circumscribed agricultural lands, and warfare (Carneiro 1970). Indeed, irrigation may have been important in some areas of the world and still other factors important in other areas of the world. It is neither necessary nor fruitful to look for a unitary explanation. However, the irrigation hypothesis should not be discarded on the basis of the criticisms that so far have been directed against it.

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