

RESEARCH IN
ECONOMIC
ANTHROPOLOGY

ECONOMIC ASPECTS OF WATER MANAGEMENT
IN THE PREHISPANIC NEW WORLD

Editors: VERNON L. SCARBOROUGH
University of Cincinnati

BARRY L. ISAAC
University of Cincinnati

SUPPLEMENT 7 • 1993



JAI PRESS INC.

Greenwich, Connecticut

London, England

THE SOCIAL ORGANIZATION OF
PREHISPANIC RAISED FIELD
AGRICULTURE IN THE LAKE
TITICACA BASIN

Clark L. Erickson

INTRODUCTION

When flying or walking over the vast plains (*pampas*) of the high Andean plateau (*altiplano*) of the northern Lake Titicaca basin, one is impressed by the immensity of landscape modification undertaken by pre-Columbian farmers.¹ Hundreds of thousands of raised field platforms that extend in every direction are a stunning testimony, even in their eroded state, to Andean institutions for the sociopolitical organization of labor and land (see Figure 1). The highly structured patterning of the landscape reflects an explicit concern with order, both of land and society. The scope of the sophisticated engineering of water management is truly monumental. It would be easy to interpret these earthworks as the enterprise of a highly centralized state. After extensive

Research in Economic Anthropology, Suppl. 7, pages 369-426.

Copyright © 1993 by JAI Press Inc.

All rights of reproduction in any form reserved.

ISBN: 1-55938-646-0

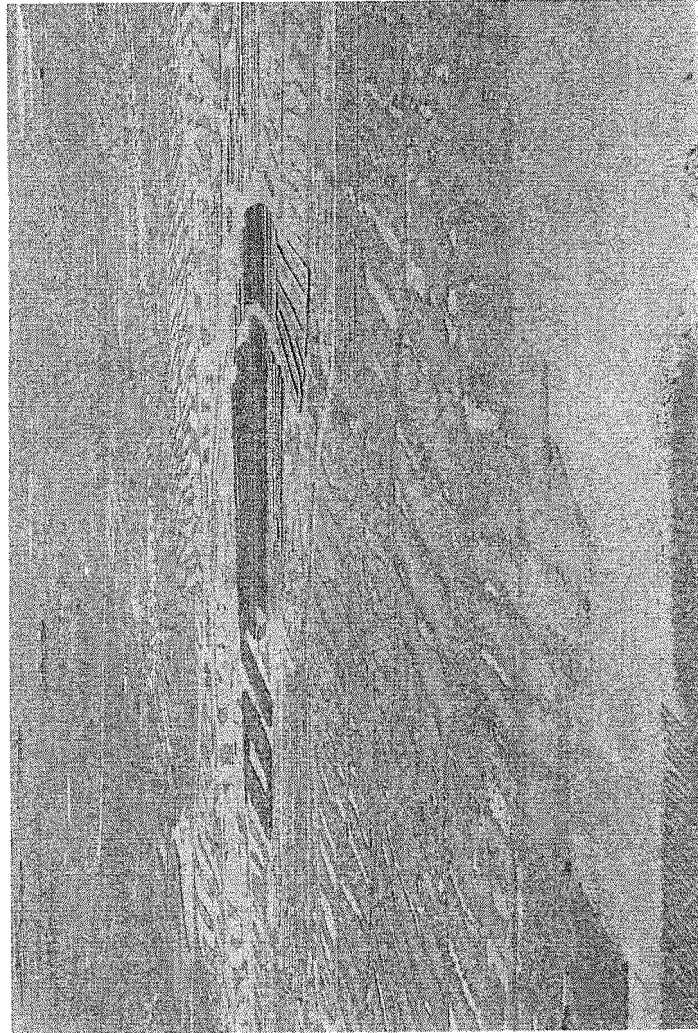


Figure 1. Pampa Landscape near Huatta, Peru, Showing Prehispanic and Rehabilitated Raised Fields (Lighter areas are field platforms; darker areas are canals between fields.)

archaeological survey and excavation of raised fields and associated settlements, and after working with contemporary Andean farmers on rehabilitating the ancient raised fields, I have become convinced otherwise. I argue here that various sources of evidence strongly indicate that raised field farming was organized, at least initially and probably throughout its history, at the local level. These precolumbian agricultural works are the accumulation of the activities of many generations of farmers, producing a totally human-made landscape.

Two major theoretical issues have been continually addressed in studies of the evolution of intensive agricultural systems, but only recently in terms of raised fields. The most conspicuous has been the relationship between social organization and agriculture, in particular, the amount of centralization necessary to carry out intensive agriculture. If raised fields require administration, coordination and planning, and massive amounts of labor, one would expect to find them inevitably associated with centralized bureaucratic government. The other issue involves the causes of agricultural evolution and agricultural intensification. If raised fields were labor intensive, they would not have been adopted unless the farmers were forced to do so by population pressure (according to the Boserup [1965] model) or by state demands for surplus production. These two issues are interrelated, although rarely discussed as such.

Traditionally, archaeologists have closely associated intensive agricultural systems with highly centralized political control. In the case of raised field agriculture, an analogy is often made to large irrigation systems, assumed to be associated with centralization and bureaucracy in the planning and operation of such systems, as argued by Karl Wittfogel (1957) many years ago. To the contrary, I have found that prehispanic raised field agriculture in the Lake Titicaca Basin developed early (ca. 1000 B.C.), apparently in the absence of population stress and state organization. I argue that, even during the various periods when state polities were present in the zone, raised fields were built and managed by local communities. Ethnographic analogy, experimental archaeology, ground survey, aerial photographic interpretation, and excavation provide evidence that raised field technology was well within the means of small-scale organizations.

A useful classification for the analysis of social organization associated with water management has been presented by Scarborough (1991:120), based on Chambers (1980). He contrasts the "top down view" with the "bottom up view." The top down view is in many ways similar to the elite-focused perspective taken by Wittfogel (1957) regarding irrigation systems. The bottom-up view takes the perspective of the farmer and the community-level institutions which make irrigation systems work. In discussing the case of the Lake Titicaca raised fields, Kolata (1991:100, 112-113) uses the terms, "bottom up perspective" (or "the *ayllu*/local level organization hypothesis") and "top down perspective."²

A similar perspective is used here to contrast archaeological interpretations of the social organization of prehispanic raised field agriculture in the Lake Titicaca Basin. I would also like to show that a synthesis of these opposing approaches is possible.

THE TOP-DOWN APPROACH TO INTENSIVE AGRICULTURE

The Wittfogel Hypothesis and Its Critique

The relationship between sociopolitical organization and intensive agriculture has long been an important topic in anthropology, history, and geography. The most important treatment of the subject was Wittfogel's *Oriental Despotism: A Comparative Study of Total Power* (1957; also see Wittfogel 1955, 1972) and the subsequent critical response by scholars from many disciplines. Wittfogel (1955, 1957) argued that large-scale hydraulic agriculture required a high degree of administrative centralization in order to mobilize and coordinate labor for irrigation activities, to plan hydraulic engineering, and to provide capital. Over time, the need for centralized administration gave rise to the stagnant "despotic societies" or "agro-managerial despotism" (adapted from Marx's concept of the Asiatic Mode of Production) found historically in many parts of the world. Wittfogel saw inevitable deterministic links between water management and centralized social systems. In his comparative studies, he argued that centralized despotic societies arising out of a reliance on irrigation agriculture could be documented in the prehistoric record.

Wittfogel's hypothesis had wide ranging implications for comparative studies of the origins of the state and has had a lasting impact on archaeological and ethnological interpretation (e.g., Steward 1955). Ethnographers provided richly detailed studies of the social and technical elements of contemporary irrigation systems (Leach 1959, Fernea 1970, Gray 1963, Geertz 1980, Palerm 1955, 1973; Hunt & Hunt 1974, 1976; Hunt 1988; Mitchell 1973, 1976, 1977, 1991; Guillet 1987, 1992; Gelles 1986, 1990, n.d.a-b; Lewis 1991; Kelly 1983, Spooner 1974, Netting 1974) and archaeologists provided cases with time depth to test the hypothesis (Woodbury 1961, Earle 1978; Hunt & Hunt 1974, 1976; Price 1971, Steward 1955, Sanders & Price 1968, Doolittle 1990, Adams 1966, Butzer 1977, Millon 1962, Wheatley 1971, Downing & Gibson 1974b, Park 1992, Sanders et al. 1979, and others). These studies are generally critical of Wittfogel's deterministic, unilineal model of causality and the necessary relationship between despotic societies and irrigation. Instead, they argue that communities have traditional informal means of dispute resolution and cooperation that permit large-scale irrigation outside of a state apparatus. This position does

not deny that the state can be directly involved in intensive agriculture, but rather claims that there have been some instances in which the state was clearly not involved.

Neo-Wittfogelian Thinking Applied to Prehispanic Raised Fields

Although most scholars focusing on agricultural systems have rejected the causal relationship between hydraulic agriculture and the rise of the state, certain archaeologists and geographers still support the assumption that intensive agriculture, such as raised fields (Kolata 1983, 1986:759, 1987, 1991; Wilkerson 1983:64; Matheny 1978:206-210; Darch 1983:2; Turner 1983:15; Armillas 1971:660; Doolittle 1990:115-135, 149, 154; Moore 1988; Stanish n.d.; Boehm de Lameiras 1988; Palerm 1955:37-39, 1973; Matheny & Garr 1983; Parsons 1991; Brumfiel 1991; Sanders et al. 1979:280-281), terraces (Sanders et al. 1979, Conrad & Demarest 1984), and large irrigation systems (Kus 1980, Matheny 1978:209, Matheny & Garr 1983, Sanders & Price 1968, Ortloff et al. 1982) are, by necessity, associated with centralized forms of sociopolitical organization, if not states. This perspective could be considered typical of the "top-down approach" to prehispanic agriculture.

Many scholars cited above would deny that they are following Wittfogel's claims, agreeing, at least theoretically, that major agricultural landscapes could have been created by non-state organizations. However, except for Kolata (1986, 1991), their use of terms such as "centralization," "centralized direction," "centralized administration," and "centrally organized" in describing raised field agriculture is vague and imprecise (for examples, see Wilkerson 1983:64, Boehm de Lameiras 1988:92; Parsons 1991:22, 34; Brumfiel 1991:44, Moore 1988:274, Armillas 1971:660, Darch 1983:2, Matheny & Garr 1983:99). As a result, the critical question of causality and necessity is avoided, but customary assumptions about intensive agriculture can still be embraced comfortably. In the case of raised field agriculture, many of these scholars accept the assumptions that (1) raised fields are a labor intensive form of agriculture, (2) raised field planning, construction, and maintenance require a certain degree of centralized bureaucratic management, and (3) as a result, farmers would not (and could not) adopt the raised field agricultural system unless forced to and directed by authoritative centralized polities (e.g., states).

Much of the classical debate involving Wittfogel's hydraulic hypothesis revolves around the problem of terminology. What do we mean by "centralization"? Can non-states be "centralized"? Can irrigation and social organization be quantified and compared cross-culturally? Several scholars have attempted to grapple with these issues (Millon 1962, Leach 1959, Kelly 1983, Hunt & Hunt 1974, Hunt 1988, Geertz 1980, Gelles 1990), but it is beyond the scope of this paper to fully address these questions. I recognize that the

various degrees of centralization fall along a continuum, but for the purposes of this paper, I use Gelles's (1990:20) definition of "centralization":

Centralization...generally refers to complex and stratified political systems which are characterized by an administrative machinery, judicial institutions, and specialists. The term serves to differentiate these from evolutionary or structurally (diachronically or synchronically) more 'simple' ones. Centralized systems...are seen as 'growing out of' other simpler systems which are kinship based, examples of which are often found in the nearby vicinity. Evolutionists point to the state and centralization as responses to the need for increasing and higher levels of integration and organization, or more cynically, as an instrument of domination of the ruling class.

Centralization, according to Flannery (1972:417), "represents a 'linearization' of the linkage between the special-purpose arm of a higher-order system (the federal government) and an important variable (water) in a lower-order system (the local village ecosystem); response is now direct, rather than buffered by the village government." Throughout this essay, I refer to centralized political system, centralized bureaucracy, centralized social organization, and the centralized state. These terms are used interchangeably with the concept of the state (see Flannery 1972:403-404).

Intensive agriculture is commonly associated with dense and urban populations, often within state societies (Boserup 1965, Sanders et al. 1979, Denevan & Turner 1985, Parsons 1991, and others). Economic models of preindustrial societies used by archaeologists generally stress the need for nonagricultural urban populations, especially an elite group, to develop efficient means to extract surplus agricultural production from the rural hinterlands (Parsons 1991). Common means of extracting such surpluses are tribute payments, markets, exchange, trade and, more rarely, the direct control of agricultural production.

The common association between intensive agriculture and centralized bureaucracy does not imply a relationship of causality or necessity. Many Mayanists have discussed the intensive nature of raised field farming and its apparently inherent relationship to centralized authority (Pohl 1990a:2, 12 & her concluding chapter; Scarborough 1991, Matheny 1978:206-210, Matheny & Garr 1983:99; several chapters in Harrison & Turner 1978). Present-day Maya farmers are viewed as practicing "devolved" or "extensive" agriculture in the form of slash-and-burn, or swidden, whereas their distant ancestors practiced "evolutionarily advanced" forms of agriculture such as terracing, raised fields, and irrigation (e.g., Harrison & Turner 1978).³ Population pressure and/or complex sociopolitical organization is generally believed to have been responsible for the development of these intensive systems. Early radiocarbon dates on raised field agriculture in the Americas, such as those presented by Puleston (1977b) for Albion Island in Belize, are often dismissed as improbable because of the lack of population pressure and state organization

at those dates (e.g., Pohl 1990b; Turner & Harrison 1978:358-359, 1983:253, 255, 270; and others).⁴ The Maya may have directly controlled the agricultural production of raised fields, as many scholars have argued, but this does *not* mean that earlier raised fields in a non-state context could not have also existed.

Through our raised field agricultural experiments, stratigraphic excavations, radiocarbon and thermoluminescence dating, survey, ethnobotany, soil studies, and aerial photographic interpretation, I likewise hope to demonstrate that small groups of prehispanic farmers constructed and maintained raised fields in the Lake Titicaca Basin. I argue that these independent, experimentally-derived data provide a better "fit" with the ethnographic, historical, and experimental case studies of the sociopolitical organization of raised field agriculture than do the archaeological scenarios mentioned above (excluding Puleston's work [1977a, 1977b]). This position does not deny the possibility that raised fields were on occasion constructed and managed directly by the state, but rather stresses that small-scale farming communities are capable of producing the productive landscapes we see in the archaeological record.

The scale of the irrigation system has always been a key problem in the Wittfogel thesis.⁵ Prehistoric, ethnohistoric, and ethnographic cases of irrigation societies demonstrate the diversity of alternatives of social organizational from simple to complex and the ranges of scale from small to large regional systems (see Spooner 1974, Hunt & Hunt 1974, Hunt 1988, Price 1971, Scarborough 1991). Robert Hunt's (1988) detailed comparative study of irrigation agriculture and social organization concluded that many large irrigation systems (ranging from 700 to 458,000 ha) operate without any centralized authority. The implications of this scale problem have been generally neglected by archaeologists. Only a small minority of the archaeologists and geographers who have done research on raised fields have urged caution with regard to the assumption that raised field agriculture must be associated with large-scale, centralized organization (see Bronson 1978, Harris 1978:310-318, Siemans 1983:50; also see Turner & Harrison 1978:361-368, Denevan 1970:653, and Denevan 1982:186).

Local communities have developed complex means for managing large regional irrigation systems that do not always rely on the development of hierarchical and centralizing institutions (for the Andean region, see Mitchell 1973, 1976, 1977; Guillet 1987, 1992; Treacy 1989a-b; Gelles 1986, 1990; n.d.a-c; Seligmann & Bunker 1986; and Sherbondy 1982, 1987, 1992; for Mesoamerica, see Hunt 1988, Hunt & Hunt 1974, Doolittle 1984, 1990). The local institutions developed for insuring the smooth functioning of hydraulic agriculture could be considered a form of "heterarchy," or complex sociopolitical institutions which rely on nonhierarchical, horizontal, cross-cutting infrastructure (Crumley 1987). This is a powerful, alternative way of viewing the concept of social complexity, while many traditional classifications deny complexity to societies or groups that are not centralized and/or

hierarchical. These alternative, heterarchical principles can be seen in Andean communities where ritual-symbolic traditions of water, earth and mountain worship, reciprocal labor exchange, rotating offices of water mayors, the *ayllu*, and dual organization provide the basis for water management (e.g., Gelles 1986, 1990; n.d.a-c; Zuidema 1986; Sherbondy 1982, 1987, 1992; Guillet 1992; and others; for Bali, see Lansing 1987, 1991, and Geertz 1980). Present-day raised field management in highland New Guinea (discussed below) also provides a good example of the noncentralized community form of organization.

Top-down bureaucratic meddling in local community-based farming systems may actually be a detrimental and inefficient strategy (Treacy 1989a, Montmollin 1987, Netting 1990, Leaf 1992, Lansing 1991, Guillet 1992; Gelles 1990, n.d.a-b; Lees 1986). As Leaf (1992:116) notes, "Social scientists with practical involvements in irrigation management uniformly reject the idea that authoritarian control is natural or inevitable—or even workable." The nearly complete failure of the "Green Revolution" in the Andean region during the 1960s/70s is a prime example of the problems of a highly technical, top-down approach. In the case of raised field rehabilitation in the Lake Titicaca Basin, top-down approaches have been less successful than more grassroots approaches (Erickson & Brinkmeier n.d., Erickson & Candler 1989).

One could question whether the prehispanic elite of the Americas would be interested in local-level decisions regarding mundane agricultural production. Montmollin (1987) has provided an interesting critique of the "managerialist thesis" in archaeological interpretation. He considers these perspectives to be based in an "etic," rational, maximizing, adaptationist interpretation (one which equates better managed with better adapted for long-term survival). In his "emic" approach to management by the prehispanic Mesoamerican elites, Montmollin notes that (1) the day-to-day production is managed at lower social levels, (2) the Mesoamerican elite were not professional bureaucrats, and (3) the concern for political resources, not economic rulership, was most prominent. According to Montmollin (1987:56), rulers were more interested in "being custodians of relations between polity and cosmos, cosmic balance" and "interactions between and within polities, heirs, successionship, usurpation, rotation, dynastic politics." One could argue that this emic approach could be extrapolated to the prehistoric elite of most of nuclear America. This would not be to claim that elites were never concerned about tribute flow, intensification of agriculture, and the co-opting of labor which sustained their position and the state, but rather that they were often disassociated from the tedious and routine management of local production. At the very least, Montmollin's argument requires a re-examination of the nature of centralized control.

Several studies support a model of local, not state, control of Andean agriculture. A major goal of Inka elite expansionist policy was to extend

irrigation and terracing for the generation of state surplus (Conrad & Demarest 1984:129-130). Despite the overt interest of the Inka elite in irrigated terracing, local systems appear to have been managed by local community groups. Even within the Inka capital of Cuzco, terraces were constructed and managed by local *ayllus*, not the state (Zuidema 1986, Sherbondy 1982, 1987, 1992). Nor does the ethnographic record for terrace water management in the South Central Andes support a model of direct control by the Inka state (Treacy 1989b, Guillet 1987, 1992). On the North Coast, the large, intervalley La Cumbre canal constructed during the Late Intermediate Period has been attributed to the Chimu state (Kus 1980, Ortloff et al. 1982). However, Netherly (1984) has demonstrated that the regional irrigation networks of the north coast of Peru were locally managed systems and that the intervalley canal was probably a rare case of state intervention in local agriculture. The state's role in irrigation was probably limited to providing the capital and *mit'a* labor for rebuilding canal networks after natural disasters such as El Niño flooding (Moseley et al. 1981, Netherly 1984).

Gelles (1990, n.d.a-b; also see Treacy 1989a-b, Guillet 1992) has discussed the dialectic between state and local organization of irrigation water in the community of Cabanaconde in the Colca Valley of Peru. The local system is based on the Andean dual organization model—the division of the community into "upper" and "lower" halves—and sacred water, mountain, and earth worship. It combines complex ritual and social mechanisms that have traditionally controlled the hydraulic resources. The local model, of which dual organization is a fundamental component, provides a form of cultural resistance to the secularization of water management and other modern state interferences and is intimately tied to ethnic identity. In contrast, the recently introduced Peruvian state system uses appointed managers as "water controllers" and stresses civic duty and the "rational," sequential distribution of water. The intrusion of the state system into the traditional local system has had a disorganizing effect on the distribution of water and tends to favor local elites, resulting in rising tensions and local resistance.⁶ These studies show that the relationship between state and local systems can be complex, and the issue of control cannot be assumed to have a simple answer. For example, it cannot be assumed that Tiwanaku elites managed the raised fields in the southern Lake Titicaca Basin.

THE BOTTOM-UP APPROACH TO INTENSIVE AGRICULTURE

In response to the influential theory proposed by Wittfogel (1957) and Steward (1955) regarding the relationship between bureaucratic central organization (in particular, the despotic state) and intensive agriculture, anthropologists

produced a wide range of ethnographic case studies of irrigation societies of different scales (e.g., Fernea 1970, Millon 1962, Woodbury 1961, Leach 1959, Mitchell 1976, Hunt & Hunt 1976, Gray 1963, Price 1971, Downing & Gibson 1974b, and others). The general consensus of these studies is that some level of coordination is necessary for the proper functioning of irrigation societies, but that the locally-based sociopolitical organization available to farmers in "traditional" peasant societies is sufficient for planning, construction, maintenance, distribution of water resource, and resolution of conflicts over water and land.

Stephen Lansing's *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali* (1991) provides an excellent example of how sophisticated farming systems involving a network of tens of thousands of hectares of irrigated terraced rice padi fields can be constructed, managed, and maintained independently of state control or interference, although they operate within the bounds of a modern state society. In Bali, kin-based cooperative groups of farmers are bound with other groups over wide areas through a hierarchical system of "water temples," where necessary complex scheduling, decision making, and cooperation is accomplished in a ritual context. Lansing demonstrates that tightly ordered, technologically sophisticated "engineered agricultural landscapes" of regional proportions can be efficiently managed by local groups and local ceremonial centers. Although the irrigation system exists within the boundaries of a modern state, the farming activities are under local control. In the words of Valeri (1991:136), "this *centered* (rather than *centralized*) system of coordination is independent of the state and, in fact, somewhat in conflict with it."

Ethnographic and contemporary raised field practices in New Guinea and Irian Jaya of Indonesia provide another possible analogy for examining the social organization of agriculture (see Heider 1970 for the Dani, Pospisil 1963 for the Kapauku, Serpenti 1965 for the Kiman, and Golson 1977 and Gorecki 1982 for the Kuk). Very dense populations are supported by a combination of raised field and swidden agriculture. Raised field systems, including some very large regional complexes, exhibit an impressive organization of raised field platforms and canals, field boundaries, fence lines, and drainage canals. These agricultural earthworks appear similar to those of the Lake Titicaca basin in terms of structural complexity and integration. Despite the high degree of landscape order, many of the basins where raised fields are used today have been farmed only for a short time (a relatively recent reintroduction of raised fields). Although a wide range of sociopolitical organization is found within these societies, the raised field farming is a noncentralized, nonhierarchical, and relatively "egalitarian" kin-based activity.

Ethnographic analogy and cross-cultural comparison must be used cautiously. New Guinea raised field agriculture is practiced in a different environmental and cultural context from that of the Lake Titicaca Basin and

should not be taken as a model of the Andean case. However, at a very general level, the New Guinea analogy demonstrates that sophisticated raised field farming sustaining large populations can be organized within family and localized sociopolitical units. The raised fields of New Guinea do not provide any evidence that Andean fields were associated with one type of sociopolitical organization or another. They do, however, prove that it is possible to practice raised field agriculture within a noncentralized organization, and this possibility must not be automatically discounted for the Andean case.

RAISED FIELD AGRICULTURE

Raised field agriculture is a remarkably efficient, sustainable, and productive technology. Raised fields are large, elevated platforms constructed to improve agricultural production by removal of soil from adjacent canals. Morphology of fields varies greatly, but the platforms in the Lake Titicaca basin (see Figure 2) tend to be rectangular, 0.2-1.0m tall, 5-10m wide and up to 50m long. Remains of prehispanic raised fields are found throughout the Americas in a wide range of environment and temporal contexts (Parsons & Denevan 1967; Denevan 1970, 1982; Siemans 1989; and others). There is a large literature on prehistoric, ethnographic, and contemporary forms of raised field agriculture in various parts of the Old World (Farrington 1985, Denevan & Turner 1974). The most common context of raised field farming is permanent or seasonal wetlands, in particular, areas near rivers, lakes, poorly drained soils, or permanent swamps and marshes. The widespread distribution of the technology in time and space in both the Old and New Worlds suggests that it was adopted independently in most cases by farmers seeking to exploit wetland ecosystems. A number of archaeological, agronomic, and ethnographic studies have defined the function of raised field farming as improving soil conditions through increasing topsoil depth, providing aeration, mixing and burying organic matter by turning over soils, locally draining waterlogged soils, and ameliorating the effects of adverse agro-climates such as frosts, droughts, and flooding. Canals or ditches adjacent to the field platforms conserve water, act as a heat sink for storage of solar energy, collect and produce organic sediments, and provide a habitat for economically important species of plants and animals and possible aquaculture. Periodic "mucking," or removal of organic sediments collected and/or produced in the canals for placement on the cropping platforms, provides soil renewal and sustainable high production (Denevan & Turner 1974; Denevan 1970, 1982; Erickson 1985, 1988a-b, 1992a; Garaycochea 1986a-b, 1987; Kolata 1991; Kolata & Ortloff 1989; and others).

Even as eroded archaeological remains, a raised field system spread out over the Andean landscape is an impressive sight. The orderliness of the patterning,

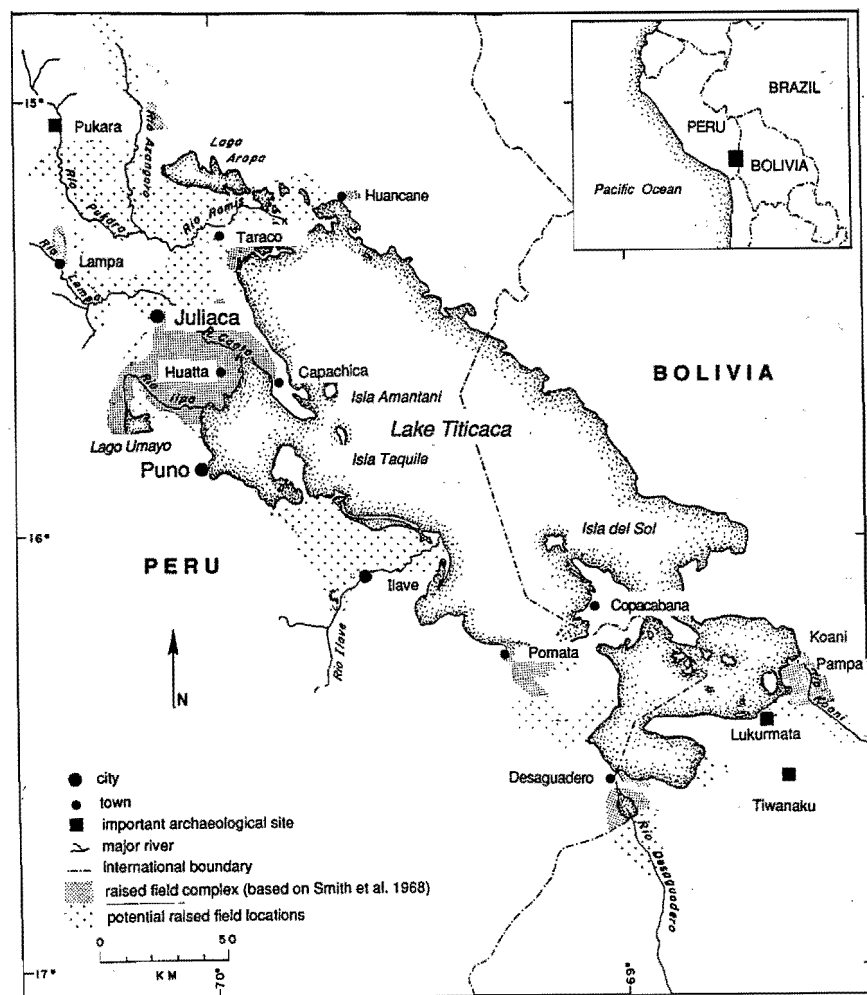


Figure 2. Location Map of Prehispanic Raised Field Systems, Major Archaeological Sites, and Modern Population Centers in the Lake Titicaca Basin

usually a highly structured, rectilinear grid of blocks or bundles of raised fields, is stunning. This vast anthropogenic landscape seems to have been associated with centralized bureaucratic states simply because of its massive scale and structural integration. When viewed with the commonly unspoken, unanalyzed Wittfogelian assumptions, it seems that these structured and orderly remains could not have been constructed by the local social organization of Andean farmers.⁷ I argue here that this reasoning is based on unsound assumptions. These landscapes represent the results of thousands of years of evolving local and regional farming systems and the gradual accumulation of landscape capital or landscape infrastructure by both communities and states.

THE IRRIGATION MODEL AND RAISED FIELD AGRICULTURE

Many researchers have supposed that raised fields are similar or identical to large-scale irrigation systems and have the same or similar requirements (Scarborough 1991, Matheny & Garr 1983, various chapters of Harrison & Turner 1978; Kolata 1986, 1991; Ortloff & Kolata 1989). This "irrigation model" of raised field agriculture has led to confusion about the functions and organization of the system. A strong hydraulic element has been documented for raised field farming (Lennon 1982, 1983; Erickson 1988a, Kolata 1991, Scarborough 1991, Ortloff & Kolata 1989, Denevan & Turner 1974, and others), but the specific needs and goals of raised field farmers are very different from those of farmers relying on irrigation.

Raised field agriculture can be considered a form of hydraulic agriculture. In both irrigation and raised field agriculture, water resources are managed through complex engineering constructions enabling the manipulation and conservation of water. Despite this similarity, raised fields differ from irrigation systems in several important ways. Irrigation systems are commonly found in arid areas, while raised field systems are most common in areas of seasonally high rainfall, waterlogging of soils and standing water, and/or high humidity (e.g., the tropical savannas of Ecuador, Colombia, Venezuela, and Bolivia, the highland basin of Lake Titicaca; and the highland regions of the Valley of Mexico). While water scarcity is a limiting factor in irrigation systems, an *excess* of water is commonly the problem in areas where raised fields are found.⁸ The removal of water from the raised planting surfaces never poses the kinds of problems that the distribution of water, as a scarce resource, presents in irrigation systems. Accordingly, scheduling and equitable distribution of water resources is of minimal importance in raised field agriculture. Irrigation systems require that water be transported and distributed over wide areas of cropland, potentially crossing political, social, and ethnic boundaries in the longer canal systems. Raised fields, on the other hand, do not require the movement of large amounts of water across territorial boundaries.⁹

Although we lack detailed comparative data, raised fields appear to be less labor intensive than irrigation systems in terms of construction and general maintenance (at least in comparisons with Andean terrace irrigation farming; see Treacy 1989a-b, Erickson & Candler 1989, Erickson 1988a). For example, sedimentation of canals is a factor in both systems but, in contrast to irrigation, raised field functioning depends on the capture, removal, and recycling of sediments, which is considered to be a positive feature, not a detrimental drawback. It was probably advantageous to fill the canals with water as soon as possible at the beginning of the rainy season and to conserve the water in them as long as possible into the dry season, in order to extend the cropping period. The transport of water to achieve this goal is part of the hydraulic function of raised fields, but it bears little resemblance to the coordination of regional irrigation systems. Scarborough (1991:113) has referred to the hydraulic management of raised fields as "still water canalization," whereby water is not transported long distances from source to destination in areas with little topographic relief. Hydraulic features also might have included eliminating encroachment of salt water into field canals (Ortloff & Kolata 1989, Erickson 1988a, Palerm 1955), although this has not been adequately demonstrated.

Because of these differences, raised fields do not require the same amount of coordination and cooperation as irrigation systems. I will also argue that the small, modular blocks of raised field systems can function successfully without the coordination of regional systems, in contrast to most medium and large-scale irrigation systems. In other words, one does not have to rely on close coordination with one's neighbors in order to farm raised fields. This point has been clearly demonstrated in our experimental raised fields in Peru, where only small, isolated parts of the total system have been reconstructed, and in the ethnographic record of raised field farming in non-Western societies.

A STATE MODEL OF RAISED FIELD ORGANIZATION IN THE ANDES

Kolata (1983, 1986, 1987, 1989, 1991) has argued that the raised fields of Koani Pampa, the Tiwanaku Valley, and Desaguadero floodplain of Bolivia were "Tiwanaku estates" of the elite. He (1991:120) contends that "Tiwanaku established proprietary agricultural estates in which ownership and usufruct rights were vested directly in state institutions, or perhaps more precisely in the hands of the elite, dominant classes." Kolata (1991:100) believes that "the organization of agricultural production in this core entailed structured, hierarchical interaction between urban and rural settlements, characterized by a substantial degree of political centralization and the mobilization of labor by social principles that reached beyond simple kinship relations." Kolata goes beyond most archaeologists in arguing for the need for centralization and

bureaucracy to do raised field agriculture, and he believes that the state was *directly* involved in the production system. Kolata (1991:119) states that "archaeological instances of capital investments in expanding reclamation of potentially arable land and in altering and controlling the hydraulic regime of the raised field systems *directly implies* the action of a regional political authority" (my emphasis). He (1991:120) believes that "periodic mobilization and coordination of a substantial non-resident labor force demanded a political order with powerful regional authority to alienate land and co-opt labor, and at least a rudimentary bureaucratic system to track the extraction of labor service from subject communities and the subsequent flow of produce from state-operated fields." Although he specifically states that this system of "centralized state action" is not "despotic" in the Wittfogelian sense, Kolata speaks of "mass alienation of land and labor by elite" with "ruthless efficiency" (ibid.: 121), an apparent contradiction. A detailed argument has been presented for this hypothesis (see Kolata 1986, 1991), but the basic, underlying theme is that raised fields and the associated agricultural infrastructure are too complex for common farmers to plan, construct, and manage and, thus, had to be "designed by the agroengineers of Tiwanaku" (1991:101).¹⁰

The argument provided by Kolata (1986:760, 1991:115) to support this thesis is (1) the apparent hierarchical structure of settlements associated with raised field in Koani Pampa, Bolivia, with evidence of elite administrators' and common farmers' residences, (2) the need for a highly organized labor force directed by a technically sophisticated administration to construct and maintain fields and the agricultural hydraulic infrastructure, and (3) the relatively close correlation between the chronology of raised field use/abandonment and the origin/collapse of the Tiwanaku state.

Settlements range from small house mounds of farmers and field guardians to larger, "monumental" platform mounds attributed to elite state administrators. According to Kolata, residential settlements within the raised field area are not numerous enough to account for the labor necessary for construction and maintenance; thus, corvée labor had to be brought in by the Tiwanaku state from the outside. Structures such as "river-by-pass systems" or "river shunts" with artificial earthen levees, aqueducts associated with irrigation and drainage, river canalization and diversion, causeways, and dikes are examples of earthmoving projects believed to have been undertaken by Tiwanaku (Kolata 1991:101, 104; Ortloff & Kolata 1989).¹¹ Kolata and colleagues have argued that these engineering elements are part of a complex agricultural infrastructure constructed by Tiwanaku "agroengineers" (Kolata 1991:101), and that this infrastructure was beyond the capabilities of locally autonomous village level organization (1991:115).¹² The dating of these infrastructural features has been difficult (Kolata 1986, 1991; Ortloff & Kolata 1989), although indirect association with urban settlements suggests to them a Tiwanaku IV and Tiwanaku V construction and use (A.D. 400-1100) (see Figure 3).

Time	Culture	Period/Horizon
1750-		
1500-	<i>Inka</i>	Late Horizon
1250-	<i>Aymara Kingdoms</i>	Late Intermediate Period
1000-	<i>Lupaca</i> <i>Pacajes</i>	
750-	<i>Tiwanaku V</i>	Middle Horizon
500-	<i>Tiwanaku IV</i>	
250-	<i>Tiwanaku III</i>	Early Intermediate Period
AD/BC-	<i>Pukara</i>	
250-		
500-	<i>Chiripa</i>	Early Horizon
750-	<i>Qaluyu</i> <i>Wankarani</i>	
1000-		
1250-		Initial Period
1500-		
1750-		
2000-		Preceramic

Figure 3. Chronology of the Lake Titicaca Region

Improved dikes and artificial levees on rivers to prevent flooding of the pampa lands are still constructed in the northern Lake Titicaca Basin. For instance, community projects have been undertaken for many years to prevent flooding of the Río Coata (see Figure 4) and Río Illpa. Here, huge embankments up to 2.5m tall and 3m wide at the base are constructed of sod cut from the pampa. Some of these massive dikes run for kilometers on both sides of the rivers. Similar in terms of labor investment are the programs to construct raised roads within the pampa, using the same methods as those now used to reconstruct raised fields. These projects are undertaken by small local groups, under their own incentive and without external coordination.

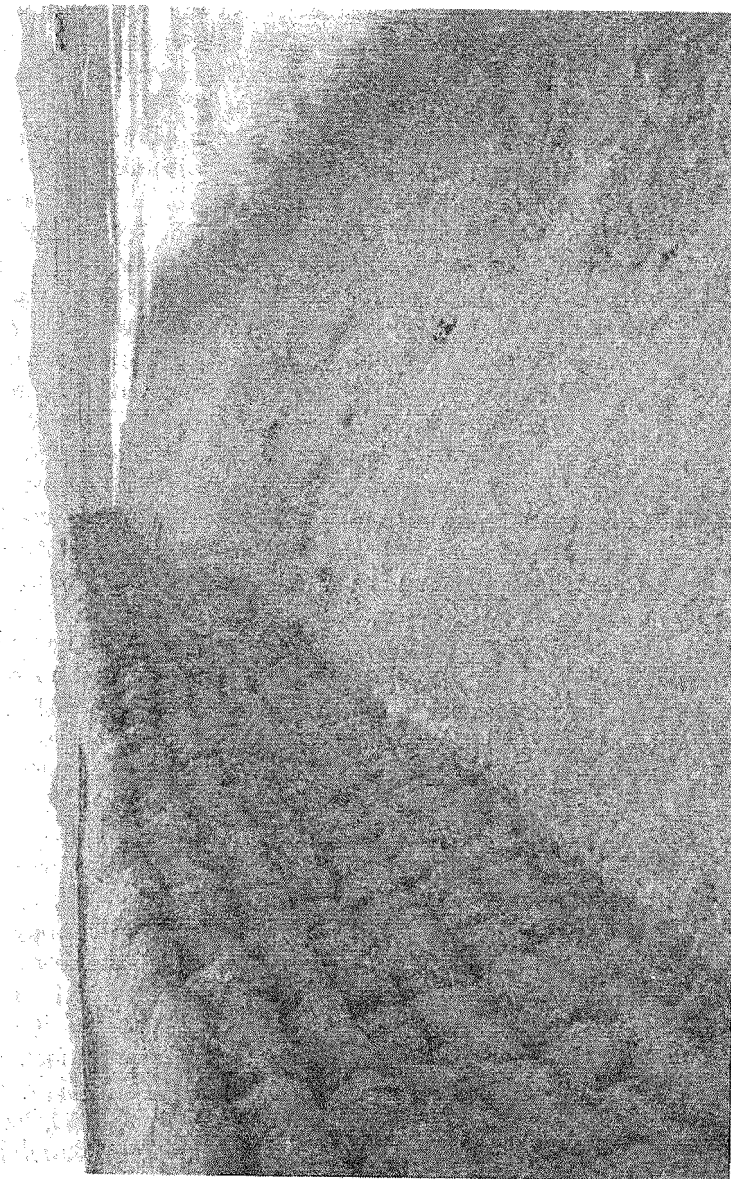


Figure 4. Modern Canalization and Artificial Levees Constructed of Sod Blocks by the Community of Coata, along the Río Coata

Kolata (1991:120) sees a pattern of "state action at a distance" in the settlement distribution, in contrast to what he hypothesizes is the model of local control of raised fields (e.g., key sites at critical infrastructural points in the water control system). As I argue below, local control at the household or *ayllu* level would produce a dispersed pattern of settlement within field systems (identical to what is found in Koani Pampa), and there would be no need for hierarchical "control points" of the raised field water management system.

Some raised fields may have been associated and contemporaneous with the Tiwanaku state, but the total distribution of these fields is unknown. Kolata (1991:124, n. 1) has calculated that Tiwanaku engineers constructed 150 km², or 15,000 ha, of raised fields, based on study of aerial photographs, ground survey, and conjecture. Smith et al.'s (1968) figures are conservative (see Erickson 1988a), but those calculated by Kolata and colleagues for Tiwanaku should be considered with caution. For instance, there are 30 km² of preserved fields in the Middle and Lower Tiwanaku Valley, and another 60-65 km² of fields are projected to account for those that may have been destroyed through erosion (Kolata 1991:124, Albarracín & Mathews 1990:117). Many of these features are more similar to large lazy beds (*wachos*, or narrow sod platforms for potatoes) than to true raised fields (Mathews n.d.a).¹³ In addition, neither the Koani Pampa nor the Desaguadero Valley has been adequately surveyed. These estimates for Tiwanaku raised field distribution remain uncertain until detailed photographic interpretation, excavation, and ground survey are completed.

The areal extent of the fields is not the only problem. The affiliation of the Tiwanaku Valley raised fields to Tiwanaku IV and Tiwanaku V periods is based on the dating of raised fields in Koani Pampa (Kolata 1983, 1986, 1989, 1991; Kolata & Graffam 1989) primarily using field associations with occupation sites (Albarracín & Mathews 1990:117). Recent excavations of raised fields in the Middle Tiwanaku Valley by Mathews (n.d.b) have demonstrated that some fields were constructed and used very late in the Tiwanaku sequence and well into the post-Tiwanaku period. According to the spatial and temporal distribution of rural occupation sites as presented in site survey maps (Mathews n.d.b: Maps 2-7), the raised fields could just as easily be attributed through site association dating to the whole spectrum of prehispanic cultures occupying the immediate area. For instance, fields near the urban center of Tiwanaku could be affiliated with any of the pre-Tiwanaku cultures, the mature Tiwanaku Phases (A.D. 375-1000/1100)¹⁴ or with the post-Tiwanaku presence on the site and vicinity. The only direct contexts for dating raised fields to Tiwanaku were three excavations in fields near Luqurmata within a very small (6.5 ha) block of raised fields where diagnostic sherds were recovered in field fill dating to Tiwanaku IV and Tiwanaku V (A.D. 400-1000/1100) (Kolata & Graffam 1989, Graffam 1990:122-135, 243). Graffam's (1990:133-135) ceramic analysis indicates that the fields were constructed and used between A.D. 400 and A.D.

1100. A corrected radiocarbon date of 1085 ± 90 BP (A.D. 865, ETH 3178) from a hearth stratigraphically above the fields provides a *terminus ante quem* for use (Graffam 1990:135). A radiocarbon date of A.D. 950 ± 100 is given for a "raised field complex," although no archaeological context is described (Ortloff & Kolata 1989:517). Graffam (1990:153) has dated an aqueduct structure associated with a small raised field block near the type site of Chiripa to Tiwanaku III-V through ceramics. An aqueduct at Lukurmata was dated to Tiwanaku IV-V by diagnostic sherds (Ortloff & Kolata 1989). The river channelization structures in Koani Pampa and the river by-pass shunts of the Tiwanaku Valley have not been adequately dated. There is evidence that the canalization may be relatively modern and that it relates to pastoral use of the pampa (Graffam 1990:43, 172). The most serious problem is Kolata's extrapolation of the Tiwanaku IV-V dates from only three excavation trenches in raised fields and a single excavation in an aqueduct structure at a single site (Lukurmata) to an area of 150 km² of raised fields in the assumed "Tiwanaku heartland."

Critical to Kolata's state administration argument is that the field system was abandoned with the collapse of the Tiwanaku bureaucracy (e.g., Kolata 1983:262, 1986:753, 1987:41). Graffam (1989, 1990, 1992) presents archaeological evidence, based on survey and excavation of both occupation sites and fields, that raised field construction and use continued in the Koani Pampa long after the collapse of the Tiwanaku state. He estimates that the majority (68%) of the fields visible on the surface in Koani Pampa were constructed and used in the Late Intermediate Period (A.D. 1000-1476). Mathews' (n.d.b) excavations of raised fields near Tiwanaku also demonstrate post-Tiwanaku construction and use. There is also a possibility that raised fields predate the Tiwanaku state (before A.D. 375). Graffam recovered limited evidence that Chiripa farmers (800-400 B.C.) may have been involved in raised field construction (Graffam 1990:242; also see Kolata 1986, 1991). Stanish (n.d.) has found that fields in Moyopampa, near Juli, were constructed from the early part of the Early Intermediate Period (200 B.C.-A.D. 600) through the Late Intermediate Period. This evidence highlights the problems of dating fields and the extrapolation of this dating over such large areas.

When Koani Pampa is compared to other raised field contexts in the Lake Titicaca Basin, an interesting observation can be made, namely, that the patterning of fields in Koani Pampa appears relatively less structured than that of Huatta pampa or other raised field areas presented in Smith et al. (1968). The predominant form of field, "the combed field" type (Smith et al. 1968, Kolata 1986, Graffam 1990) is analogous to natural levee geomorphological features of abandoned and active rivers within the pampa.¹⁵ These are in striking contrast to the more orderly, structured form of fields in most of the large blocks in the northern Lake Titicaca Basin and the smaller blocks along the western edge of the lake (Smith et al. 1968; Erickson 1985, 1988a; Lennon

1982, 1983). It could be argued, based on patterning, that the raised fields in Koani Pampa are "more primitive," or less structured, having started out as early farming on natural river levees to prevent flooding. Later farmers may have copied the natural form artificially with the construction of raised fields as more land was needed. The combed fields may represent an old pattern, which established the model for rebuilding and reconstruction throughout the farming history of Koani Pampa.

Much of Kolata's original formulation of the idea of Tiwanaku state control of the raised fields relies on the ability to identify "elite" and "commoner" settlements in the archaeological record (Kolata 1986). According to his model, the elite administrative sites should be larger, more centrally located, and have a material culture distinct from that of the smaller, rural farmsteads within Koani Pampa. Kolata (1983:260-261) argues that the elite sites within the raised field blocks are monumental platforms of "enormous proportions" with "large scale corporate construction" (his hierarchical level 3) built of fill by the Tiwanaku state. Ceramic inventories suggest a higher number of "elite" wares on the larger sites than on the small farming sites, but this argument is not very convincing after considering that sites of Kolata's "administrative" category are found by the hundreds in the Huatta plain in Peru. Today, many of these mounds are densely occupied by small hamlets of non-elite farmers and fishermen. In regard to the "elite" ceramics, so little useful work has been done on Tiwanaku ceramics that it is difficult to argue for diagnostics of "elite" versus "commoner" pottery. Fancy Tiwanaku keros, a hallmark of the Tiwanaku urban center and large satellite sites, are also regularly found in small farming settlements in the southern Lake Titicaca Basin. This same problem of identifying state presence within zones of raised fields applies to interpretations made for *chinampa* agriculture under the Aztecs (Parsons 1991, Sanders et al. 1979, Brumfiel 1991, and others).

EVIDENCE FOR A LOCAL MODEL OF RAISED FIELD ORGANIZATION

Do traditional agricultural systems of a large regional scale require state "agro-engineers" and elite managers in order to be planned, constructed, used, and maintained? The immense literature of cross-cultural case studies of water management mentioned above presents a strong case that the answer is "not necessarily." Very few traditional irrigation systems are under state control, even those that exist within modern state boundaries. The same can be said for other forms of intensive agriculture, such as terracing. Then, what about the massive and extensive raised field system constructed before the arrival of the Spanish in the Lake Titicaca Basin of Peru and Bolivia? Were the pre-Tiwanaku and Tiwanaku fields organized and run by the state?

In this section, data on field chronology, field patterning, settlements and settlement survey, experimental archaeology, and abandonment are presented from fieldwork studies undertaken by the Raised Field Agricultural Project between 1981 and 1986 (Erickson 1985, 1987, 1988a-b, 1992a). These data provide indices for addressing issues regarding the social organization of raised field agriculture in the northern Lake Titicaca Basin. In addition, they may have wide-reaching implications for raised fields in other areas of the Andean highlands and elsewhere.

The Dating of Raised Field Agriculture

Raised fields appear to have been established at a relatively early date and have a long history in the northern Lake Titicaca Basin. The direct dating of ceramics recovered from excavations of 11 raised field locations by thermoluminescence (TL) has provided data on the chronology and evolution of raised field agriculture. The TL-based chronology is internally consistent with raised field stratigraphy. Diagnostic ceramics from several contexts within raised fields also provide support. Radiocarbon dates and ceramic dates from excavations in occupation mounds within the raised field blocks provide indirect evidence to support this chronology. Two phases of construction and use have been documented. Phase I is characterized by small wavelength fields,¹⁶ dating to ca. 1000 B.C.-A.D. 300, stratigraphically buried under later large Phase II fields that probably date to the Late Intermediate period (A.D. 1000-1476). Blocks of fields in the northern basin were partially abandoned or "deintensified" during the Tiwanaku Middle Horizon and the Inka Late Horizon (Erickson 1987, 1988a).

It is clear that widespread raised field construction began long before the appearance of the state and continued during the periods of state collapse in the Lake Titicaca Basin. I have argued (Erickson 1987, 1988a) that this farming system evolved out of an early lacustrine and riverine wetland economy based on agriculture, hunting, fishing, and gathering. Because of the high yields to labor ratio and the simple organizational requirements, raised field agriculture would have been an efficient alternative to other agricultural technologies (discussed below). Sometime during the Initial Period (1800-900 B.C.), raised fields were firmly established in the northern lake plains around Huatta and possibly in the southern basin, as well.¹⁷ The system gradually expanded to include over 82,000 ha of fields and became more sophisticated through time.

Field Patterning

The argument is commonly made that, if raised fields (or other forms of intensive agriculture) show patterning, planning, and formal structure, the

construction must have been centrally planned and organized. All prehispanic and modern raised fields found in the Americas and elsewhere demonstrate formal structure, as do most agricultural systems. Since scholars disagree on their subjective evaluations of how to classify the continuous variation between unstructured and structured landscapes, this issue may never be resolved.

Raised fields in the Huatta pampa and elsewhere demonstrate clear structural patterning. This patterning has two very distinct levels. The most basic structure is one of individual bundles or blocks of 5-7 parallel fields (Lennon 1982, 1983; Smith et al. 1968) (see Figures 5 and 6) bounded by canals or encircling embankments (see Figures 7 and 8). In addition, these individual bundle units are prominent because of the alternating directions of field orientation between blocks. This has been called the "checkerboard pattern" (see Figure 5) the most common form of raised fields (Smith et al. 1968).¹⁸ All of the field types in the northern Lake Titicaca basin have a general orientation towards the cardinal directions. The regularity of wavelength within and between field blocks indicates careful planning and suggests that there was a possible prehispanic measurement system for field layout. Nevertheless, our experiments demonstrate that raised fields are simple to plan and lay out using string and stakes.

In their discussion of field form and its potential relationship to social organization, Smith et al. (1968:357-359) interpret the general irregularity of overall field patterning and the lack of major irrigation canals as the work of small groups of cooperating individual farmers. Lennon (1982) disagrees with regard to field patterning, arguing that there is a strong indication that fields were constructed for relatively complex hydraulic functions; in terms of social organization necessary for construction, however, he concedes that these fields could have been built by individual farmers (ibid.:227, 189).

Lennon's (1982) detailed analysis of these individual bundles of raised fields (normally rectangular or square) is very important for my interpretation of the land tenure and social organization of raised field agriculture. He found that the average block size of fields (including canals) sampled in the riverine area was 2,300 m². This figure correlates closely with my calculations of the area of raised fields (2,665 m²) that a single household of 5 could construct and manage in a year, according to our experimental labor figures discussed below (Erickson 1988a). This basic unit could be a prehispanic expression of the basic Andean *topo* measurement used in the Colonial period and in some communities today. The crop production from such a unit would also provide the necessary caloric values to sustain that household for a year (based on potato production). In addition, I found that a family of 5 could easily construct a block this size in a season. This evidence strongly suggests a local organization of field tenure organized among family and local communities.

A second level of organization can be seen in larger divisions of complexes of raised fields into irregular polygons, the most common form being a narrow

pie-shaped wedge. These complexes of fields are bounded by large straight canals (of greater length, depth, and width than the common raised field canals) (see Figure 7). These canals routinely radiate from "centers" (on low hills overlooking the plain, on mounds, and sometimes from no visible topographic feature) (see Figure 9). The arrangement of these canals is strikingly similar to the structure of the *ceques* described by Inka Cuzco, a system of sociopolitical and ceremonial organization (Zuidema 1990, Bauer 1992).¹⁹ I argue that, in the case of raised fields in Huatta, these canals probably reflect *ayllu* divisions or subdivision of the community of raised field farmers. These radial systems are also a key feature of the rotational fallow systems and sectorial farming, described for contemporary Andean farmers (Orlove & Godoy 1986, Guillet 1981), which may have also been used by raised field farmers to organize planting schedules, crop rotation, and land tenure.²⁰ The patterning that occurs in the prehispanic raised fields is that which would be expected in an Andean farming community where parcels of land (in this case, raised fields) are divided according to traditional Andean structures of family and communal land distribution, probably at the level of *ayllu* or *saya*.

These agricultural earthwork structures in the raised field landscape of the Lake Titicaca region exhibit remarkable formal traits of symmetry, modularity, and hierarchy over a wide area. Within the 52,000 ha block of fields in the Huatta pampa, there is much regional diversity in field form (Erickson 1985, 1988a; Lennon 1982, 1983). These morphological distinctions probably represent different local community expressions of ethnicity or style, or possibly temporal differences in field construction and use. Despite these differences, there is a certain generic level of similarity of raised field morphology over time and space that suggests a shared regional tradition of a proper underlying structural principle of raised field layout and construction.

The raised fields of Koani Pampa, Lukurmata (Kolata & Graffam 1989, Graffam 1990, Kolata 1986, 1991), and the Valley of Tiwanaku (Albarracín & Mathews 1990, Kolata 1991, Mathews n.d.b), assumed by Kolata to be contemporaneous with Tiwanaku IV and Tiwanaku V (A.D. 375-1000/1100), also show considerable variation in morphology. The aerial photographs and illustrations indicate that there are a remarkable variety of sizes and forms in a small, concentrated area of raised fields. Albarracín and Mathews (1990:37) note differences between the Tiwanaku Valley fields and Koani Pampa fields, suggesting that the contrasts are due to different ecological adaptations or different construction periods. The variety of field forms could also be related to noncentralized construction, as well as ecological and chronological factors. Following Kolata's state model for raised field agricultural organization, one might expect that field patterns would be more regular and uniform, dictated by centralized bureaucratic planning. This is certainly not the case, even in the Tiwanaku heartland.

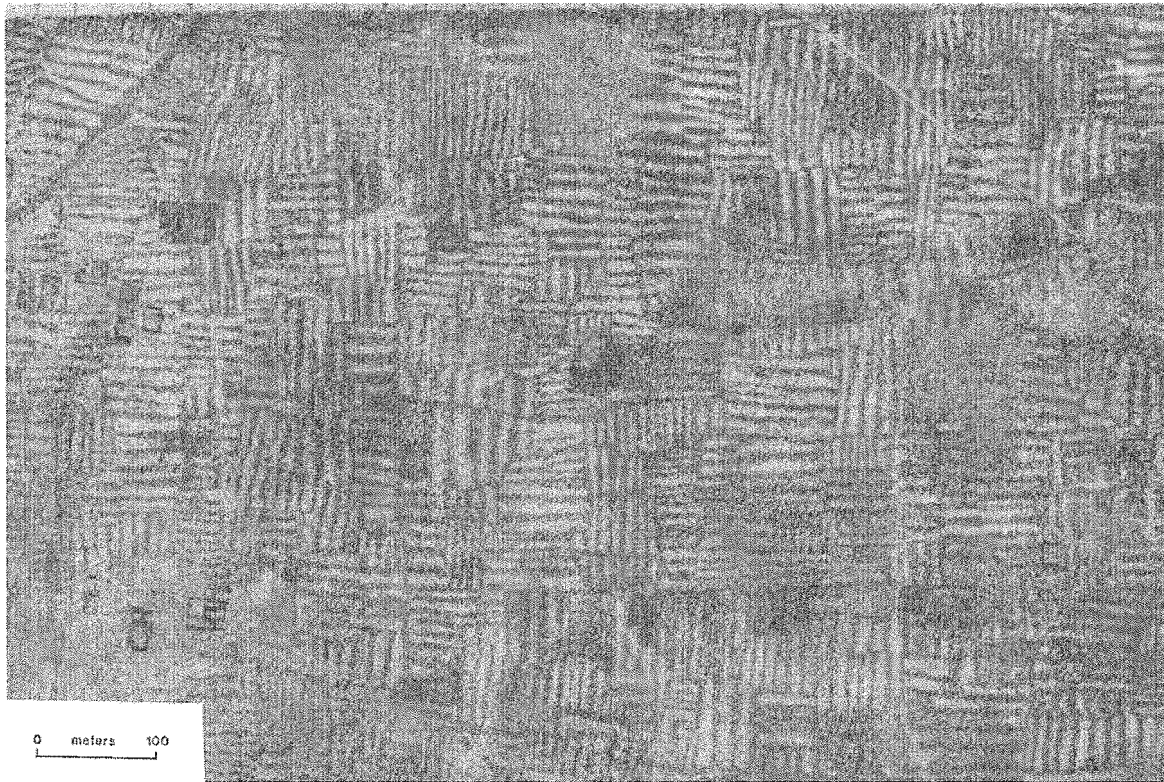


Figure 5. Aerial Photograph of Raised Fields of the "Checkerboard Pattern," near Huatta



Figure 6. Aerial Photograph of Large Raised Fields of the "Ladder Pattern," near Pomata

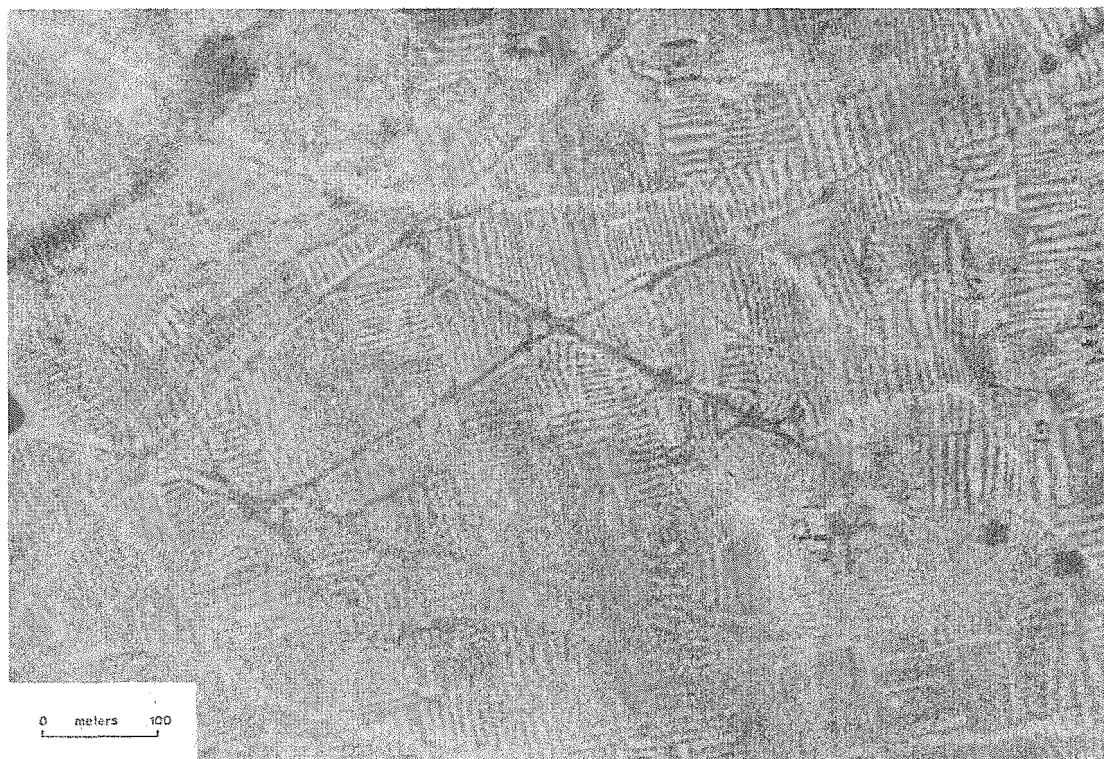


Figure 7. Aerial Photograph of Raised Fields of the "Checkerboard Pattern" and "Embanked Pattern," near Huatta (Several major canals divide the field blocks into sectors.)

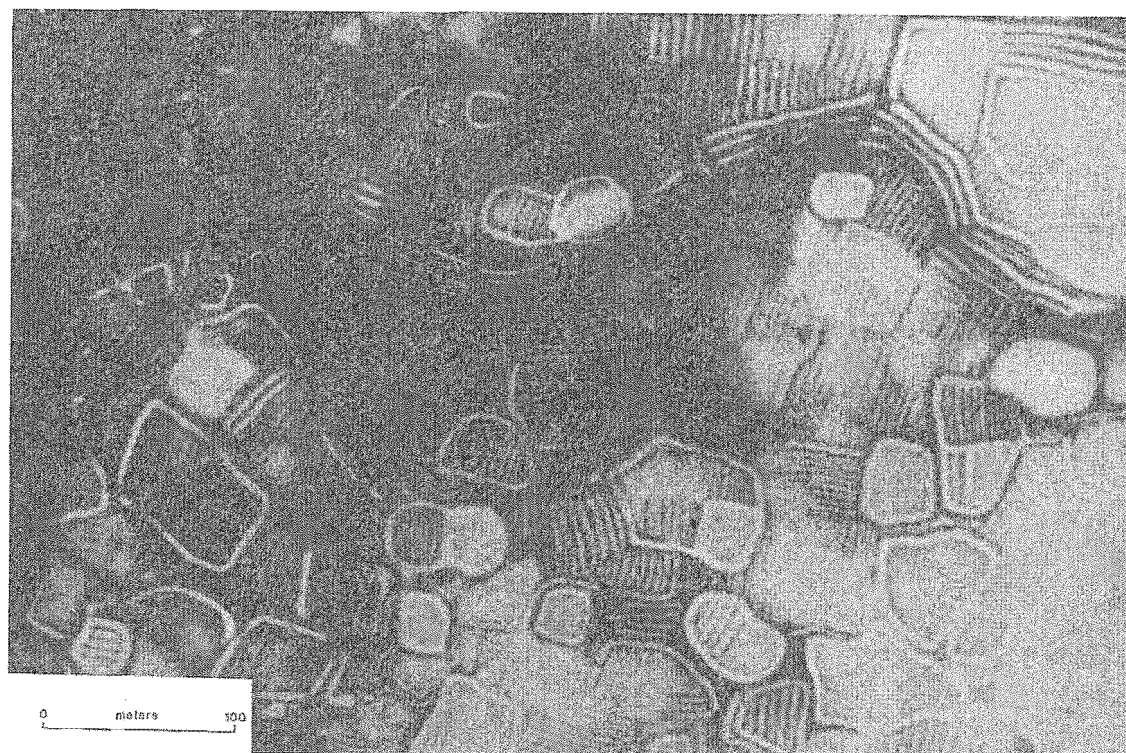


Figure 8. Aerial Photograph of Raised Fields of the "Embanked Pattern" at the Edge of Lake Titicaca, Huatta

Settlements and Settlement Survey

The density of residential sites associated with raised field farming is remarkable. In the contiguous block of 52,000 ha of raised fields around Huatta, I estimate that there are some 1,000 mounds larger than single-house mounds. If single-house mounds are added to this list, the figure would be many times greater. Most of these mounds are relatively evenly distributed on the pampa, but the largest concentrations are near the lake edge or are islands within the lake shallows (see Figure 10). Dense concentrations of sites are also found on the hillslopes and valleys that ring the raised field-covered plains. Occupation mounds are easy to locate on the ground in the flat terrain of the lake plain. They also are easy to distinguish on aerial photographs using stereo pairs to discern the low relief. Mounds range in size from individual house mounds or temporary field camps of several square meters to huge earthen structures covering many hectares and rising up to 15 meters above the natural surface of the pampa.

The dating of these mounds is difficult without excavation. Surface collections made during 1981-1986 indicate that most, if not all, of the larger mounds are multicomponent sites, spanning the Initial Period to the present. This situation appears to be similar to that of Koani Pampa (Kolata 1986; Graffam 1989, 1990), the Taraco peninsula, and Juli Pampa (Stanish n.d.).²¹ Albarracín and Mathews (1990) had similar problems providing convincing associations of sites to raised field complexes in their Tiwanaku Valley survey.²²

Limited excavations in three prehispanic residential sites were made in 1983.²³ The excavations confirmed that the sites were occupied primarily by farmers. Common artifacts included thousands of basalt flakes from the sharpening of stone hoes, as well as numerous ceramics (from both well-made serving vessels and common utilitarian wares). Organic remains included fish, bird, and camelid bone, as well as carbonized plants such as chenopods, shrubs used for cooking, and tuber fragments. The mounds are clearly the result of "tell-like" accumulations of adobe and sod structures that had been occasionally leveled and constructed upon at later periods. The profiles of the excavations showed several meters of stratigraphically superimposed house floors. Excavations indicated that some areas had received quantities of fill to raise the occupation platform. A number of sites have cut stones on the surface, and one site, Pancha, may have held a platform with a stone retaining wall dating to the early Pukara (200 B.C.-A.D. 600) or possibly pre-Pukara (before 200 B.C.) occupation of the site. Other than this, there is no evidence of any administrative or bureaucratic "centers" identified with any known prehispanic state society within the farming settlements of the pampa. Evidence of a state administrative presence has not been found within the raised field blocks.

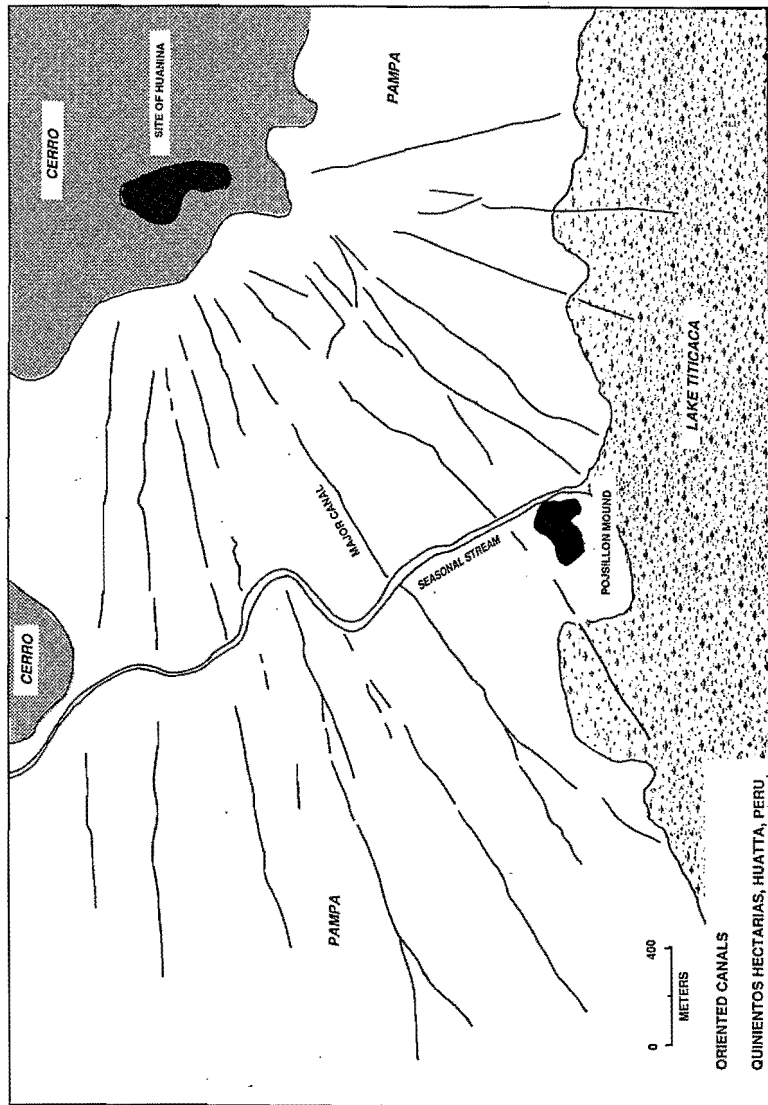


Figure 9. Section of Radial Canal Network within Raised Fields, Huatta, Peru (This feature possibly represents an ancient form of land tenure based on the *ceque* system.)

Many of these mounds are still occupied today, some seasonally and some permanently. There is no reason to expect that the use of these mounds was much different in the past, except that the population living on the pampa was probably much greater. Housemounds near the lakeshore or within the lake (which become small islands during the rainy season) are occupied by fishermen or farmers who use these locations to gain access to the dense mats of aquatic plants for animal forage. These pampa sites were settlements of raised field farmers, not elite managers or bureaucrats. The distribution of small to large mounds is what would be expected in a rural landscape of farming communities exploiting the natural and agricultural resources of the lake and pampa. Locally produced fine Inka ceramics occur on many of the larger mounds, but these appear to have been occupations that post-date the use of the raised fields.

EXPERIMENTAL ARCHAEOLOGY: LABOR AND PRODUCTION

Between 1981 and 1986, the Raised Field Agricultural Project worked with local Quechua-speaking communities in a small-scale experimental program of raised field agriculture (Erickson 1985, 1988a-b; Erickson & Candler 1989, Erickson & Brinkmeier n.d.; Garaycochea 1986a-b, 1987). In addition, several other related development projects promoting raised field rehabilitation were inspired by this work, on both the Peruvian and Bolivian sides of the Lake Titicaca basin (Ramos 1986, 1990; Rivera 1989, Kolata 1991). Much of the work has been continued by governmental and nongovernmental institutions.

Experimental raised fields were modelled on archaeological data recovered from topographic mapping, survey, and excavation of prehistoric fields. Experimental fields were rehabilitated or reconstructed eroded prehispanic fields. Raised fields blocks of up to 10 ha in area were constructed in the communities of Huatta, Coata, and Capachica, Department of Puno, within the *pampas* on the edges of Lake Titicaca. Communities (*parcialidades*, possibly descendants of the original *ayllus*) were approached by the research team and meetings were organized to discuss raised fields with members (*comuneros*). Participants were offered free potato seed as an incentive in return for the use of the individual's or community's land, the labor of the community for the construction, maintenance, and harvest of the fields, and the recording of labor and production data involved in raised field farming. The participants also received all the harvest, which was divided amongst the community group or families.

Figure 10. Prehispanic and Modern Settlements on the Flooded Pampa, near Huatta (Contemporary farmers use ancient mounds for dry house sites.)



Andean Social Organization and Labor Mobilization

The household and the supra-household *ayllu* have been considered the basic social, political and economic units in the rural Central Andes. These institutions—combined with the dual organization of communities or *sayas*, culturally defined land divisions such as *suyu*, *chuta*, and *ceques*, and reciprocal labor relationships—are very powerful and resistant structural forces for mobilizing labor, coordinating large public projects, resolving disputes, controlling land tenure, and spatially organizing populations.

Although believed to be widespread and of considerable time depth, the *ayllu* is difficult to define precisely (see Zuidema 1990, Allen 1988, Isbell 1985, Conrad & Demarest 1984:97-98, 105). In an excellent survey of the concept, Urton describes *ayllus* as “particular units of social organization,” and states (1992:230):

In general terms, *ayllus* are named, clanlike groupings of people whose internal unity and differentiation from each other are based on a variety of factors, including landholding, kinship, festival sponsorship, and the performance of public labor projects. *Ayllus* have been central institutions in community organizations from pre-Hispanic times to the present day in the Andean nation-states of Peru, Bolivia, and Ecuador.

As Urton stresses, it is not an inflexible or static institution and “the persistent nature of the *ayllus* as a central institution of social organization in Pacariqtambo is linked to the support and services that certain members of the community are constantly in need of, and by the recurring demands associated with building and maintaining community facilities” (Urton 1992:235) and is “continually reproduced and transformed” (ibid.:235). In some cases, there appears to be a certain hierarchical nature to the *ayllus*, which can be formed at various levels, depending on local contexts and needs.²⁴ In many cases, *ayllus* are ranked. Higher levels of community organization are the *sayas*, or asymmetrical moieties made up of numerous *ayllus*. Most scholars agree that the *ayllu* has a long history and certainly is responsible for many of the monumental works constructed before the Spanish conquest of the Andes. Because of the material manifestations of the *ayllu* and its works, it should be possible to archaeologically document the *ayllu*. Urton points to the segmental maintenance of the church plaza by the eight *ayllu* groups of the town, the territoriality of *ayllu* residence, and the land tenure organization of the agricultural landscape surrounding the town as examples.

As Urton (1992) notes, the *ayllu*'s existence is centered around the need for organizing local services and labor. Institutions of Andean labor reciprocity are an efficient means of mobilizing work forces of various sizes to complete suprafamily projects, ranging from individual agricultural fieldwork to

sponsorship of public rituals and community construction projects. At the lowest level, work is shared through *ayni*, a symmetrically balanced form of labor between individuals who are equals. Labor performed by one individual is repaid at a later date. For larger projects, work is commonly done through *minka* or *faena*, other forms of reciprocal labor. *Minka*, organized at the group level, is asymmetrical and includes the exchange of goods for short-term labor or services mobilized for an individual's or community's benefit. *Faena*, also asymmetrical, is often a form of labor tax imposed by communities on their individual members for construction and maintenance of local infrastructure (roads, schools, canals) and has a coercive element (Gelles 1986:138). The *mit'a*, or state system of mass mobilization of rotational corvée labor practiced by the Inka, is—at least functionally and symbolically—a form of *minka* or *faena* writ large.²⁵

Dual organization is ubiquitous in the ethnographic literature on communities in the Central Andes. It is characterized as asymmetrical moieties, or *sayas*, usually referred to as *anansaya* (“upper” half) and *urinsaya* (“lower” half) in the Quechua-speaking zones. Traditional irrigation management, or “the local model of irrigation,” revolves around dual organization of communities under “water mayors,” and earth and mountain worship (Gelles 1990:154-156). Besides the spatial and social components of the system, this dual organization is also important in ritual. The organization of Andean irrigation is tightly tied to calendrical rituals, which are an integral part of local water management (Zuidema 1990, Sherbondy 1982, 1987, 1992; Gelles 1990, n.d.b; Treacy 1989b, and others). Most scholars agree that the institutions of dual organization, earth and mountain worship, *ayllu*, and reciprocal labor relationships have deep historical roots in the Andes, although these institutions have certainly been transformed over time.²⁶ Working with ethnohistorical documents in the north coast of Peru, Netherly (1984) has identified a local segmentary system of ranked dual organization and hierarchically nested community groups, which were in charge of hierarchical levels of the irrigation system.

In our experimental fields, labor was organized by the community groups or individual households. Specified workdays of 5 hours each were called on by the community for the communal work project (*faena*). Adult male heads of family (or designated adult substitutes) were responsible for showing up for the days of work. Communal work groups ranged from 5 to 60 individuals, depending upon interest and community membership. If additional days were required to complete the preplanned work, they were added to the community work schedule. Participation of the communal groups was continued over many years, with field blocks becoming larger and more dispersed over time. Some groups utilized another traditional form of labor mobilization, referred to as *tarea*. Here, each *comunero* is assigned a set area of raised fields to reconstruct at his/her own pace. This segmental organization for construction

for public works has been documented in Andean prehistory (Hastings & Moseley 1975).

The tools used to construct the fields were those available to all farmers in the area—the Andean footplow (*chakitaqlla*), hoe (*rawkana*), wooden clod-breaker (*waqtana*), shovel, and pick (see Figure 11). Large woolen cloths were also used to transport loose soil from canal to field surface. Field and canal boundaries were marked by string, using the old abandoned field and canal surfaces as models. The rich organic soil of the A horizon from the sediment-filled canals was cut into sod blocks using the footplow and placed as a retaining wall and fill for the raised field platform. The platforms were built up to a height of 20-50 cm and were bordered with correspondingly deep adjacent canals (see Figure 12). Sod blocks and clods were broken up with picks and clod-breakers, and field surfaces were formed into a cambered shape for drainage.

Fields were planted in local crops—potatoes, oca, ulluco, isaño, quinua, cañihua, maize, winter wheat, peas, broad beans, tarwi, and various garden vegetables. Fields received no fertilizers. Maintenance activities such as weeding and banking of tuber crops were done in the same manner as in traditional fields.

The research team also worked with some individual farmers (*parceleros*) and non-community groups of farmers. These farmers tended to construct small blocks of rehabilitated raised fields adjacent to households, taking on the form of house gardens. Labor was commonly mobilized using *ayni*, symmetrical reciprocal labor exchange between neighbors and extended-family members. These fields generally were better constructed and better maintained than the community fields. In 1989, individual farmers were adopting raised fields faster than community groups. Ground and aerial survey demonstrated that hundreds of families in the pampa of Huatta, Coata, and Caracoto had begun to construct small plots near their houses.

Several assumptions about the way raised fields work were shown to be erroneous in our experimental research. One erroneous assumption is that raised fields need a high level of centralized organization for construction and maintenance. The raised fields were constructed by communal groups and individual families using the traditional Andean labor reciprocity, *ayni*, *minka*, and *faena*. Piecemeal construction of raised fields over 10 years by individual households and communities has resulted in over 100 ha of rehabilitated fields in the Huatta area (Juan Palao, pers. com.) and 150 ha in the Koani Pampa/Valley of Tiwanaku (Oswaldo Rivera S. and Enrique González A., pers. comm.). Several blocks of communal fields in Huatta and Coata belonging to small communities have grown to over 15 ha by accretion over an 8-year period. The traditional reciprocal labor institutions, *ayni* and *minka*, proved an efficient means of mobilizing labor for raised field farming. Clearly, small groups of farmers are capable over time of creating a large-scale, heavily modified, regional landscape.



Figure 11. Cutting Sod Blocks with the Andean Footplow (*chakitaqlla*) for the Construction of Raised Fields, Community of Yasin, Huatta

Raised Fields, Labor Investment, and Production

Raised fields are not necessarily labor intensive. Because few experiments constructing raised fields with manual labor had been conducted (e.g., Puleston 1977a, Gómez-Pompa et al. 1982, Muse & Quintero 1987), previous labor estimates were based on simplistic comparisons with other forms of traditional agriculture or, more commonly, with labor estimates for moving earth (e.g., Erasmus 1965). According to the Boserup (1965) hypothesis on agricultural intensification and the "Law of Least Effort" (Zipf 1949), intensive forms of agriculture requiring large inputs of labor and energy for construction and maintenance will be adopted by traditional farmers only if population stress becomes too great or, according to the Wittfogelian counterpart to the theory, if the centralized political state forces local farmers to adopt the technology.

Our experimental data indicate otherwise. The initial construction of raised fields—digging canals and transferring soil to construct the platforms—involves a relatively large input of labor (in comparison to traditional *wacho* lazy bed construction). From several years of controlled experimental construction using manual labor in diverse locations in the Huatta pampa, we estimate that 200–1,000 person-days of labor are necessary to construct 1 ha of raised fields and canals (Erickson 1988a, Erickson & Candler 1989, Garaycochea 1986a, 1987). These figures have been duplicated experimentally in other areas (Ramos 1986). The work is considerably faster than estimates previously calculated using earthmoving figures (Erasmus 1965) for prehispanic raised field construction (Denevan 1982, Turner 1983). This lower calculation for construction is probably due to the different techniques used in earthmoving and the advantages of working in the grasslands, where large sod blocks can be easily cut and moved using the Andean footplow. In addition, the traditional labor mobilization institutions of the Andean community and family groups are an efficient means of providing the necessary work force.

Labor input on raised fields becomes almost negligible when labor and production are considered over the long term. Raised field agriculture is efficient and sustainable because fields can be farmed continuously with high productivity for many years. Many raised field platforms in Viscachani Pampa in the Huatta area have been farmed for over 10 years without a significant decline in productivity. Raised field maintenance requirements are low (occasional weeding, irrigation, and banking tubers). Harvest takes longer than on regular potato fields²⁷ because the production is so much higher (see Figure 13). The fertility of raised fields is maintained through the periodic re-excavation of sod in dry canals or organic mucks and sediments in wet canals and the placing of these materials on the field platforms. Estimates of 270-person days/ha [\approx 5 hour/day] have been calculated for raised field construction and necessary maintenance (annual and periodic) over the long



Figure 12. Manual Reconstruction of Raised Fields by the Community of Yasin, Huatta, for Experiments

run (a 10-year period), based on experimental results (Erickson 1988a, Erickson & Candler 1989). The figures are even more impressive in terms of the agricultural production returns on labor input. Production data from several years of experimental raised field potato harvests range from 8 to 16 metric tons of potatoes per hectare, or 2-3 times that of regular potato farming.²⁸ This yield converts to 37 kg of potatoes per person-day of work, in sharp contrast to the 19 kg per person-day of work for regular fields in the Andean region (Erickson 1988a). Given such a reliable, sustainable production, farmers may have adopted raised field farming early in Andean prehistory without having been forced to do so by population pressure or other stresses such as state imperatives.

Another premise that the experimental fields showed to be incorrect was that the fields would not function without the rehabilitation of the complete regional hydraulic system as envisioned by Kolata (1991). Small, isolated blocks of rehabilitated raised fields did produce remarkable harvests, despite being surrounded by eroded, unreconstructed, abandoned raised fields. It is clear that larger, contiguous blocks of fields would produce the desired microclimate effects better than small, isolated blocks (Erickson 1988a, Grace 1983), but the individual components of regional raised field systems do not require the rehabilitation of the whole system to function (see Figure 1). There is no need to invoke large-scale hydraulic integration and a state-level organizational apparatus for raised fields to function properly.

COLLAPSE AND ABANDONMENT

In discussing the Tiwanaku raised fields of the Koani Pampa, Kolata (1983:262, 1986:753, 1987:41) suggests that one of the potential causes of the collapse of raised field farming was the disintegration of the Tiwanaku state after the Tiwanaku V Phase.²⁹ He assumes that, without the bureaucratic organization of the state, raised field farming would break down. His evidence for the co-occurrence of the Tiwanaku collapse and raised field abandonment comes from early excavations of a limited number of occupation mounds within Koani Pampa (Kolata 1986, 1987). Graffam (1989, 1990, 1992) has recently demonstrated that raised field construction continued in Koani Pampa and the Taraco Peninsula after the fall of Tiwanaku during the Late Intermediate Period. According to Graffam's investigation of house mounds and associated fields, the majority of visible raised fields in the best-preserved section of Koani Pampa are post-Tiwanaku. Survey work in the Tiwanaku Valley itself demonstrates that raised fields, terraces and *qochas* (sunken gardens) continued to be constructed during the post-Tiwanaku period (Albarracín & Mathews 1990:146-147, Mathews n.d.b). There is considerable debate regarding the level of political organization present during the Late Intermediate Period in the



Figure 13. Potato Harvest from Raised Fields by the Community of Primera Collana, Huatta

Lake basin, but most agree that it was less centralized than during the Middle Horizon (Stanish n.d., Graffam 1992:885). Thus, raised field production appears to have continued under local sociopolitical organization, independent of state administration.³⁰

Our investigations in the Huatta pampa indicate that the rise and fall of local states had little to do with the success or failure of raised field systems. Field blocks may have been abandoned periodically as part of a rotational fallow system or because of low demand. Two climaxes of raised field construction and use appear to have been before Pukara developed into a major center (and possible state) and during the Late Intermediate Period in the Huatta pampa (Erickson 1987, 1988a). Raised fields in the northern basin may have been abandoned for a time during the Middle Horizon (A.D. 600-1000) and Late Horizon (A.D. 1476-1534), the periods of state (Tiwanaku and Inca) presence in the region. Raised fields under community control were apparently resilient and functioned independently of centralized state control, which waxed and waned in the region.

INFRASTRUCTURE, CAPITAL, AND EVOLUTION OF REGIONAL LANDSCAPES

The vast Huatta pampa is covered with earthworks that could represent elements of agricultural infrastructure of a level beyond the basic organization of raised field blocks and bundles of fields. The most impressive are the extensive canal networks, discussed above, which divide and interconnect raised field blocks into social and functional units, and which may have also had a hydraulic function (Lennon 1982, 1983; Erickson 1988a). In addition, there are artificial levees associated with most, if not all, active and nonactive river and stream channels crossing the pampa. Smith et al. (1968) reported large causeways from Machacamarca associated with raised fields. Do these earthworks necessarily represent the work of supralocal bureaucratic organizations that controlled the labor of local farming communities? Are they beyond the scale of engineering ability of small social units?

Kolata (1991) has argued that the "regional" infrastructure of earthworks—including artificial canalized sections of the Rio Catari, the river by-pass systems or river shunts in Koani pampa and the Tiwanaku Valley, causeways/dikes, and aqueducts—are definitely projects of a state because they would have been far beyond the labor and organizational capability of local groups of farmers. Admittedly, these constructions are impressive engineering accomplishments, but it is premature to deny the possibility of local level construction.

What is often forgotten by scholars studying agricultural infrastructure is the considerable time depth of the evolution of cultural landscapes in the

Americas. What we see today in the form of massive infrastructural modifications of the slopes, deserts, and *pampas* is the gradual accumulation of constructions produced by hundreds of generations of farmers. Archaeological evidence indicates that the raised fields of the Lake Titicaca Basin have a long evolutionary history and that they certainly were not all constructed at a single point in time. Agricultural landscapes take on a high degree of engineering complexity, or "integrativeness," over time. Several scholars have referred to this phenomena as the accumulation of "landscape capital" by traditional farmers (Brookfield 1986, Bronson 1972, 1975). This capital includes infrastructures such as terraces, irrigation systems, dikes, fences, ponds, reservoirs, aqueducts, road networks, and raised fields. As Doolittle (1984) has noted, these complex systems evolve over long periods of time, through what could be considered a piecemeal accretion process, the day-to-day activities "that take place in the normal course of cultivation and maintenance" (Doolittle 1990:151; also see Downing & Gibson 1974a:x, Donkin 1979:120, 133).³¹ Much of the early construction of fields, boundaries, canals, and settlements of any system is relatively haphazard and unstructured. The process involves working out the kinks of the production system through experimentation and fine tuning. This process is not necessarily a conscious, intentional effort, or part of a long-term plan on the part of the farmers, but rather results from the simple annual rebuilding or maintenance activities which altered and improved elements of the infrastructure. Over time, as a result of these activities, the system may take on a high degree of formal structural patterning. What we see today as archaeologists is a complex, sophisticated, and once highly productive system spread over a regional cultural landscape. This landscape is a result of the gradual accumulation of landscape capital. I would argue that the raised field systems and the associated irrigation, *qocha*, terracing complex are the result of a similar process of accumulation of landscape capital over a long period of time by small-scale farmers organized in traditional community structures such as the *ayllu*. As Glick (1970:173-174) notes, "The physical aspects of a system can be deceiving and Wittfogel... seems to say that an impressive irrigation system must be the work of an impressive government, an agromanerial despotism commanding an unpaid labor force."

Leach's (1959) warning about scale, sociopolitical organization, and chronology is relevant here. He states that the 55 km Kalawewa canal network in Ceylon "looks like a colossal and highly organized piece of bureaucratic planning, the work of one of Wittfogel's idealized Oriental Despots. But if so, the planning must have been done by a kind of Durkheimian group mind! The system took about 1400 years to build" (Leach 1959:13). In addition, Leach (1959:14) states that, "although the Ceylon irrigation works and the associated palace and temple construction works do represent a gigantic accumulation of capital resulting from an enormous number of man-hours of labour, this

fact does not *in itself* imply any massive control over labour resources by the "bureaucratic rulers." If Tiwanaku IV and Tiwanaku V represent the period of the Tiwanaku state and the period of raised field construction, the creation of the now abandoned landscapes could have been spread over a 600-year period. An even longer period of 2,000 years of construction is suggested by dates for raised fields in the northern basin (Erickson 1987, 1988a; Stanish n.d.). This is more than enough time for small-scale organizations to produce these highly structured and productive agricultural landscapes. There is no need to invoke the state to explain the origin of all these works.

Over the years of experimental construction of raised fields in the communities around Huatta between 1981 and the present, farmers have altered and improved the methods of construction and maintenance of the plots to increase labor efficiency and production and to reduce risk. This fine-tuning of the system involves primarily trial and error procedures. Raising the elevation of platforms after problems of flooding and using living sod walls to protect field edges from erosion are some examples of such changes. These alterations are conducted seasonally or when maintenance is necessary. This form of landscape capital improvement can also be seen in the larger, regional hydraulic and transportation works such as the river canalization and dike program (discussed above), where dikes are periodically repaired and improved after serious flooding problems to prevent future inundation. This accretion process can also be seen in the construction and maintenance of community road causeways in the *pampas*, which are continually rebuilt and modified to provide the necessary drainage to use the *pampas* for farming and grazing. This is the gentle process of incremental change in action.

ALTERNATIVE SYSTEMS OF AGRICULTURAL PRODUCTION

Because raised field agriculture is such an impressive production system, a major misconception is the implication that raised fields were the main or only economic system available to farmers during the Middle Horizon (A.D. 600-1000) in the Tiwanaku core area, as implied by Kolata (1986:748, 760; 1991; Ortloff & Kolata 1989). The new survey work in the Tiwanaku Valley undertaken by Albarracín and Mathews (1990; also see Albarracín 1992) demonstrates that Tiwanaku peoples used multiple systems of production. Their work provides evidence of extensive terracing and *qochas*, in addition to raised fields.

Terracing has not been investigated in much detail, but the technology had been mastered by the Early Intermediate Period (200 B.C.-A.D. 600). The ceremonial precinct at Pukara was placed on monumental terraces. During the Middle Horizon, large areas of residential zones of Lukurmata and Pajchiri

were located on artificial terraces (Kolata 1986, 1987). Many of the terrace systems in the Lake Titicaca Basin are integrated into raised field systems through continuation of boundary walls that extend from the hillslopes into the *pampas* (Erickson 1988a). If terraces were constructed for occupation, they may also have been in use for agricultural production at a very early time. The advantages of favorable lakeshore microclimates, higher rainfall, better soils, and longer growing seasons made labor-intensive terracing a practical option for lake edge farmers. The archaeological record indicates that pre-Tiwanaku farmers, and colonial and contemporary farmers (Aymara, Quechua, and Ufu-Puquina), also relied heavily on lacustrine and aquatic resources such as fish and gathered plants, as well as camelid herding (Erickson 1988a).

These diverse production strategies available to Tiwanaku, in addition to long-distance trade and establishment of production colonies in multiple resource zones (Browman 1981), suggest that the central resource base for Tiwanaku was much broader than the limited raised field model presented by Kolata (1986, 1991). We should also note that these multiple resource production systems were in place long before the establishment of Andean states in the Lake Titicaca Basin.

THE RELATIONSHIP OF RAISED FIELD AGRICULTURE TO THE STATE

If the success of raised field agriculture does not rely on state bureaucratic management, then what is the relation between the prehispanic state and raised fields? Raised fields did not "cause" the first state in the Lake Titicaca Basin, but this impressive agricultural system is certainly indirectly related to the development of the state. Raised fields farming preceded the state by possibly 500-1000 years (Erickson 1987, 1988a; Stanish n.d.). Because raised field agriculture is an intensive and effective form of production technology, it is usually discussed in the context of surplus production, not subsistence production. Inherent in discussions of the state's relationship to raised fields is the state's need to produce large quantities of surplus to sustain urban populations, craftspeople, the elite, and state activities and enterprises. There is no doubt that the state would have a strong interest in raised field agriculture, appropriating this surplus through taxation, expropriation of peasant labor for construction and maintenance of new fields, establishment of colonies of state agriculturalists, and/or direct government control of fields.

Kolata, Graffam, and I have argued that the vast extension of raised fields represent much more than a subsistence economy. The highly productive regional landscape was definitely important in setting the stage for state development. The fields were effective means of generating huge surpluses and

sustaining large nonfarming populations. But, while the state may have had a strong influence over raised field production through taxation, it does not follow that the state necessarily had a direct hand in the planning, construction, and administration of raised fields. There is no need to invoke direct Tiwanaku state control over raised field farming, the "top-down" approach. Indirect demands and pressures such as taxation, co-option of labor, and tribute demands can induce farmers to intensify and boost levels of surplus production. The Tiwanaku state may even have expanded the agricultural frontier into marginal zones. This still does not mean that the Tiwanaku elites necessarily planned and managed all of the fields in the Lake Titicaca Basin, or that raised field agriculture did not exist or was not productive before the Tiwanaku state.

What raised fields and other landscape capital systems did was to tie farmers to the land, making them relatively immobile and subject to labor taxes and tribute. Such a situation is beneficial to the state in that such farmers can easily be controlled and labor and goods can easily be expropriated for the elite's purposes. As in the Inka case of terracing (Conrad & Demarest 1984, Sherbondy 1982, Murra 1980), the state may have encouraged the expansion of raised fields at the community level in order to create a more favorable economic environment. As long as the tribute flowed from the local communities, it would not be in the state's best interest to meddle with well-established and efficiently functioning raised field agriculture.

Raised fields have a long history in the Lake Titicaca Basin, much longer than that of the Tiwanaku state, which may have lasted less than 600 years. Why would early farmers adopt raised field agriculture at a time when there was no demand for surplus from urban populations and the state? Because raised field farming is more labor efficient, more productive, and less risky than alternative technologies, it would have been one of the best choices for early farmers in the Lake Titicaca basin making the transition from lacustrine-based hunting and gathering economies (Erickson 1987, 1988a). Raised fields evolved from a subsistence to a surplus production system as local demands and population grew. By the Initial Period and Early Horizon, these demands could have included: taxation and tribute to local *ayllu* and supra-*ayllu* lords and temples; support of a nonfarming population, including craft specialists and such other specialists as warriors, religious officials, pastoralists, fishermen, hunters, and collectors; local reciprocity, gift giving, and barter; long-distance exchange of resources between ethnic groups of different environmental zones; procurement of exotic goods as part of a prestige good economy; support of pilgrimage activities of important regional shrines; underwriting ritual and ceremony; and the stockpiling of production for adverse times. The combined demands of subsistence and social production were continuously high. All of these activities are documented in the archaeological record for pre-Tiwanaku cultures of the Lake Titicaca Basin (Kolata 1983, Erickson 1988a, Bermann 1990, Albarracín 1992, Browman 1981, Moseley 1992). Archaeological survey

has demonstrated that populations around the lakeshore were dense and that many of the pre-state and post-state settlements are located within or near remains of raised fields (Erickson 1988a, Albarracín & Mathews 1990, Stanish n.d.). Raised fields must have supplied the needs of many different types of sociopolitical organizations, both state-level and non-state, throughout prehistory.

In summary, raised field were developed, constructed, and maintained by farmers organized in localized *ayllus* and communities. The Andean states of the region developed and collapsed with regularity, but the agricultural systems organized at lower levels continued relatively unaffected and perhaps thrived. To suppose that raised field farming could only be planned, executed, and maintained by the highly centralized state is to disregard the rich agricultural knowledge and organizational potential of the Andean farmer, both past and present. This is not a stale academic issue to be debated by scholars, but has very specific implications in regard to whether or not raised field farming can be reintroduced at the local level in the Andes and elsewhere. The evidence strongly indicates that the assumption that raised field agriculture requires state administration is incorrect.

CONCLUSIONS

Most discussions of raised fields have focused on the technology and the environmental and evolutionary context of raised field farming (Denevan 1970, 1982; Denevan & Turner 1974; and others). The cultural materialism and cultural ecology perspectives tend to dominate this literature. Little emphasis has been placed on the sociopolitical context of raised field agriculture, in contrast to the rich discussion regarding the organization of prehistoric irrigation systems. Kolata and others have presented a provocative hypothesis regarding the relationship of raised fields and the state. The primary assumption is that, because raised fields are an intensive form of agriculture, they must have been constructed and controlled by centralized bureaucratic institutions. I have reviewed these perspectives and presented an alternative model, that they were developed and managed by local household and community organizations.

Hierarchically organized, highly centralized, complex state-level society was probably never the norm in Andean prehistory. Widespread "horizon styles," commonly assumed to be associated with the expansion of state organizations, appear and disappear throughout the Andean chronological sequence (Moseley 1992). Class struggle, ethnic unrest, and peasant rebellion date to at least the Late Horizon and possibly earlier (Patterson 1992). Documentary data for the Lake Titicaca Basin indicate widespread warfare and interethnic unrest during the post-Tiwanaku Late Intermediate Period and Late Horizon

(Julien 1983). The most enduring Andean organizational structures over these long periods of time appear to have been the household and supra-household community level *ayllu* organizations (Alberti & Mayer 1974a; Mayer 1974, 1976; Stanish 1992, Isbell 1985, Urton 1992). Despite these long periods of unrest and lack of strong state presence, intensive raised field agriculture flourished in the northern Lake Titicaca Basin under local control. The raised field system did not need the state.

Archaeological, ethnohistorical, and ethnographic case studies document that large-scale regional, intensive forms of agriculture are associated with a wide range of social systems. To automatically assume that the sociopolitical organization associated with these systems has to be centralized and directed by bureaucracies would be a mistake. It is clear that raised field agriculture is highly sustainable and efficient for the production of subsistence and surplus foodstuffs. At times, large and dense populations must have been sustained by raised field agriculture. But it is important to remember that raised fields were used in the Titicaca Basin before, during, and after the Tiwanaku phenomena. There is no necessary relationship between the Tiwanaku state and the construction and management of raised field systems.

The implications of the debate among scholars regarding the social organization of prehistoric raised field agriculture are potentially far reaching. Both the Peruvian and Bolivian governments, in addition to numerous governmental and nongovernmental organizations, have adopted raised field technology to certain degrees as part of development programs for the rural *altiplano* (Erickson & Candler 1989, Kolata 1991; Rivera 1989, Erickson & Brinkmeier n.d., Brinkmeier 1985, Erickson 1992b, Garaycochea 1988). Much of the planning and organization for the diffusion of this technology has been haphazard—some groups favoring a heavy-handed “top-down approach,” others focusing on a more grassroots development, or a “bottom-up approach” (for details, see Erickson & Brinkmeier n.d.). The future and success of raised field agriculture may depend heavily on what prehistoric archaeology can tell these development institutions about the optimal level of social organization for the reintroduction of raised field farming in the Andes.

ACKNOWLEDGMENTS

This essay has benefitted greatly from comments, discussions, and interactions with many individuals interested in intensive agricultural systems over the past 10 years. I thank Kay Candler, Dan Brinkmeier, Alan Kolata, Charles Stanish, William Denevan, Kent Mathewson, John Treacy, Jeffrey Parsons, Donald Lathrap, Thomas Lynch, Paul Gelles, William Isbell, Michel Muse, Paul Goldstein, Michael Moseley, Ignacio Garaycochea, Gray Graffam, and Jim Mathews. Kay Candler, Dan Brinkmeier, and Ignacio Garaycochea aided in the archaeological and experimental fieldwork in Huatta between 1981 and 1986. Various field seasons of research were conducted with generous

grants from the Social Science Research Council, the National Science Foundation, and the Interamerican Foundation. Gray Graffam, Charles Stanish, Barry Isaac, Paul Gelles, Kay Candler, and Jim Mathews provided detailed criticism at various stages of the manuscript. We strongly disagree on many key points and their critique made me rethink several issues. I especially thank the people of Huatta and Coata who participated wholeheartedly in the archaeological and experimental project and personally taught me about the “bottom-up” approach to the social organization of agriculture and what dedicated communities could do for and by themselves.

NOTES

1. An early version of this essay was presented in the Symposium, “The Emergence of the Andean State in the Circum-Titicaca Basin,” organized by Charles Stanish, Alan Kolata, and Mario Rivera at the 47th International Congress of Americanists, New Orleans, Louisiana, June 7-11, 1992.
2. Kolata (1991:112) has referred to the Ayllu/Local Level Organization Hypothesis as the “new orthodoxy.” I would argue that the bottom-up approach has not been considered or accepted by most archaeologists writing about intensive agriculture.
3. Wittfogel (1957:184-188) used the prehispanic Maya as a case of “marginal agromanageial society.” According to him, they did not practice irrigation agriculture *per se*, but rather used hydraulic works for accumulating and storing water (the *cenotes*, *chultuns*, and *aguadas*). These systems were believed to have been derived from highland Mesoamerican sources. Marcus (1983) is one of the few Mayanists writing about prehispanic Maya fields who has stressed caution regarding the automatic association of raised fields with centralized authority.
4. This is ironic, considering that Puleston's (1977a, 1977b) pioneering experimental work with raised fields clearly demonstrated that small groups of farmers could easily construct blocks of raised fields.
5. Wittfogel (1957) was careful to distinguish between “hydroagriculture,” in which farmers use small-scale traditional irrigation systems, and “hydraulic agriculture,” in which the government controls large-scale irrigation networks and flood control structures. The literature on prehispanic intensive agriculture, in particular that written by archaeologists, tends to neglect this scale problem. In addition, Wittfogel did not argue that all large-scale irrigation systems necessarily will result in the despotic state.
6. Additional commentary regarding the problems of compatibility of centralized state bureaucracy and local organization of irrigation agriculture can be found in Coward (1976, 1979, 1980a-b), Chambers (1980), Lees (1986), Lewis (1991), and Lansing (1991).
7. The construction and maintenance of terracing and irrigation systems throughout the Andes are commonly attributed to Inca state policy imposed on local communities through *mit'a* labor and land tenure changes (e.g., Conrad & Demarest 1984). This Inca analogy has been used by archaeologists to interpret the organization of raised field agriculture. Much of the terracing in the Andes is referred to by scholars as “Inca terracing,” although there is a near complete lack of archaeological study of these features. Although the Inca were responsible for large tracts of terracing, it is clear that terracing as an Andean agricultural technology does not have its origins with the Inca state and that pre-Inca terracing is widespread (Denevan et al. 1987, Treacy 1989b, Malpass 1987, Donkin 1979). The irrigated terraces of the Inca capital of Cuzco were constructed and operated at the *ayllu* level, not by the state (Sherbondy 1982, 1987; Zuidema 1986). As Leach has noted in regard to Ceylon, the attribution of hydraulic works to historical individuals or states is often unfounded: “Might it not be that the ‘greatness’ of the hydraulic monarch is itself a product of propaganda myth?”; and, “While myth invariably attributes their construction to the initiative

of a single outstanding monarch, archaeology shows each has been slowly developed over a long period of time" (Leach 1959:13).

8. I have argued that many of the large canals that bisect raised field blocks may have been used to create and maintain artificial wetlands environments instead of "draining" these areas (Erickson 1988a). Much of the structure of fields, canals, and embankments would have actually impeded the drainage of water.

9. Several scholars have hypothesized that salinization of raised field surfaces was prevented by moving and distributing fresh water to field canals from aqueduct structures (Stanish, pers. comm.; Kolata & Ortloff 1989). It has not been demonstrated that salinization was a problem facing raised field farmers. Our experiments have shown that rehabilitated fields in areas with extensive surface salt accumulation produced as well as those in areas without salts.

10. In the 1991 article, Kolata appears to equate the sophisticated nature of the raised field technology (waterlogging protection, management of hydraulic resources, high sustainable production, elevated carrying capacity, production and recycling of nutrients, and micro-climate improvements) with the need for a sophisticated and complex system to permit it to operate. I have argued that the two concepts are distinct and have no necessary relationship (Erickson 1988a). Also implicit in Kolata's and other work is the assumption that raised fields are necessarily "intensive" and, following the "Law of Least Effort," that farmers will not adopt this system unless forced to by the state or by environmental stress such as population pressure. The high productivity documented in the Bolivian experiments demonstrates that raised field farmers are capable of producing large surpluses. This does not necessarily mean that the impetus for the generation of these surpluses was state policy.

11. Stanish (n.d.) also argues that, in the case of Moyopampa, Peru, the larger, more integrated raised field complexes associated with hydraulic structures (aqueducts and canals) must have been state controlled, while smaller blocks without these features may have been organized at a lower level by *ayllus*.

12. If the aqueducts and river channelization found within the Tiwanaku field blocks functioned, as Kolata and Ortloff (1989) have argued, to prevent flooding and lower water tables within the pampa by diverting water directly into Lake Titicaca, the optimal hydraulic conditions within field canals may have been disputed. Graffam (1990:43, 172) has argued that these hydraulic modifications are more appropriate for pastoral use of the pampa during later prehistory or the historical period. The recent artificial tampering with the annual flooding of the Huatta pampa, a necessary factor in prehispanic and contemporary raised field farming, has been detrimental to the raised field agriculture being reintroduced in the area (Erickson & Brinkmeier n.d., Erickson & Chandler 1989).

13. Mathews (n.d.b) reports on excavations of several raised fields near the urban center of Tiwanaku. Although small, these fields are larger than *wachos* commonly used by farmers today.

14. I follow the chronology presented in Keatinge (1988:xv) for the Central Andes. The Tiwanaku phase sequence is based on Kolata (1983, 1986, 1991).

15. It should be noted that the raised fields of the Koani Pampa are highly variable according to the published maps (Kolata 1986:Figure 4; also see Graffam 1990) and aerial photographs that I have studied from the Instituto Geográfico Militar archive. Fields within the Valley of Tiwanaku near the site of Tiwanaku appear to be very different, smaller with the more orderly checkerboard and ladder forms (Mathews n.d.a:4-5, n.d.b). Mathews (n.d.a) suggests that these differences may be due to the Tiwanaku Valley fields being older than those of Koani Pampa or to the different ecological context (riverine vs. lacustrine).

16. Wavelength is the distance from canal center to adjacent canal center (passing over a raised field platform). More accurate measurements can be made by averaging many measurements. It provides an important and accurate measurement with which raised fields can be compared (Erickson 1988a).

17. Kolata (1986, 1987) and Graffam (1990) report finding Chiripa ceramics (which span that Initial Period and Early Horizon) within the fill of Middle Horizon and Late Intermediate Period

occupation mounds in the pampa of Koani. These sherds possibly represent earlier occupations by raised field farmers in the pampa, but this has not been firmly established (Kolata 1986, 1991; Graffam 1990). There is also Early Horizon material at the site of Luqurmata (Bermann 1990). A short survey I conducted in 1975 along the northern shoreline of the Taraco Peninsula delineated numerous Early Horizon settlements adjacent to prime raised field land. This has also been addressed by Graffam (1990). At the beginning of the Tiwanaku state, the raised field zones were already being occupied and utilized by farmers.

18. Long "linear" raised fields extending several kilometers are commonly found in the Capachica region north of Huatta (Smith et al. 1968). They extend perpendicularly from the base of the slopes and cross the pampa to the lake shallows. Another rare form is the "ladder" field pattern, a bundle of short fields between two parallel canals, found in the Pomata region. These also probably represent a social structure of land tenure similar to the more common "checkerboard" pattern (Erickson 1988a). These systems resemble the present-day land tenure that is commonly organized as long, thin strips of land extending from hillcrests across the pampas to the lake edge, sometimes extending out from the lake edge into the *totorales* (cattails).

19. There is evidence that the local *ayllu* organization of irrigation agriculture in Cuzco was based on the form of the *ceque* model (Sherbondy 1982, 1987, 1992; Zuidema 1986).

20. This radial system of organization has been discussed for various pre-Columbian cultures, such as its presence in the Nasca lines (Aveni 1990), Inka irrigation (Sherbondy 1982, 1987, 1992; Zuidema 1986), and Inka settlement patterning (Hyslop 1990). Other, related but non-radial forms, have been documented (Urton 1992).

21. Dating of occupation mounds by surface collections is inadequate. There tends to be an overabundance of diagnostic late prehistoric ceramics on the surface, which masks the presence of occupation at earlier periods. Relating these mounds to the construction and use of the raised fields is even more difficult. Kolata (1986) has attempted to relate mounds and fields by associations of proximity in Koani Pampa. I have argued elsewhere (Erickson 1987, 1988a, 1992, n.d.b) that mounds and fields should be dated independently to establish contemporaneity. Kolata (1986, 1991) and Graffam (1989, 1990, 1992) have also used mounds that they argue are integrated into field systems for dating, although their interpretations often differ. Stanish (n.d.) has recently argued that mounds within the Juli Pampa may have been occupied only when the raised fields were in a state of abandonment.

22. Even though the raised fields were not directly dated during survey, Mathews and Albarracín (1990) assume that most of the fields are associated with, and thus are contemporaneous with, Tiwanaku IV and Tiwanaku V period sites. It is interesting that their maps (Mapas 2-7) show that the numbers of settlements increase in the raised field zones after Tiwanaku collapses. They note (1990:146) that some of the fields continued to be in use during the post-Tiwanaku period but the map shows a much reduced area under cultivation. How they determined this reduction of field use from surface evidence is not clear.

23. A monograph presenting these excavation results is currently in preparation. Preliminary analysis is briefly summarized in Erickson (1988a-b).

24. Bertonio's 16th-century terms and Platt's (1987) study of the Aymara *ayllu* have been used by Graffam (1992:886) and Albarracín (n.d.) to support the presence of hierarchy in traditional *ayllu* organization.

25. There are many terms used in the literature for a variety of Andean institutions of labor mobilization. Some additional examples include *chuqu* (Graffam 1990:72), *washka-washka*, *tuma*, *uyari*, *rantin*, *turnapeón* (Fonseca 1974:87), and *voluntad*, *waje-waje*, *yanapi*, and *ayuda* (Mayer 1974:47). There is little agreement on precise definitions of these terms, and their use is highly variable in the Andean region.

26. Gelles (n.d.c) has recently argued that certain elements of the system of dual organization were imposed by the Inka on the farming populations of the Colca Valley as a means of organizing production, taxation, and expropriation of labor. According to Gelles, this system, combining

elements of both Inka and Spanish Colonial political economy, has been transformed over time into a local model of water management.

27. By "regular fields," I mean the fields currently used by Quechua and Aymara farmers in the Lake Titicaca Basin. These include dry fields on slopes and hills ringing the pampa and the *wachos*, or narrow sod lazy beds constructed for potato cultivation. These fields are prepared by wooden scratch plows pulled by teams of oxen, tractors, or the *chakitaqlla*. The use of irrigation is rare in Huatta.

28. Raised field experiments conducted in the southern Lake Titicaca Basin have recorded even high estimates of potato production using fertilizers (Kolata 1991).

29. Kolata states that "there seems to have been a massive agricultural collapse, probably brought on by the political disintegration of the Tiwanaku empire. After this time, the drained fields of the Pampa Koani were never reutilized" (1983:262), and that "the evident decline in human activity on the Pampa Koani after Tiwanaku V times was related to the disintegration of the Tiwanaku state, with the collapse of strong central authority inducing disruption of the formidable seasonal maintenance requirements of the field systems" (1986:753).

30. In a recent article, Graffam (1992) argues that the post-Tiwanaku, *ayllu*-based Pacajes polity relied on raised field agriculture as a means of subsidizing a large, pastoral herding component.

31. Doolittle (1990:3) has recognized that, "Studies that either compare ancient irrigation systems in their temporal contexts or emphasize the environmental factors responsible for the use of different systems fail to recognize the long-term and cumulative nature of technological changes. Carl O. Sauer's (1952:9) observation that 'Ideas must build upon ideas' seems to have been lost. For the most part, technological change involves degree rather than kind. Although changes in types of technology have never been uncommon, change in the nature of a particular kind of technology have been more typical."

This process is obvious in the evolution of raised fields in the Northern Titicaca basin, where earlier Initial Period and Early Horizon fields have wavelengths of 5m, whereby the later Late Intermediate Period fields have wavelengths of over 10m (Erickson 1987, 1988a). The fields are morphologically and structurally the same; the scale has simply changed over time. I do not mean to suggest here that agricultural landscapes were never formed rapidly or that states are incapable of implementing or drastically altering large scale production systems. Inka agricultural policies, such as that practiced for the establishment of agricultural colonies in Cochabamba (Wachtel 1982) or the reworking of production systems in the Mantaro Valley (D'Altroy 1992, Hastorf 1992), are prime examples of the state's role in redefining the Andean landscape.

REFERENCES

- Adams, Robert McC. (1966) *The Evolution of Urban Society*. Chicago: Aldine.
- Albarracín-Jordan, Juan V. (1992) *Prehispanic and Early Colonial Settlement in the Lower Tiwanaku Valley, Bolivia*. Ph.D. Dissertation, Southern Methodist University.
- (n.d.) "The Tiwanaku Settlement System: The Integration of Ayllu-like Nested Hierarchies in the Lower Tiwanaku Valley." Manuscript.
- Albarracín-Jordan, Juan V., and James E. Mathews (1990) *Asentamientos prehispánicos del Valle de Tiwanaku, Vol. 1 (Prehispanic Settlements in the Tiwanaku Valley, Vol. 1)*. La Paz: Producciones CIMA.
- Alberti, Giorgio, and Enrique Mayer (1974a) "Reciprocidad andina: ayer y hoy" ("Andean Reciprocity: Yesterday and Today"). Pp. 13-38 in G. Alberti and E. Mayer (eds.), 1974b, *infra*.
- (1974b) *Reciprocidad e intercambio en los Andes peruanos (Reciprocity and Exchange in the Peruvian Andes)*. Lima: Instituto de Estudios Peruanos.

- Allen, Catherine (1988) *The Hold Life Has: Coca and the Cultural Identity of an Andean Community*. Washington, DC: Smithsonian Institution Press.
- Armillas, Pedro (1971) "Gardens on Swamps." *Science* 174:653-661.
- Aveni, Anthony, ed. (1990) *The Lines of Nasca*. Philadelphia: American Philosophical Society.
- Bauer, Brian (1992) "The Royal Roads of the Incas: An Analysis of the *ceques* of Collasuyu, Cuzco." *Latin American Antiquity* 3:183-205.
- Bermann, Marc P. (1990) *Prehispanic Household and Empire at Lukurmata, Bolivia*. Ph.D. dissertation, University of Michigan.
- Boehm de Lameiras, Brigitte (1988) "Subsistence, Social Control of Resources, and the Development of Complex Society in the Valley of Mexico." Pp. 91-102 in John Gledhill, Barbara Bender & Mogens Trolle Larson (eds.) *State and Society: The Emergence and Development of Social Hierarchy and Political Centralization*. London: Unwin Hyman.
- Boserup, Ester (1965) *The Conditions of Agricultural Growth: The Economics of Population Pressure*. Chicago: Aldine.
- Brinkmeier, Daniel A. (1985) *A Plan for Disseminating Information about Traditional Agriculture to Indigenous Farmers in the Department of Puno, Peru*. M.A. Thesis, Iowa State University, Ames.
- Bronson, Bennett (1972) "Farm Labor and the Evolution of Food Production." Pp. 190-218 in Brian Spooner (ed.) *Population Growth: Anthropological Implications*. Cambridge, MA: M.I.T. Press.
- (1975) "The Earliest Farming: Demography as Cause and Consequence." Pp. 52-78 in Stephen Polgar (ed.) *Population Ecology and Social Evolution*. The Hague: Mouton.
- (1978) "Angkor, Anuradhapura, Prambanan, Tikal: Maya Subsistence in an Asian Perspective." Pp. 255-300 in Peter Harrison & B. L. Turner II (eds.), 1978, *infra*.
- Brookfield, Harold C. (1986) "Intensification Revisited." *Pacific Viewpoint* 25:15-44. Wellington.
- Browman, David L. (1981) "New Light on Andean Tiwanaku." *American Scientist* 64(4): 408-419.
- Brumfiel, Elizabeth M. (1991) "Agricultural Development and Class Stratification in the Southern Valley of Mexico." Pp. 43-62 in H. Harvey (ed.) *Land and Politics in the Valley of Mexico*. Albuquerque: University of New Mexico Press.
- Butzer, Karl (1977) *Early Hydraulic Civilization in Egypt: A Study in Cultural Ecology*. Chicago: University of Chicago Press.
- Chambers, Robert (1980) "Basic Concepts in the Organization of Irrigation." Pp. 28-50 in E. Walter Coward (ed.), 1980b, *infra*.
- Conrad, Geoffrey, and Arthur Demarest (1984) *Religion and Empire: The Dynamics of Aztec and Inca Expansionism*. Cambridge, ENG: Cambridge University Press.
- Coward, E. Walter, Jr. (1976) "Indigenous Organization, Bureaucracy, and Development: The Case of Irrigation." *Journal of Development Studies* 13:92-105.
- (1979) "Principles of Social Organization in an Indigenous Irrigation System." *Human Organization* 38:28-36.
- (1980a) "Irrigation Development: Institutional and Organizational Issues." Pp. 15-27 in E. Walter Coward, Jr. (ed.), 1980b, *infra*.
- , ed. (1980b) *Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences*. Ithaca, NY: Cornell University Press.
- Crumley, Carole L. (1987) "A Dialectical Critique of Hierarchy." Pp. 155-169 in Thomas C. Patterson & Christine W. Gailey (eds.) *Power Relations and State Formation*. Washington, DC: American Anthropological Association.
- D'Altroy, Terence N. (1992) *Provincial Power of the Inka Empire*. Washington, DC: Smithsonian Institution Press.
- Darch, J. P., ed. (1983) *Drained Field Agriculture in Central and South America*. Oxford: British Archaeological Reports, International Series, No. 189.

- Denevan, William M. (1970) "Aboriginal Drained-Field Cultivation in the Americas." *Science* 169:647-654.
- (1982) "Hydraulic Agriculture in the American Tropics: Forms, Measures, and Recent Research." Pp. 181-203 in Kent V. Flannery (ed.) *Maya Subsistence*. New York: Academic Press.
- Denevan, William M., Kent Mathewson, and Gregory Knapp, eds. (1987) *Pre-Hispanic Agricultural Fields in the Andean Region*. Oxford: British Archaeological Reports, International Series, No. 359, Parts i and ii.
- Denevan, William M., and B. L. Turner II (1974) "Forms, Functions, and Associations of Raised Fields in the Old World Tropics." *Journal of Tropical Geography* 39:24-33.
- (1985) "Prehistoric Manipulation of Wetlands in the Americas: A Raised Field Perspective." Pp. 11-30 in Ian Farrington (ed.), 1985, *infra*.
- Donkin, R. A. (1979) *Agricultural Terracing in the Aboriginal New World*. Tucson: University of Arizona Press.
- Doolittle, William (1984) "Agricultural Change as Incremental Process." *Annals of the Association of American Geographers* 74:124-137.
- (1990) *Canal Irrigation in Prehistoric Mexico: The Sequence of Technological Change*. Austin: University of Texas Press.
- Downing, T. and M. Gibson (1974a) "Preface." Pp. ix-xi in T. Downing & M. Gibson (eds.), 1974b, *infra*.
- , eds. (1974b) *Irrigation's Impact on Society*. Tucson: University of Arizona Press.
- Earle, Timothy (1978) *Economic and Social Organization of a Complex Chiefdom: The Halelea District, Kauai, Hawaii*. Ann Arbor: University of Michigan, Museum of Anthropology.
- Erasmus, Charles J. (1965) "Monument Building: Some Field Experiments." *Southwestern Journal of Anthropology* 21:277-301.
- Erickson, Clark L. (1985) "Applications of Prehistoric Andean Technology: Experiments in Raised Field Agriculture, Huatta, Lake Titicaca, Peru, 1981-1983." Pp. 209-232 in Ian Farrington (ed.), 1985, *infra*.
- (1987) "The Dating of Raised Field Agriculture in the Lake Titicaca Basin of Peru." Pp. 373-383 in William M. Denevan, Kent Mathewson & Gregory Knapp (eds.), 1987, *supra*.
- (1988a) *An Archaeological Investigation of Raised Field Agriculture in the Lake Titicaca Basin of Peru*. Ph.D. dissertation, University of Illinois, Urbana-Champaign.
- (1988b) "Raised Field Agriculture in the Lake Titicaca Basin: Putting Ancient Andean Agriculture Back to Work." *Expedition* 30(2):8-16.
- (1992a) "Prehistoric Landscape Management in the Andean Highlands: Raised Field Agriculture and Its Environmental Impact." *Population and Environment* 13(4):285-300.
- (1992b) "Applied Archaeology and Rural Development: Archaeology's Potential Contribution to the Future." *Journal of the Steward Anthropological Society* 20:1/2: 1-16.
- (n.d) "Methodological Considerations in the Study of Ancient Andean Field Systems." Forthcoming in Kathryn L. Gleason & Naomi Miller (eds.) *The Archaeology of Garden and Field*. Philadelphia: University of Pennsylvania Press.
- Erickson, Clark L., and Daniel A. Brinkmeier (n.d.) *Raised Field Rehabilitation Projects in the Northern Lake Titicaca Basin*. Manuscript, 1991.
- Erickson, Clark L., and Kay L. Candler (1989) "Raised Fields and Sustainable Agriculture in the Lake Titicaca Basin." Pp. 230-248 in John Browder (ed.) *Fragile Lands of Latin America: Strategies for Sustainable Development*. Boulder, CO: Westview Press.
- Farrington, Ian, ed. (1985) *Prehistoric Intensive Agriculture in the Tropics*. Oxford: British Archaeological Reports, International Series, No. 232, Part i and ii.

- Ferne, R. A. (1970) *Shaykh and Effendi: Changing Patterns of Authority among the El Shabana of Southern Iraq*. Cambridge, MA: Harvard University Press.
- Flannery, Kent V. (1972) "The Cultural Evolution of Civilizations." *Annual Review of Ecology and Systematics* 4:399-426.
- Fonseca Martel, César (1974) "Modalidades de la minka" ("Types of Minka"). Pp. 86-109 in Giorgio Alberti & Enrique Mayer (eds.), 1974b, *supra*.
- Garaycochea Z., Ignacio (1986a) *Rehabilitación de camellones en la comunidad campesina de Huatta, Puno* (Rehabilitation of Raised Fields in the Peasant Community of Huatta, Puno). Agricultural Engineering thesis, Department of Agronomy, Universidad Nacional del Altiplano, Puno, Peru.
- (1986b) "Potencial agrícola de los camellones en el altiplano Puneño" ("Agricultural Potential of the Raised Fields in the Puno Plateau"). Pp. 241-251 in Carlos de la Torre & Manuel Burga (eds.) *Andenes y camellones en el Perú andino: Historia, presente y futuro* (Terraces and Raised Fields in Andean Peru: History, Present and Future). Lima: Consejo Nacional de Ciencia y Tecnología.
- (1987) "Agricultural Experiments in Raised Fields in the Titicaca Basin, Peru: Preliminary Considerations." Pp. 385-398 in William M. Denevan, Kent Mathewson & Gregory Knapp (eds.), 1987, *supra*.
- (1988) *Community Based Organisations and Rural Development with a Particular Reference to Andean Peasant Communities*. M.A. Thesis, Agricultural Extension and Rural Development Centre, Reading University, Reading, England.
- Geertz, Clifford (1980) *Negara*. Princeton, NJ: Princeton University Press.
- Gelles, Paul H. (1986) "Sociedades hidráulicas en los Andes: Algunas perspectivas desde Huarochiri" ("Hydraulic Societies in the Andes: Some Perspectives from Huarochiri"). *Allpanchis* 27 (año 18):99-148 (Cuzco).
- (1990) *Channels of Power, Fields of Contention: The Politics and Ideology of Irrigation in an Andean Peasant Community*. Ph.D. dissertation, Harvard University.
- (n.d.a) "Ecology and Ritual: The Cultural Construction of Water Availability in Cabanaconde (Caylloma, Arequipa), Peru." Paper presented before the 47th International Congress of Americanists, New Orleans, 1991.
- (n.d.b) "Channels of Power, Fields of Contention: The Politics of Irrigation and Land Recovery in an Andean Peasant Community." Forthcoming in David Guillet & William P. Mitchell (eds.) *Irrigation at High Altitudes: Socio-political Aspects of Water Control in the Andes*. Washington, DC: American Anthropological Association.
- (n.d.c) "Equilibrium and Extraction: Dual Organization in the Andes." Manuscript.
- Glick, Thomas F. (1970) *Irrigation and Society in Medieval Valencia*. Cambridge, MA: Harvard University Press.
- Golson, Jack (1977) "No Room at the Top: Agricultural Intensification in the New Guinea Highlands." Pp. 602-638 in J. Allen, J. Golson & Rhys Jones (eds.) *Sunda and Sahul*. New York: Academic Press.
- Gómez-Pompa, Arturo, Héctor Luis Morales, Epifanio Jiménez Avila, and Julio Jiménez Avila (1982) "Experiences in Traditional Hydraulic Agriculture." Pp. 327-342 in Kent V. Flannery (ed.) *Maya Subsistence*. New York: Academic Press.
- Gorecki, Pawel P. (1982) *Ethnoarchaeology at Kuk: Problems in Site Formation Processes*. Ph.D. dissertation, Department of Anthropology, University of Sydney.
- Grace, Barry (1983) *The Climate of the Altiplano, Department of Puno*. Puno: Canadian International Development Agency.
- Graffam, Gray (1989) "Back across the Great Divide: The Pakaq Señorío and Raised Field Agriculture." Pp. 33-50 in Virginia J. Vitzthum (ed.) *Multidisciplinary Studies in Andean Anthropology*. Ann Arbor: Michigan Discussions in Anthropology, 8 (Fall 1988).

- _____. (1990) *Raised Fields without Bureaucracy: An Archaeological Examination of Intensive Wetland Cultivation in the Pampa Koani Zone, Lake Titicaca, Bolivia*. Ph.D. dissertation, University of Toronto.
- _____. (1992) "Beyond State Collapse: Raised Fields and Pastoral Finance in the South Andes." *American Anthropologist* 94:882-904.
- Gray, Robert F. (1963) *The Sonjo of Tanganyika: An Anthropological Study of an Irrigation-Based Society*. London: Oxford University Press.
- Guillet, David (1981) "Land Tenure, Agricultural Regime, and Ecological Zone in the Central Andes." *American Ethnologist* 8:139-156.
- _____. (1987) "Terracing and Irrigation in the Peruvian Highlands." *Current Anthropology* 28:331-348.
- _____. (1992) *Covering Ground: Communal Water Management and the State in the Peruvian Highlands*. Ann Arbor: University of Michigan Press.
- Harris, David (1978) "The Agricultural Foundations of the Lowland Maya Civilization: A Critique." Pp. 301-324 in Peter Harrison & B. L. Turner II (eds.), 1978, *infra*.
- Harrison, Peter D., and B. L. Turner II, eds. (1978) *Pre-Hispanic Maya Agriculture*. Albuquerque: University of New Mexico Press.
- Hastings, Charles, and Michael Moseley (1975) "The Adobes of Huaca del Sol and Huaca de la Luna." *American Antiquity* 40:196-203.
- Hastorf, Christine (1992) *Agriculture at the Onset of Political Inequality*. Cambridge, ENG: Cambridge University Press.
- Heider, Karl (1970) *The Dugam Dani: A Papuan Culture in the Highlands of West New Guinea*. New York: Wenner-Gren Foundation, Viking Fund Publications in Anthropology, No. 49.
- Hunt, Robert C. (1988) "Size and the Structure of Authority in Canal Irrigation Systems." *Journal of Anthropological Research* 44:325-355.
- Hunt, Eva, and Robert Hunt (1974) "Irrigation, Conflict and Politics: A Mexican Case." Pp. 127-158 in T. Downing & M. Gibson (eds.), 1974b, *supra*.
- Hunt, Robert, and Eva Hunt (1976) "Canal Irrigation and Local Social Organization." *Current Anthropology* 17:389-411.
- Hyslop, John (1990) *Inka Settlement Planning*. Austin: University of Texas Press.
- Isbell, Billie Jean (1985) *To Defend Ourselves: Ecology and Ritual in an Andean Village* (2nd ed.). Prospect Heights, IL: Waveland Press.
- Julien, Catherine J. (1983) *Hatuncolla: A View of Inca Rule from the Lake Titicaca Region*. Berkeley: University of California Press.
- Keatinge, Richard (1988) "Preface." Pp. xii-xvii in his (ed.) *Peruvian Prehistory*. Cambridge, ENG: Cambridge University Press.
- Kelly, William W. (1983) "Concepts in the Anthropological Study of Irrigation." *American Anthropologist* 85:880-886.
- Kolata, Alan L. (1983) "The South Andes." Pp. 241-286 in Jesse D. Jennings (ed.) *Ancient South Americans*. San Francisco: W. H. Freeman.
- _____. (1986) "The Agricultural Foundations of the Tiwanaku State: A View from the Heartland." *American Antiquity* 51:748-762.
- _____. (1987) "Tiwanaku and Its Hinterland." *Archaeology* 40(1):36-41.
- _____, ed. (1989) *Arqueología de Luqurmata, T. 2, La tecnología y organización de la producción agrícola en el estado de Tiwanaku (Archaeology of Luqurmata, Vol. 2, The Technology and Organization of Agricultural Production in the State of Tiwanaku)*. La Paz: Instituto Nacional de Arqueología and Ediciones Puna Punku.
- _____. (1991) "The Technology and Organization of Agricultural Production in the Tiwanaku State." *Latin American Antiquity* 2:99-125.

- Kolata, Alan, and Gray Graffam (1989) "Los campos elevados de Lukurmata, Bolivia" ("The Raised Fields of Lukurmata, Bolivia"). Pp. 173-212 in Alan Kolata (ed.), 1989, *supra*.
- Kolata, Alan L., and Charles Orloff (1989) "Thermal Analysis of Tiwanaku Raised Field Systems in the Lake Titicaca Basin of Bolivia." *Journal of Archaeological Science* 16:233-262.
- Kus, James (1980) "La agricultura estatal en la costa norte del Perú" ("State Agriculture on the North Coast of Peru"). *América Indígena* 40:713-729 (Mexico).
- Lansing, J. Stephen (1987) "Balinese 'Water Temples' and the Management of Irrigation." *American Anthropologist* 89:326-341.
- _____. (1991) *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali*. Princeton, NJ: Princeton University Press.
- Leach, Edmund (1959) "Hydraulic Society in Ceylon." *Past and Present* 15:2-26.
- Leaf, Murray J. (1992) "Irrigation and Authority in Rajasthan." *Ethnology* 31:115-132.
- Lees, Susan (1986) "Coping with Bureaucracy: Survival Strategies in Irrigated Agriculture." *American Anthropologist* 88:611-622.
- Lennon, Thomas J. (1982) *Raised Fields of Lake Titicaca, Peru: A Pre-Hispanic Water Management System*. Ph.D. dissertation, University of Colorado, Boulder.
- _____. (1983) "Pattern Analysis of Prehispanic Raised Fields of Lake Titicaca, Peru." Pp. 183-200 in J. P. Darch (ed.), 1983, *supra*.
- Lewis, Henry T. (1991) *Ilocano Irrigation: The Corporate Resolution*. Honolulu: University of Hawaii Press.
- Malpass, Michael (1987) "Prehistoric Agricultural Terracing at Chijra in the Colca Valley, Peru." Pp. 45-66 in William M. Denevan, Kent Mathewson & Gregory Knapp (eds.), 1987, *supra*.
- Marcus, Joyce (1983) "Lowland Maya Archaeology at the Crossroads." *American Antiquity* 48:454-488.
- Matheny, Ray T. (1978) "Northern Maya Lowland Water-Control Systems." Pp. 185-210 in Peter Harrison & B. L. Turner (eds.), 1987, *supra*.
- Matheny, Ray T., and Denise Garr (1983) "Variation in Prehispanic Agricultural Systems of the New World." *Annual Review of Anthropology* 12:79-103.
- Mathews, James E. (n.d.a) "Preliminary Investigations of Prehistoric Raised Fields in the Tiwanaku Mid-Valley, Tiwanaku, Bolivia." Paper presented before the 17th Annual Midwest Conference on Andean and Amazonian Archaeology and Ethnohistory, Mount Pleasant, MI, 1991.
- _____. (n.d.b) "Raised Field Excavations in the Middle Tiwanaku Valley, Bolivia: Implications for Chronology of Raised Field Agriculture." Manuscript.
- Mayer, Enrique (1974) "Las reglas del juego en la reciprocidad andina" ("The Rules of the Game in Andean Reciprocity"). Pp. 37-65 in Giorgio Alberti & Enrique Mayer (eds.), 1974b, *supra*.
- _____. (1977) "Beyond the Nuclear Family." Pp. 67-80 in Ralph Bolton & Enrique Mayer (eds.) *Andean Marriage and Kinship*. Washington, DC: American Anthropological Association, Special Publication No. 7.
- Millon, Rene (1962) "Variations in Social Response to the Practice of Irrigation Agriculture." Pp. 56-88 in Richard Woodbury (ed.) *Civilizations in Desert Lands*. Salt Lake City: University of Utah Anthropological Papers, No. 62.
- Mitchell, William P. (1973) "The Hydraulic Hypothesis: A Reappraisal." *Current Anthropology* 14:532-534.
- _____. (1976) "Irrigation and Community in the Central Peruvian Highlands." *American Anthropologist* 78:25-44.
- _____. (1977) "Irrigation Farming in the Andes: Evolutionary Implications." Pp. 36-59 in Rhoda Halperin & James Dow (eds.) *Peasant Livelihood: Studies in Economic Anthropology and Cultural Ecology*. New York: St. Martin's Press.

- (1991) *Peasants on the Edge: The Struggle for Survival and the Transformation of Social and Religious Organization in the Andes*. Austin: University of Texas Press.
- Montmollin, Oliver de (1987) "Temporal and Social Scales in Prehispanic Mesoamerica." *Archaeological Review from Cambridge* 6(1):51-61.
- Moore, Jerry D. (1988) "Prehistoric Raised Field Agriculture in the Casma Valley, Peru." *Journal of Field Archaeology* 15:265-276.
- Moseley, Michael (1992) *The Incas and Their Ancestors: The Archaeology of Peru*. London: Thames & Hudson.
- Moseley, M. E., R. A. Feldman, and C. R. Ortloff (1981) "Living with Crisis: Human Perception of Process and Time." Pp. 231-267 in M. Nitecki (ed.) *Biotic Crisis in Ecological and Evolutionary Time*. New York: Academic Press.
- Murra, John V. (1980) *The Economic Organization of the Inca State, Suppl. 1, Research in Economic Anthropology*. Greenwich, CT: JAI Press.
- Muse, Michael, and Fausto Quintero (1987) "Experimentos de reactivación de campos elevados del Peñón del Río, Guayas, Ecuador" ("Experiments in Reactivating the Raised Fields of Peñón del Río, Guayas, Ecuador"). Pp. 249-266 in W. M. Denevan, K. Mathewson & G. Knapp (eds.), 1987, *supra*.
- Netherly, Patricia (1984) "The Management of Late Andean Irrigation Systems on the North Coast of Peru." *American Antiquity* 49:227-254.
- Netting, Robert McC. (1974) "The System Nobody Knows: Village Irrigation in the Swiss Alps." Pp. 67-76 in T. Downing & M. Gibson (eds.), 1974b, *supra*.
- (1990) "Population, Permanent Agriculture, and Politics: Unpacking the Evolutionary Portmanteau." Pp. 21-61 in Steadman Upham (ed.) *The Evolution of Political Systems: Sociopolitics in Small-Scale Sedentary Societies*. Cambridge, ENG: Cambridge University Press.
- Orlove, Benjamin, and Ricardo Godoy (1986) "Sectorial Fallowing Systems in the Central Andes." *Journal of Ethnobiology* 6:269-304.
- Ortloff, C., and A. Kolata (1989) "Hydraulic Analysis of Tiwanaku Aqueduct Structures at Lukurmata and Pajchiri, Bolivia." *Journal of Archaeological Science* 16:513-535.
- Ortloff, C. R., M. E. Moseley, and R. A. Feldman (1982) "Hydraulic Engineering Aspects of the Chimu Chicama-Moche Intervalley Canal." *American Antiquity* 47:572-595.
- Palerm, Angel (1955) "The Agricultural Basis of Urban Civilizations in Mesoamerica." Pp. 28-42 in Julian Steward (ed.), 1955, *infra*.
- (1973) *Obras hidráulicas prehispánicas en el sistema lacustre del Valle de México (Prehispanic Hydraulic Works in the Lake System of the Valley of Mexico)*. Mexico, DF: Instituto Nacional de Antropología e Historia.
- Park, Thomas (1992) "Early Trends towards Class Stratification: Chaos, Common Property, and Flood Recession Agriculture." *American Anthropologist* 94:90-117.
- Parsons, James, and William Denevan (1967) "Pre-Columbian Ridged Fields in New World Archaeology." *Scientific American* 217(1):92-100.
- Parsons, Jeffrey (1991) "Political Implications of Prehispanic Chinampa Agriculture in the Valley of Mexico." Pp. 17-41 in H. Harvey (ed.) *Land and Politics in the Valley of Mexico*. Albuquerque: University of New Mexico Press.
- Patterson, Thomas (1992) *The Inca Empire: The Formation and Disintegration of a Pre-Capitalist State*. Oxford, ENG: Berg.
- Platt, Tristan (1987) "Of Mirrors and Maize: The Concept of *yanantin* among the Macha of Bolivia." pp. 228-259 in John Murra, Nathan Wachtel & Jacques Revel (eds.) *Anthropological History of Andean Politics*. Cambridge, ENG: Cambridge University Press.
- Pohl, Mary D. (1990a) "The Rio Hondo Project in Northern Belize." Pp. 1-19 in Mary Pohl (ed.), 1990b, *infra*.

- , ed. (1990b) *Ancient Maya Agriculture: Excavations on Albion Island, Northern Belize*. Boulder, CO: Westview Press.
- Pospisil, Leopold (1963) *Kapauku Papuan Economy*. New Haven, CT: Yale Publications in Anthropology, No. 67.
- Price, Barbara (1971) "Prehispanic Irrigation Agriculture in Nuclear America." *Latin American Research Review* 6:3-60.
- Puleston, Dennis E. (1977a) "Experiments in Prehistoric Raised Field Agriculture: Learning from the Past." *Journal of Belizean Affairs* 5:36-43.
- (1977b) "The Art and Archaeology of Hydraulic Agriculture in the Maya Lowlands." Pp. 449-467 in Norman Hammond (ed.) *Social Processes in Maya Prehistory*. New York: Academic Press.
- Ramos, Claudio (1986) "Evaluación y rehabilitación de camellones o 'kurus' en Asillo" ("Evaluation and Rehabilitation of Raised Fields, or 'kurus,' in Asillo"). *Allpanchis* 27(año 18):239-284 (Cuzco).
- (1990) *Rehabilitación, uso y manejo de camellones: propuesta técnica (Rehabilitation, Use and Management of Raised Fields: Technical Proposal)*. Lima: Programa de Rehabilitación y Uso de Waru-Waru, Centro Canadiense de Estudios y Cooperación Internacional-Centro de Comunicación Audiovisual para la Educación Popular.
- Rivera Sundt, Oswaldo (1989) "Una tecnología que viene del pasado" ("A Technology That Comes from the Past"). *Anales del Seminario de Desarrollo Rural, Serie Documentos* 4-1-119-90:60-91 (La Paz).
- Sanders, William T., and Barbara Price (1968) *Mesoamerica: The Evolution of a Civilization*. New York: Random House.
- Sanders, William T., Jeffrey R. Parsons, and Robert Santley (1979) *The Basin of Mexico: The Cultural Ecology of a Civilization*. New York: Academic Press.
- Sauer, Carl (1952) *Agricultural Origins and Dispersals: The Domestication of Animals and Foodstuffs*. New York: American Geographical Society.
- Scarborough, Vernon L. (1991) "Water Management Adaptations in Non-Industrial Complex Societies: An Archaeological Perspective." Pp. 101-145 in Michael Schiffer (ed.) *Archaeological Method and Theory, Vol. 3*. Tucson: University of Arizona Press.
- Seligmann, Linda, and Stephen Bunker (1986) "Organización social y visión ecológica de un sistema de riego andino" ("Social Organization and Ecological View of an Andean Irrigation System"). *Allpanchis* 27(año 18):149-179 (Cuzco).
- Serpenti, L. M. (1965) *Cultivators of the Swamps: Social Structure and Horticulture in a New Guinea Society*. Assen: Royal van Gorlum.
- Sherbondy, Jeanette (1982) *The Canal Systems of Hanan Cuzco*. Ph.D. dissertation, University of Illinois, Champaign-Urbana.
- (1987) "Organización hidráulica y poder en el Cuzco de los Incas" ("Hydraulic Organization and Power in Inca Cuzco"). *Revista Española de Antropología Americana* 17:1117-153.
- (1992) "Water Ideology in Inca Ethnogenesis." Pp. 47-66 in Robert Dover, Katherine Seibold & John McDowell (eds.) *Andean Cosmologies through Time: Persistence and Emergence*. Bloomington: Indiana University Press.
- Siemens, Alfred H. (1983) "Modelling Pre-Hispanic Hydroagriculture on Levee Backslopes in Northern Veracruz, Mexico." Pp. 27-54 in Janice Darch (ed.), 1983, *supra*.
- (1989) *Tierra Configurada (Configured Land)*. Mexico, DF: Consejo para la Cultura y las Artes.
- Smith, Clifford T., William M. Denevan, and Patrick Hamilton (1968) "Ancient Ridged Fields in the Region of Lake Titicaca." *The Geographical Journal* 134:353-367.
- Spooner, Brian (1974) "Irrigation and Society: The Iranian Plateau." Pp. 43-57 in T. Downing & M. Gibson (eds.), 1974b, *supra*.

- Stanish, Charles (1992) *Ancient Andean Political Economy*. Austin: University of Texas Press.
- (n.d.) "A Regional Settlement Perspective on Prehispanic Raised Field Agriculture in the Titicaca Basin." Manuscript.
- Steward, J., ed. (1955) *Irrigation Civilizations: A Comparative Study*. Washington DC: Pan American Union, Social Science Monograph No. 1.
- Treacy, John M. (1989a) "Agricultural Terracing in the Colca Valley: The Promises and Problems on an Ancient Technology." Pp. 209-229 in John Browder (ed.) *Fragile Lands of Latin America: Strategies for Sustainable Development*. Boulder, CO: Westview Press.
- (1989b) *The Fields of Corporaque: Agricultural Terracing and Water Management in the Colca Valley, Arequipa, Peru*. Ph.D. dissertation, University of Wisconsin, Madison.
- Turner, B. L. II (1983) "Constructional Inputs for Major Agrosystems of the Ancient Maya." Pp. 11-26 in J. P. Darch (ed.), 1983, *supra*.
- Turner, B. L. II, and Peter D. Harrison (1978) "Implications from Agriculture for Maya Prehistory." Pp. 337-374 in Peter Harrison & B. L. Turner II (eds.), 1978, *supra*.
- , eds. (1983) *Pulltrouser Swamp: Ancient Maya Habitat, Agriculture, and Settlement in Northern Belize*. Austin: University of Texas Press.
- Urton, Gary (1992) "Communalism and Differentiation in an Andean Community." Pp. 229-266 in Robert Dover, Katherine Seibold & John McDowell (eds.) *Andean Cosmologies through Time*. Bloomington: Indiana University Press.
- Valeri, Valerio (1991) "Afterword." Pp. 134-144 in Stephen Lansing *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali*. Princeton, NJ: Princeton University Press.
- Wachtel, Nathan (1982) "The *Mitimas* of the Cochabamba Valley: The Colonization Policy of Huayna Capac." Pp. 199-235 in George A. Collier, Renato I. Rosaldo & John D. Wirth (eds.) *The Inca and Aztec States, 1400-1800: Anthropology and History*. New York: Academic Press.
- Wheatley, Paul (1971) *The Pivot of the Four Corners*. Chicago: Aldine.
- Wilkerson, Jeffrey K. (1983) "So Green Like a Garden: Intensive Agriculture in Ancient Veracruz." Pp. 55-90 in Janice Darch (ed.), 1983, *supra*.
- Wittfogel, Karl A. (1955) "Developmental Aspects of Hydraulic Societies." pp. 43-52 in Julian Steward (ed.), 1955, *supra*.
- (1957) *Oriental Despotism*. New Haven, CT: Yale University Press.
- (1972) "The Hydraulic Approach to Pre-Spanish Mesoamerica." Pp. 59-80 in Frederick Johnson (ed.) *The Prehistory of the Tehuacan Valley, Vol. 4, Chronology and Irrigation*. Austin: University of Texas Press.
- Woodbury, Richard B. (1961) "A Re-Appraisal of Hohokam Irrigation." *American Anthropologist* 63:550-560.
- Zipf, George K. (1949) *Human Behavior and the Principle of Least Effort*. Reading, MA: Addison-Wesley.
- Zuidema, R. Tom (1986) "Inca Dynasty and Irrigation: Another Look at Andean Concepts of History." Pp. 177-200 in John Murra, Nathan Wachtel & Jacques Revel (eds.) *Anthropological History of Andean Politics*. Cambridge, ENG: Cambridge University Press.
- (1990) *Inca Civilization in Cuzco*. Austin: University of Texas Press.

PART V

DISCUSSION
