IRRIGATION FARMING IN THE ANDES: EVOLUTIONARY IMPLICATIONS | 3

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This paper explores the role of irrigation in the farming and communal life of a village in the Peruvian Andes by examining the organization of irrigation activities. Irrigation here is an adaptation to high altitude agriculture as it is organized in higher and lower zones. Dry and rainy seasons imply different principles of water distribution as well. By modifying the effects of natural ecological conditions, irrigation broadens the range of crops grown at high altitudes. The regulation and celebration of irrigation are significant aspects of the political and ritual life of the community. A dual residential barrio organization structures a dual irrigation system which is, in turn, based on dual drainage systems founded on the natural hydrology of the mountain slope.

The information from the contemporary community of Quinua is used to illuminate the water needs of Huari, an important archeological site located there. Mitchell suggests the probability that the patterns of irrigation control found in Quinua represent an ancient Andean structure and discusses the significance of the data for Wittfogel's and Steward's hydraulic hypothesis. The data suggest that irrigation was significant in the local community, but not in the evolution of the larger bureaucratic state in highland Peru.

The role of irrigation in communal organization has long intrigued scholars.* The hydraulic hypothesis of Wittfogel (1955, 1956, 1957, 1972) and Steward (1949, 1955a; Steward et al. 1955) is one manifestation of this concern. As originally proposed, this theory focused on the peculiar organizational requirements assumed to be associated with large-scale irrigation. It was postulated that large-scale irrigation requires centralized coordination to build and maintain canals and dams, as well as to distribute water. In areas where water is a scarce resource, that is, in arid and semiarid localities, this centralized control of the irrigation system

leads to increased political integration. Thus, irrigation is considered a major "cause" of the emergence of centralized political authority and supracommunity political organization.

In his research Wittfogel has emphasized the role of irrigation in the development of authoritarian political patterns of the type called "oriental despotism." Steward, on the other hand, used Wittfogel's theory to explain the origin of the "irrigation civilizations"—Mesopotamia, Egypt, China, Mesoamerica, and the Central Andes. He later revised his hypothesis of state development to incorporate other causal factors, such as microterritorial specialization, exchange of produce, and the presence of many crop varieties (Steward 1955b, 1968a, 1970). Nonetheless, Steward continued to regard irrigation as of great importance in the evolution of civilization in general, and in the development of Peruvian civilization in particular (Steward 1968a: 323; 1970: 200, 212–214, 220).

Various scholars, often working with the very same data, have both supported or attacked the hydraulic theory. However, many of their criticisms have been misdirected because of a poor understanding of the relevant variables, a point which I have elaborated elsewhere (Mitchell 1973b). The problems of analysis can be avoided if the hypothesis is reformulated to change the independent variable from the *size* of the irrigation system itself (i.e., large-scale) to the *manner* in which irrigation activities are organized. The hypothesis then becomes: If irrigation is regulated centrally in arid or semiarid environments, then there is a corresponding increase in centralized political power in other areas of social life. The extent of political power varies directly with the extent of the irrigation system and its importance to the local economy. The hypothesis in this form has not yet been tested.

In spite of the considerable theoretical interest in irrigation, we actually know very little about the ways in which societies organize their irrigation activities. Only a few studies have focused on irrigation in contemporary societies (cf. Downing and Gibson 1974; Gray 1963; Hunt and Hunt 1974; Fernea 1970; Kirkby 1973; Lees 1973; Maktari 1971; Millon 1962; Millon, Hall, and Diaz 1962). Moreover, although Peru is often cited as an example of an ancient irrigation civilization (Price 1971; Sanders and Marino 1970: 104–105; Steward 1949, 1970; Steward et al. 1955; Wittfogel 1957: 246–249 and *passim*), there has been no intensive analysis of irrigation in a contemporary community of Peru. Irrigation is usually mentioned only briefly, the few longer descriptions are limited to irrigation ritual (cf. Arguedas 1964; Isbell 1972).

This paper is intended to fill this gap in our ethnographic knowledge by analyzing the role of irrigation in the economic and communal organization of Quinua, a Quechua-speaking community of the central Peruvian highlands. The paper begins by describing the general setting of Quinua. My research describes the core of the community, which is centered around the Lurin Sayoc—Hanan Sayoc irrigation network.

Because a knowledge of local ecology is crucial for an understanding of irrigation, the section on climate and ecology describes these phenomena in some detail. The physical structure of the irrigation system and its function in agriculture are then outlined. Irrigation canals extend for several miles and are the primary source of drinking water. Essential to agriculture, irrigation is the mechanism by which farming is adapted to the vertical ecology of the mountain slope. Irrigation permits the cultivation of a broader range of crops at higher altitudes than would be possible with natural rainfall alone. The sections on the distribution of water and on the cleaning and ritual celebration of the irrigation system outline the importance of irrigation in Quinua's political and ritual life. The data from Quinua are then placed in comparative perspective by a review of the literature dealing with irrigation in Peru. These data suggest that relationships between irrigation and community, similar to those in Quinua, are more widespread in highland Peru than has hitherto been realized. Finally, in the discussion, the significance of the data for the Wittfogel-Steward hypothesis is analyzed. These data suggest that irrigation was important in the evolution of the local communty but not in the evolution of the larger, bureaucratic state in Highland Peru.

There is a further significance to the data from Quinua. Because the archeological site of Huari is located within Quinua, the data on irrigation in the contemporary community provide some insight into the water needs of this important urban center. Although the conception of hydraulic society in ancient Peru has focused on the intensively irrigated coast, the earliest large empires originated in the highlands. One of the earliest and most important of these empires is Huari, which flourished between A.D. 600 and 750, and conquered much of what is contemporary Peru (Lanning 1967: 127-140, Lumbreras 1974: 151-177; Patterson 1973: 100-102). Indeed, it is Huari that may have invented the Andean pattern of "... centralized and despotic political organization [along with] an eagerness for conquest initiated by powerful and wealthy classes in the city" (Lumbreras 1974: 165). The data from Quinua permit us to make inferences about the nature of Huari ecological adaptations and the probable role of irrigation in Huari development. Such conclusions, of course, assume a certain continuity between past and present—an assumption which must be verified by means of archeological research. However, analysis of irrigation use throughout Peru suggests that such an assumption is not unwarranted.

Location and Setting

Quinua is a district in the central Peruvian highlands (Arnold 1970, 1972a, 1972b, 1975; Mitchell 1972, 1973a, 1974a, 1974b; Tschopik 1947: 31-34). It is located to the northeast of the city of Ayacucho on the western

slopes of the range of mountains forming the eastern wall of the Ayacucho valley. The elevation of the central town is slightly less than 3,396 meters. The topography of Quinua, as in much of the highlands, consists of gentle slopes interspersed with deep and rugged ravines and gorges. These ravines (*wayqu*) are numerous and provide drainage during the rainy season. Cultivated terrain is generally found on the slopes, although land may be sown at the bottom of some of those larger ravines which do not flood during the rainy season.

Quinua is a Peruvian district. It consists of a central town surrounded by rural hamlets and dispersed settlements. The town is the administrative and ceremonial center of the district. In addition, the district is divided into geopolitical units or hamlets known as *pagos*. The center of a hamlet is usually a small nucleated village. In addition to its center, every hamlet has a group of localities (*sitios*) that pertain to it for administrative purposes.

The district is organized into two *barrios*: Lurin Sayoc and Hanan Sayoc. This division is very important in the political, religious, and ecological organization of the community. Each barrio has its own irrigation system. The barrios also alternate in giving annual religious fiestas. In the recent past each barrio also had a separate rural political organization (*varayoc*). These barrios are not moieties, a term which should be restricted to dual kinship divisions (Murdock 1949: 47). Membership and participation in the barrio is determined by residence; it is not based on rules of descent. Moreover, the barrios are not upper and lower altitudinal divisons as is frequently assumed to be the case in other parts of the Andes.

Barrio divisions are very ancient in Peru, going back to Inca and probably pre-Inca times (Baudin 1961: 139-140; Castro Pozo 1946: 484; Garcilaso de la Vega 1966: 44-45; Kirchoff 1949: 301; Means 1964: 306-308; Montesinos 1920: 29-30; Rowe 1946: 255-256 and 262-263). They are found widely in the highlands today, although the division is sometimes into three or four rather than two units (Adams 1959: 87-88; Arguedas 1964: 221-223; Isbell 1972; Mishkin 1946: 443; Snyder 1960: 78-81; Stein 1961: 125; Tschopik 1946: 541; Tschopik 1951: 152). As we shall see, the barrio division in Quinua has a hydrologic basis and the same may be true in other areas of the highlands as well.

Quinua is an independent community in which most people own their own lands. Except for a small ruling group of townsmen, and recently educated young people, most of the population of 5,348 people consists of Quechua-speaking peasants, *campesinos* (Mitchell 1974a).[1]

The people of Quinua are subsistence farmers. Although everyone sells surplus crops from time to time, only a few townsmen produce cash crops in any significant way. Nonetheless, people ordinarily do not produce all the food that they consume. Agricultural production is directly related to the mountain ecology and each ecozone specializes in particular foodstuffs (Mitchell 1974b). Although Quinuenos try to have fields located in several ecozones, they are never able to achieve complete self-sufficiency. Consequently, there is a lively exchange in foodstuffs between various ecozones. Moreover, Quinuenos have traditionally obtained goods through trade with other areas of Peru, such as coca and chili peppers from the montaña jungles to the east, and wool and hides from Huancavelica, a high-altitude region to the west.

The market, held in the central town each Sunday, is an important mechanism for integrating the exchange between different ecozones. Most exchanges in the market are by barter—women of different ecological zones exchanging their surplus crops. In addition, a man or woman occasionally may journey to a different ecozone to trade. The person may, for example, bring potatoes and wool from the higher altitudes to exchange for corn grown in lower altitudes. Some men, in the past, also engaged in long-distance trade by mule train with other areas of Peru. Since the increase in truck transportation, such organized trade by mule train has disappeared. Today, some individuals may take their own

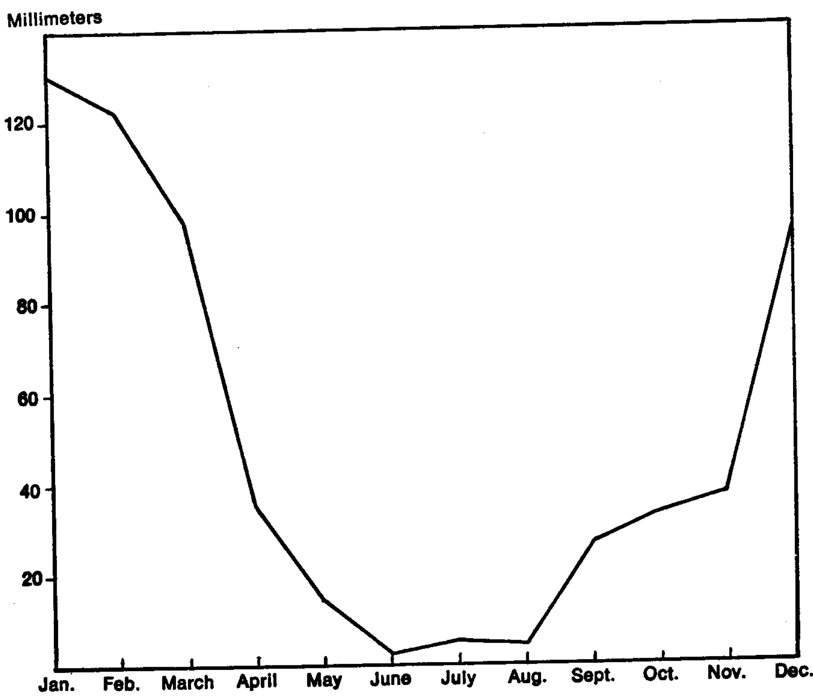

Figure 3-1 MEAN ANNUAL RAINFALL IN CITY OF AYACUCHO 1962–1965

Data from Rivera 1967

produce, usually to Ayacucho or Lima, by truck. Such exchange, however, is still very small in scope.

Climate and Ecology

Agriculture in Quinua, as elsewhere in the world, is dependent upon temperature and moisture. In Quinua, these variables are determined by the seasons of the year and by altitude. Because irrigation is used to modify the effects of these natural forces, it is necessary to discuss them briefly.

Quinua has two major seasons: the rainy season and the dry season. The rain begins gradually in September or October, increases in intensity until it reaches its maximum in January and February, then tapers off until it ends around April. The dry season begins in May and lasts until September or October (Rivera 1967, 1971: 37–45; see Figures 3-1 and 3-2). The onset and end of each of the seasons vary from year to year. The amount of rainfall at the beginning of the rainy season differs considerably from one year to the next. It is not until December that the rains

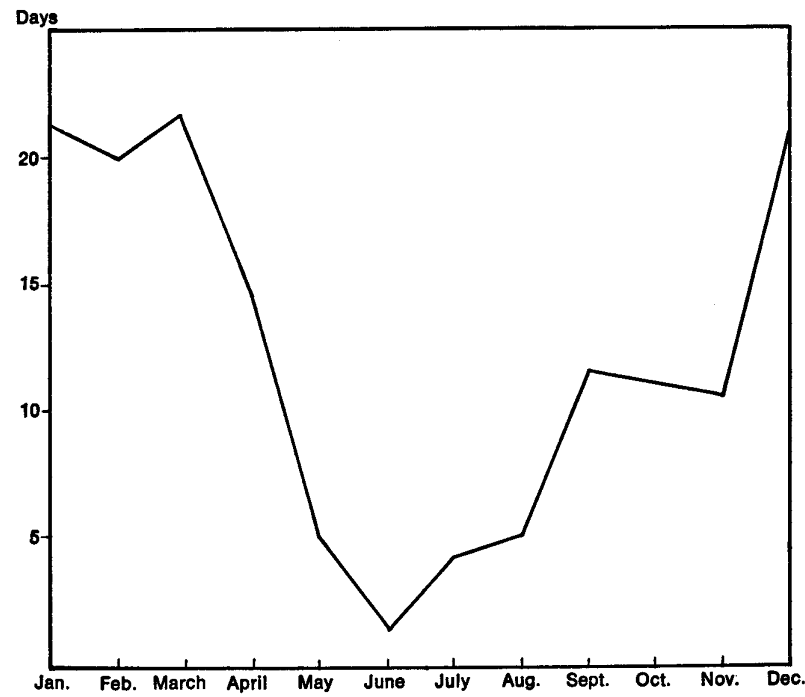

Figure 3-2 MEAN NUMBER OF DAYS WITH RAINFALL IN CITY OF AYACUCHO 1962–1965

Data from Rivera 1967

consistently come in full force. Distinct dry periods also occur in the middle of the rainy season itself.

Temperature varies with the seasons (see Table 3-1). The dry season, especially June and July, is the coldest period, and a frost sometimes forms at night in these months (Rivera 1967; 1971: 30-37). The temperature increases gradually in August, so that the rainy season is the warmest time of year. Although the data in Table 3-1 are for the city of Ayacucho, the situation is similar to Quinua, except that Quinua is colder.

Moisture and temperature are also affected by altitude (Mitchell 1974b). The higher the altitude, the colder the climate. In addition, altitude affects cloud cover and moisture loss. Higher altitudes are cloudier, a frequent phenomenon in mountain environments such as Peru (cf. Bowman 1916: 155; Hunt and Hunt 1974; 137; Peattie 1936: 65-66). The farther down the mountain slope, the greater the total amount of sunshine. Both sunshine and high temperature cause greater water loss from soil and plants (evapotranspiration), so that the terrain becomes drier as one moves down the mountain slope (Arnold 1975; Tosi 1960).[2]

The effects of altitude on temperature and moisture produce five major ecological zones in Quinua (Arnold 1975; Mitchell 1974b; see Table 3-2).[3] Agriculture is practiced in all but the highest zone, which is too cold. Irrigation farming, however, is restricted to the lower montane savannah and the valley bottom.

The highest ecological zone is the alpine rain tundra/subalpine wet paramo (4,100+m). This zone, usually characterized as the high puna in Peru, is above the level of agriculture, and is very cold, moist, and cloudy. Below it lies the montane prairie (4,000-4,100 m). This area is characterized by *ichu* grass and other frost-resistant, small-size vegetation. It is

Table 3-1 MEAN TEMPERATURE IN CITY OF AYACUCHO, 1962-1966

	Degrees Centigrade		
Month	AVERAGE TEMPERATURE	ABSOLUTE MAXIMUM	ABSOLUTE MINIMUM
January	15.6	27.0	7.0
February	15.2	25.4	7.0
March	14.6	25.2	6.2
April	14.9	26.3	3.4
May	14.2	25.6	2.2
June	12.4	25.0	-0.2
July	13.0	25.4	-0.5
August	14.1	26.6	1.4
September	15.0	27.1	4.3
October	16.1	27.8	4.6
November	16.6	29.6	4.7
December	16.0	28.0	5.9

SOURCE: Data from Rivera 1967.

somewhat warmer than the higher zone, so that although still above the tree line, tubers can be grown there. Still farther down the mountain slope is the moist forest (3,400-4,000 m). It is characterized by a dense underbrush of small trees and shrubs. It is warmer than higher zones, so that frost-resistant, quick-maturing crops are grown in addition to tubers. The lower montane savannah (2,850-3,400 m) is immediately below the moist forest. The central town is located in the savannah and most of Quinua's population lives here. It is Quinua's major cultivation region and the area in which eucalyptus trees are grown. Most fields in the savannah are irrigated, and it is farming in this zone that is described below. The savannah is divided on the basis of irrigation use and altitude into two ecological regions: the upper savannah (3,050-3,400 m) and lower savannah (2,850-3,050 m). In Quinua the upper savannah is more than two times greater in area than the lower savannah. Immediately below the savannah lies the lowest environmental zone in Quinua, the lower montane thorn steppe (2,500-2,850 m). This zone includes the bottom of the Ayacucho valley and is much warmer, sunnier, and drier than the higher ecological zones. It is covered with cactus and in some areas the vegetative cover resembles a cactus forest. Most of the thorn steppe is unirrigated. It is too dry to be maintained with the very limited irrigation water descending from the savannah, so that only plants with low water needs are grown. Irrigation farming is practiced in this zone only at the bottom of the Ayacucho valley, where a plentiful supply of water is obtained from the Rio Chacco. This valley irrigation has different ecological functions from that in the savannah, and is outside the scope of this report. Irrigation in this region is not a high-altitude adaptation, as in the savannah, but an adaptation to the dry season to permit double cropping.

The Irrigation System

The central area of Quinua lies on a mountain slope with two major drainage systems. One system drains into Huamangura ravine, while the other drains into Hatun Wayqu (big ravine). The dual division of Quinua into Lurin Sayoc barrio and Hanan Sayoc barrio reflects this hydrological situation, and the ecological and cultural boundaries coincide. The hydrologic basis for the barrio division is not verbally recognized by the community, and it may be for this reason that it has not been reported elsewhere in Peru, although the literature suggests that the pattern occurs elsewhere.

The irrigation system exploits these drainage patterns. There are two separate irrigation systems: one for the barrio of Hanan Sayoc and another for Lurin Sayoc. The source of irrigation water is in the alpine rain tundra/subalpine wet paramo and montane prairie. These zones are

Table 3-2 QUINUA ECOLOGICAL ZONES

Ecological Zone	*Elevation*	*General Characteristics*	*Irrigation Use*	*Climate*
Alpine Rain Tundra and Subalpine Wet Paramo	4,100 m+	High *puna* grasslands Grazing	Source of irrigation water	Cold, moist, cloudy
Montane Prairie	4,000–4,100 m.	Grassland Grazing and tuber cultivation	Source of irrigation water	
Montane Moist Forest	3,400–4,000 m	Dense underbrush of small trees and shrubs Cultivation of tubers and frost resistant, quick-maturing crops	Beginning of irrigation canals *ñawin*	↔
Lower Montane Savannah	2,850–3,400 m	Town of Quinua and major population zone Major cultivation zone	Zone of irrigated fields	
Lower Montane Thorn Steppe	2,500–2,850 m	Xerophytic vegetation Nonirrigated cultivation of short growth plants with low water needs Site of Huari	Valley bottom irrigation	Warm, dry, sunny

very moist and contain many springs and streams. Nonetheless, the water available for irrigation is sufficient only for supplementary purposes, and neither system has enough water to irrigate a dry season crop for the entire district.

The Quinua irrigation systems comprise what Robert Murphy calls "district irrigation" (in an unpublished paper cited by Wolf and Palerm, 1955). They connect several hamlets, yet are relatively small scale. The canals are not of uniform size, but vary between 25 and 85 cm wide, and between 25 and 100 cm deep. Each system extends for several miles and supplies several hamlets.

The canal system of both barrios begins in the moist forest. The region of irrigated fields is the savannah. Most fields in this zone are irrigated. The few exceptions are those fields located on ground too high for the water to reach. Canals usually flow on one side of a footpath. In the upper reaches of the system there are few branch channels. In the region of cultivated fields, however, a great many canals branch off the principal ones. These minor canals follow along the borders of the fields. Usually they are dry, and are put into use only as a particular field is irrigated.

Several reservoirs are used to store irrigation water. The two major reservoirs, located just above the central town, are filled at night. During the day, when the fields are irrigated, water can be obtained from the reservoir, or directly from the major irrigation canal, or the two sources may be combined. The reservoir is preferred because it supplies more water.

The area around the central town and the reservoirs is covered by a network of minor canals. It is these canals that permit reservoir water and canal water to be used separately. In addition, feeder canals connect the two irrigation systems in this area. These canals permit water to be diverted from either system to the other. However, water is rarely shared because of communal opposition. An additional feeder canal was built in the past decade, bringing Hanan Sayoc water from the central town to the Lurin Sayoc system at Uqi Rumi. The original diversion of Hanan Sayoc water caused considerable opposition in Hanan Sayoc, but the opposition gradually disappeared. At the present time the feeder canal is used frequently to provide Hanan Sayoc water for Murunkancha and two haciendas near Huari, areas traditionally served by the Lurin Sayoc system.

A simple system of gates is used. At the beginning of the Lurin Sayoc system, the water is diverted from the river to the canals by a very small dam. This dam, similar to those described by Woodbury and Neely (1972) for the Tehuacán Valley of Mexico, extends partway into the river and is made of stones and sod. The size of the dam may be easily modified. Regulation of water flow is crucial to the preservation of the canals, as an overflow would destroy them. In the canal system itself, water is similarly diverted. An open channel is blocked by transferring the stones and sod from a previously blocked channel. The procedure is similar in Hanan Sayoc, except that a modern cement dam is used to store water at Lake Yanaqucha Chica, the water source of the system, and a modern metal gate is used at the beginning of the canal system.

The irrigation canals and reservoirs are made of earth. Cement is used only occasionally. Consequently, seepage is a major problem. In one area a subsidiary canal follows below the major one to collect seepage.

Because there are relatively few natural springs in the savannah, irrigation also provides drinking water for people and animals. Most homes outside the central town have cisterns which are connected to the system. In addition, the Hanan Sayoc irrigation system was modified during the past decade to provide "potable" water directly to households in the central town. This potable water system also powers the town's electric generator, which was built at the same time.

Irrigation and Agriculture

It is frequently assumed that irrigation in the Andes is an adaptation to "... the long dry season and the rapid evaporation of rain water" (Metraux 1969: 67). While true, such a conception is greatly oversimplified. Irrigation in the savannah of Quinua is primarily an adaptation of high-altitude agriculture.

Quinua has two agricultural cycles: a dry season cycle (the *michka*) and a rainy season cycle (*hatun tarpuy*). Different fields are used for each crop cycle. The dry season cycle is restricted to a small proportion of the fields in the savannah. Dry season crops are planted early, usually at the beginning of August, and depend on irrigation. The amount of irrigation needed depends on the rain, as well as on the type of crop and soil. If there is no rain at all, a rare circumstance, most crops are irrigated about once a week. Sometimes this early planting is used for double cropping. Two quick-maturing crops are planted in succession. The second crop, planted around November or December, uses natural rainfall. Generally, however, the land lies fallow between dry season crops. There is inadequate irrigation water for a dry season crop throughout the district, so that the dry season planting is found only in the upper savannah, near the beginning of the irrigation system. It is distributed this way for natural, rather than political, reasons. Because of the great distance, it is much more difficult for people in the lower savannah to irrigate their fields. Since they also lose more water by seepage and evaporation, but need more water because of lower altitude dryness, they forego planting a dry season crop.

The more important, and more widespread, agricultural cycle is the rainy season planting. It produces most of the district's foodstuffs and is

present in all the ecological zones that are farmed, but utilizes irrigation only in the savannah and the valley bottom section of the thorn steppe. In the montane prairie and moist forest, the two highest zones with agriculture, the rainy season crops are planted in November or December with the onset of the rains. In these zones a limited repertoire of frost-resistant and quick-maturing crops are grown without irrigation (Mitchell 1974b). In the lower montane savannah, however, the rainy season crops are irrigated. In the upper savannah irrigation is used from September to December to extend the growing season. In the lower savannah it is used from January to April to supplement natural rainfall.

In the upper savannah irrigation is used at the beginning of the rainy season cycle to permit the planting of crops prior to the onset of the rains. This extends the growing season for crops which have longer maturation periods at higher altitudes. Because higher altitudes are colder and cloudier, they are suitable only for certain crops and even the crops grown there require a long growing season. For example, *almidon*, the most important variety of maize, requires a nine month growing season in the upper savannah, near the central town, but only six months in the lower savannah, near the hamlet of Llamahuillca. Since the rainy season usually lasts about six months, the natural growing season is too short for many important crops in the upper savannah. At these altitudes only such crops as wheat, *habas*, barley, potatoes, *olluku*, oca, and *maswa* can be grown in most years with natural rainfall alone. Other crops require the use of irrigation to extend the growing season. The most important crop in this regard is maize, especially almidon, the most important variety; indeed, informants nearly always specify maize whenever discussing irrigation.[4] However, since beans, squash, and a low-altitude variety of quinoa are frequently grown together with maize, it is probable that irrigation is used to extend the growing season of these important crops as well.

Because the amount of irrigation water is very limited, the rainy season cycle is usually planted in the upper savannah over a period of several months. It starts in the highest altitudes in September and descends, field by field, until the rains begin. With the onset of the rains the irrigation sequence is abandoned and everyone cultivates his fields simultaneously. In some years, the rains permit cultivation as early as September, although an adequate amount of rain usually doesn't arrive until December.

Irrigation is used in the upper savannah to prepare the soil, which is dry and very hard, for planting. A farmer soaks the soil thoroughly, then leaves the field to dry a day or two before plowing, after which the seed is sown. The moisture that remains in the soil from this irrigation, when combined with the sporadic rainfall at this time, is usually sufficient to permit the germination of the seeds. In very dry years the crop may require supplementary irrigation, although very little water is available for this purpose. Maize, perhaps the crop with the longest growing time, is usually planted first. Unirrigated fields usually cannot be planted until December. On such fields Quinuenos usually plant short-growth crops, such as wheat and barley. However, if the rains do come sufficiently early, even late-maturing maize can be planted in unirrigated fields.

Irrigation is used at the beginning, rather than the end, of the rainy season cycle because of moisture and frost variables. Since there is less evapotranspiration at higher altitudes, parts of the upper savannah are sometimes spongy with water during the rainy season. This causes rotting of the young roots, especially those of maize. Once the crops are established, however, rotting is not a problem. Thus, by enabling the planting of crops prior to the rainy season, irrigation is also a mechanism for ensuring proper drainage for seedlings at high altitudes. Indeed, Quinuenos describe this as the major function of the irrigation system.

The early planting of the rainy season cycle is also an adaptation to seasonal frost. The time of planting must be early enough to permit frost-sensitive crops to ripen before June and July. It is for this reason that the rainy season cycle is extended at the beginning rather than the end of the crop cycle. It is for the same reason that irrigation is not utilized in the moist forest, but is confined to the savannah. Since crops take longer to mature at higher altitudes, irrigation would be of no use in the moist forest because the growing season of late-maturing crops such as maize would extend into the period of frost.

Irrigation is used differently in the lower savannah. At these lower elevations irrigation is used to supplement natural rainfall during the growing season itself, rather than to extend the length of the growing season. In the lower savannah, crops mature more rapidly, as there is greater sunshine and higher temperatures. Here the rainy season and time needed for the maturation of most crops coincide, so that the rainy season cycle begins with the onset of the rains. However, this area is drier than the upper savannah, so that there is a greater need for supplementary irrigation during the rainy season itself. Irrigation is especially needed during the brief dry periods when the rains recede. At this time, except in years of real drought, water is not needed in the moister upper savannah and is sent down the slopes.

Except for a recent extension of the system to Mitoccasa, irrigation does not extend into the thorn steppe because of insufficient water and considerable seepage. Indeed, the branch to Mitoccasa has not yet been used for this very reason. In the thorn steppe there is also less rain and increased evaporation from the soil (Tosi 1960); consequently agriculture in this zone has a reduced crop repertoire (Mitchell 1974b). Such crops as wheat, peas, chick-peas and *qewinka* (a type of squash) are grown, but not most varieties of maize. A more varied crop repertoire would require extensive irrigation throughout the growing season.

In sum, irrigation in Quinua is an adaptation to agriculture in the lower montane savannah (see Table 3-3). It is used differently at high and low altitudes within the savannah, although it provides water for domestic purposes throughout this zone. In the upper savannah it is used to plant an early dry season crop. However, its most important use is during the rainy season cycle. In the upper savannah it is used during this cycle from September to November to extend the growing season. This permits the cultivation in this zone of most varieties of maize, and probably beans, most squash, and a low altitude variety of quinoa. It effectively doubles the area of cultivation of these crops. In the lower savannah, on the other hand, the requirements of these crops coincide with the available temperature, sunshine, and length of the rainy season, so that irrigation is used from January to April only as a supplementary source of water. What is impressive here is the economical dovetailing of functions of the irrigation system. Because of the vertical series of environmental zones, a limited amount of water goes at successive times to different places to be used for different purposes, and each region benefits according to its requirements.

Water Distribution

Different principles of water distribution operate for the dry season cycle, the rainy season cycle, and domestic usage. Political authorities are involved only during the rainy season planting, the period in which water needs are most critical. At other times, water is distributed on an informal basis by those seeking it.

Not all farmers plant a dry season crop. At the beginning of the dry season cycle water is available daily. Water is distributed by those needing it on a first-come, first-served basis. Neighbors usually go to obtain water in a group and irrigation water may be needed once a week. However, when the rainy season planting begins in September, it takes precedence

Table 3-3 IRRIGATION USE IN LOWER MONTANE SAVANNAH

Zone	*Dry Season*	*Rainy Season*
Upper Savannah cold moist	Domestic Dry season crop cycle Rainy season crop cycle a. extend growing season by preparing soil early b. prevent root rot c. guard against frost at end	Domestic
Lower Savannah warm dry	Domestic	Domestic When rains recede in rainy season crop cycle

and water is available for the dry season cycle only on Sundays. This one day is insufficient to provide all the farmers in the district with irrigation water for a dry season crop. Therefore, only those closest to the beginning of the irrigation system are able to plant the dry season crop.

During the rainy season planting, water is distributed by political officials in a formalized system known as *yaku patacha*. The planting sequence of the cycle determines division of the water, so that higher fields receive water first. The system of branching canals ensures coverage of all areas at a particular altitude before water is sent to the next level. For example, in the Lurin Sayoc irrigation system, the water is first diverted to Moya. After several days to a week, depending on the amount of water available, it goes to Lurin Sayoc hamlet. It then returns to Moya to irrigate the lower slopes and this alternating pattern is continued. If a great deal of water is available, it may be sent to each branch simultaneously. Alternatively, water may go to one branch at night and the other by day.

The water distribution (*patacha*) for Hanan Sayoc is made by the town municipal authorities. The Hanan Sayoc system, unlike that in Lurin Sayoc, is regarded as pertaining to the central town. It supplies the town's water and electricity, and townsmen generally have their fields in Hanan Sayoc, so that they use this irrigation system more intensively. Formerly, the town mayor distributed the water weekly; today it is done by an irrigation judge. People from Hanan Sayoc assemble in the plaza of the central town every Sunday to ask for water. A person who has not worked cleaning the irrigation system is not given water unless he pays a fine. The fine is generally equivalent to the daily wage of an agricultural laborer.

The water distribution for Lurin Sayoc was traditionally made by certain barrio-wide rural political officials known as the *llahta varayoc*.[5] They were considered the owners of that barrio's irrigation system and, in conjunction with the important people (*gente mayor*) of the barrio, made all relevant decisions. The town authorities did not interfere, but provided necessary materials, such as cement, for the upkeep of the system. The *llahta alcalde* and *llahta albaser*, the two top rural political officials, divided the water each week among the people who had come to ask for it. Decisions concerning each part of the system were made at the relevant source: either Chiwaku Urara, the diversion point between Moya and the rest of Lurin Sayoc, or Lurin Sayoc reservoir. With the end of the rural political system in 1970, municipal authorities assumed the maintenance of the system, but the division of water is made by the people assembled at the distribution points themselves. This acephalous method of distribution has resulted in a considerable increase in fighting. There are many arguments and people are sometimes physically assaulted. As in Hanan Sayoc, a person must work in the cleaning of irrigation ditches or pay a fine to receive water.

There are some intervening principles for the distribution of water which modify the altitude rule in both barrios. Throughout the year, Sunday is a free day. It is never assigned to a single person for his fields, but can be used by anyone on a first-come, first served basis. However, priority is given to the filling of cisterns for household use. In addition, the *gente mayor*, older people who have fulfilled many religious and political obligations, have special water rights in that they need not wait their turn for water, though they may take water out of turn only once. Anyone giving a fiesta for a saint also has first access to water.

The formal water distribution ends when the rains are in full force, usually in December. Distribution returns to the informal first-come, first-served methods of the dry season cycle, although—if water is limited—the people may give it first to the hamlet with the greatest need. At times of water scarcity the formal distribution (patacha) may be reinstituted at any time of year.

There are no irrigation specialists. Once water has been distributed it is the individual's responsibility to change the gates, store water in the reservoir, and prevent theft. A group of neighbors may irrigate simultaneously and cooperate in these activities. In Lurin Sayoc, the person assigned water goes the day before his turn to Lurin Sayoc reservoir to block the canal draining it, so that it fills with water. He then goes to Chiwaku Urara to change the water flow from Moya to Lurin Sayoc reservoir. It is his responsibility to ensure the flow of water. To do so, he places guards called *guardiantes* or *kwidahkuna*, usually members of the family or neighbors, at major branches of the canals to prevent theft. In some cases, people living near major control points may be asked to guard the gate. A man irrigating alone may walk up and down the canals to guard them. Major gates often have artificial ledges or platforms cut out of rocks where the guard may sit or sleep. In the lower reaches of the system as many as seven or eight guards are needed. The procedure is similar in Hanan Sayoc.

Although behavior generally conforms to the formal rules of water allocation, there are significant deviations. Water is often stolen by surreptitious changing of the gates. Such theft is not dealt with by political authorities. They distribute water; it is the individual's responsibility to guard his rights to it. Many arguments and fights occur during the formal water distribution. A person may claim that he has undertaken more public duties (*cargos*) than another, or that the other has not worked on the cleaning of the irrigation system. At times of informal water distribution, the issue may be decided by force. Fights occur only between people of different hamlets, for only they have different water needs. Since the end of the rural political organization (*varayoc*), such fighting and stealing has increased considerably in Lurin Sayoc. It is expected that an irrigation judge will soon begin to distribute water in that barrio to decrease the fighting. Finally, political power takes precedence over rules of water distribution. One of the most powerful townsmen has, for years, obtained water from the Hanan Sayoc system every Saturday. Powerful townsmen get irrigation water when they want it.

The Irrigation Festival and Cleaning

Yarqa Aspiy (cleaning of the irrigation canals) or *Yarqa Ruway* (working of the irrigation canals) are Quechua terms used to designate the cleaning and ritual celebration of the irrigation system. In Lurin Sayoc, the major cleaning of the irrigation system precedes its ritual celebration in fiesta by about a month, so that in Spanish the events are differentiated terminologically. The first, held in July, is called *limpia de la cequia*[6] (cleaning of the irrigation system) and the second *celebracion de la cequia* (celebration of the irrigation system) is in August. In Hanan Sayoc the two events are held simultaneously at the end of August.

All irrigation systems require periodic cleaning if they are not to collect silt. In Quinua the irrigation systems are cleaned once a year before the agricultural cycle begins, and periodically throughout the year as the need arises. The principles of work are similar in both barrios. The work is organized as a *faena*, or corvée labor. It is usually accompanied by a flute and drum, and may last one or two days. Each family using the system must provide a worker or pay a fine. The people clean up the rocks and debris in the canals and reservoirs, cut trees and brush around their edges, and shore up the canals and reservoirs with sod and stones and sometimes with cement to prevent seepage. Everyone is responsible for work on that section of the system he utilizes, so that people at the terminus clean a larger portion than people in the upper slopes. Someone who refuses to work or pay a fine is denied irrigation water. A list of workers is kept for this purpose.

Previously, the work on the Lurin Sayoc irrigation system was organized by the barrio-wide rural political organization (*llahta varayoc*), who also kept the records of the work. Since the end of the rural political organization, the irrigation cleaning has been organized by municipal authorities. For as long as Quinuenos can remember, the work in Hanan Sayoc has been organized by municipal authorities, even when there were rural political officials in this barrio.

The irrigation festival is one of the most important public celebrations in Quinua. The festival is held at the end of August before the beginning of the rainy season planting in September. Each barrio has a separate festival. The two-day Hanan Sayoc festival is always held the week after the four-day Lurin Sayoc fiesta. The festival is limited to residents of the barrio, and everyone is expected to participate in it.

In the past, the rural political organization (varayoc) of both barrios had important roles in organizing the fiesta, and the festival was one of

their most important obligations. At the present time, the varayoc still exist only in the hamlet of Moya, but their only function and their only public appearance is during this festival. The varayoc and other festival officials are responsible for honoring special crosses associated with irrigation in a complex of ceremonial obligations, which include special rituals, feasting, and dance groups. During the festival, the celebrants traverse the entire irrigation system, and ritual meals and ceremonies are held at strategic points of the system.

The irrigation festival is the most conservative fiesta in Quinua, as it probably is elsewhere in the Sierra (Zuidema 1970). Unlike most festivals, it does not involve the Catholic priest in any way. The irrigation crosses are kept in the homes of the celebrants, not the church. Only traditional drum and flute music is played. No bands and orchestras are imported from the city of Ayacucho, as for other fiestas. Nor are record players used. The conservative nature of the festival is partly maintained by the *sipu*, an institutionalized punishment of officials who neglect some aspect of their role in the fiesta.

The irrigation festival in Quinua is part of a regional system. There is a temporal sequence for the fiesta throughout the mountain range on which Quinua is located. It begins to the northwest of Quinua and moves week by week, always on a Monday, from one community to the next. Quinuenos believe that irrigation was first discovered in Chincha, the community that initiates the temporal sequence of Yarqa Aspiy, and then imitated week by week by the succeeding communities. Yarqa Aspiy is thought to commemorate the anniversary of the building of the irrigation system and for this reason is held in a temporal progression.

Comparative Irrigation Data

Irrigation is of considerable importance throughout much of the highlands and coast of Peru. Because the coast is largely desert, irrigation is necessary for most habitation and agriculture (Kosok 1965: 10). Although there are a few published accounts of coastal irrigation activities (Hammel 1962: 27–30; Holmberg 1952; Kosok 1965), the following survey is restricted to the highlands. The coastal situation is very different ecologically and because of acculturation from that which pertains in the Sierra.

Highland irrigation is both ancient and widespread (Carrion Cachot 1955; Espinoza Soriano 1971; Kosok 1965: 7–10, 36; Lumbreras 1974: 135; MacNeish 1969: 44–45; Regal 1970; Rowe 1946: 211; Sherbondy 1969). Some indication of its importance can be ascertained from the widespread belief found throughout the Andes that harvests would be increased by improved irrigation (Dobyns 1964: 31–33).

Some form of irrigation has been reported for a great many communities in the highlands. Table 3-4 lists only anthropological reports or reports written under anthropological auspices in which irrigation is

Table 3-4 IRRIGATION REPORTS FROM HIGHLAND PERU

Community	*Department*	*Source*
Accopata	Puno	Castillo et al. 1963a: 9, 67
Carcas	Ancash	Castillo et al. 1963b: 18-19, 58
Chaquichocha	Junin	Castillo et al. 1964a: 83
Choquehuarcaya	Ayacucho	R. T. Zuidema, personal communication
Chuschi	Ayacucho	Isbell 1972
Hualcan	Ancash	Stein 1961: 188, 190-191
Huancasancos	Ayacucho	R. T. Zuidema, personal communication
Huaylas	Ancash	Doughty 1968: 104-105, 153-158; 1970
Mayobamba	Lima	Morris et al. 1968: 74, 156-157, 249-251
Mito	Junin	Castillo et al. 1964b: 44, 66
Muquiyauyo	Junin	Adams 1959: 126-127
Pisac	Cuzco	Castillo 1970: 51, 54, 55, 58, 60
Puquio	Ayacucho	Arguedas 1964
San Pedro de Huancaire	Lima	Soler Bustamante 1954, 1958

mentioned as being present in the community. Most of the reports mention only the presence of irrigation and provide little information on its organization. Consequently, it is difficult to ascertain the extent to which the pattern found in Quinua prevails in other communities. However, the data suggest that irrigation is of greater importance in highland communal organization than has hitherto been realized.

In all the communities where information is available, work is communally organized on at least the major canals. Some form of corvée labor, similar to the faena of Quinua, is used to repair the irrigation system in Chuschi, Hualcan, Huaylas, Mito, Muquiyauyo, and San Pedro de Huancaire.

In addition, irrigation cults have a wide geographic distribution: they have been reported for the Departments of Ayacucho (Choquehuarcaya, Chuschi, Puquio, and Quinua), Ancash (Huaylas), and Lima (Mayobamba and San Pedro de Huancaire). Holmberg (1952) also reports an irrigation cult in the Viru valley on the coast. It is difficult to compare the cults on the basis of published information. However, the irrigation festivals in Chuschi, Puquio, and Quinua are very similar. In all three communities, it is one of the most important rituals and is (or was) organized by the rural or Indian political organization (varayoc). As in Quinua, the Chuschi festival involves costumed dance groups. The irrigation festival of San Pedro de Huancaire is also similar in certain respects to the irrigation festival in Quinua. It prepares the canals for use at the end of the rainy season and is associated with considerable ritual. It is a ceremony of major importance during which offerings are made to the water, the earth, and the ancestors, and decisions are made concerning the allocation of irrigation water. During the ceremony, the entire irrigation system is inspected and rest stops are made at traditional locations for ritual meals and ceremonies. As in Quinua and Chuschi, flowers are worn in the hatbands of the participants.

It is more difficult to ascertain the type of political control of irrigation systems. Indian or rural political officials organize (or have organized) some aspects of the irrigation system in Choquehuarcaya, Chuschi, Huancasancos, and Puquio, all located in the department of Ayacucho. In the other communities where information is available, control of irrigation is vested in national political institutions such as a *Junta de Regantes* (Irrigation Board) or a *Juez de Aguas* (Irrigation Judge).

The only clear relationship between water systems and communal divisions is for the Rio Pampas area of the Department of Ayacucho. In a personal communication, R. T. Zuidema reports that communal divisions in the Rio Pampas area are commonly associated with separate irrigation systems, as in Quinua. In Huancasancos, for example, there are four *ayllus*, each with its own irrigation canal. The political officials of the community, organized along ayllu lines, are responsible for irrigation activities. In Choquehuarcaya there are two irrigation canals. Although the community is not formally divided into two barrios, there is a separation into two groups associated with the irrigation canals during many ceremonies. This is especially true during the cleaning of the irrigation ditches. Data published on Chuschi (Isbell 1972), also in the Rio Pampas area, suggest a similar pattern. In Chuschi there are two barrios, each with a separate varayoc organization. There are also two irrigation systems, and it appears there is one for each barrio. If this is the case, the barrio division in Chuschi may have a hydrologic basis as in Quinua. Zuidema (1964: 140-148 and personal communication) also reports that in Incaic Cuzco, the divisions of Hanan Cuzco and Hurin Cuzco were also associated with separate irrigation systems. This receives some support from the Chronicler Pachacuti (n.d.: 76) who states that Hurin Cuzco and Hanan Cuzco were named after two springs called Hurinchacan and Hananchacan.

Discussion

Irrigation plays a central role in Quinua life. An adaptation to high altitude farming, it permits the cultivation of a broader crop repertoire throughout the lower montane savannah. The importance of irrigation and water to agriculture is mirrored in the organization of the community. The hydrology of the mountain slope forms the basis for the division of Quinua into two barrios. In addition, regulation of the irrigation system is an important function of the political system. Such political control is structured along barrio lines. In Lurin Sayoc irrigation activities were directed by rural political leaders, who were considered the owners of the irrigation system, while in Hanan Sayoc such control has always been assumed by the town political organization. Political leaders, however, are responsible only for the maintenance of the system and the distribution of water during the rainy season planting, the most criticial period of water distribution. At other times, water is distributed informally by those needing it. Moreover, there are no formal sanctions against stealing water, it is the individual's responsibility to prevent the theft of his water. Since the demise of the rural political organization, town authorities have assumed responsibility for the maintenance of the Lurin Sayoc system, although the distribution of water during the rainy season planting rests with the people themselves. This acephalous method of distribution has resulted in a significant increase in fighting. Finally, the celebration of the system in Yarqa Aspiy is one of the most important ceremonials in the district. It is a rural event with little town participation in either barrio. The preparation and organization of this festival was traditionally one of the most important functions of the rural political organization.

There is no archeological or ethnohistorical information available on whether the relationship between irrigation and communal organization is pre- or post-Columbian in Quinua. Although Quinuenos attribute an ancient origin to the irrigation system, its exact age is unknown. Nor is there precise information on whether Quinua itself is a pre-Columbian town, although the data suggest is it (Zuidema 1966). However, it is probable that the general patterns of irrigation control found in Quinua represent an ancient Andean structure. This assumption receives support from the fact that similar patterns are found in the organization of other communities in Peru. In addition, although the data for Quinua itself are lacking, we do know that the irrigation cult, in general, has a pre-Columbian origin (Arriaga 1968: 154; Carrion, Cachot 1955; Rowe 1946; 310; Zuidema 1970: 153). Finally, irrigation systems date from very early times in the Ayacucho region in which Quinua is located (Lumbreras 1974: 135).

The data from Quinua and from Peru in general suggest certain ramifications of the hydraulic hypothesis of Wittfogel and Steward. As I have suggested elsewhere, the irrigation system is not the independent variable of the hypothesis (Mitchell 1973b). Instead, the relevant variable is the way in which irrigation is organized by a society. Irrigation, even large-scale systems, may be organized in very different ways, with very different social consequences.

The following general conclusions about irrigation can be drawn:

1. The study demonstrates the importance of irrigation to agriculture in Quinua. It more than doubles the area in which maize, and probably beans, a variety of quinoa, and most squash are cultivated, and also makes cultivation more secure in the lower savannah. It is probable that irrigation functions similarly in many other areas of Peru. This is certainly the case for irrigated agriculture on the eastern rim of the Ayacucho valley. It is not surprising that communities on this rim tend to be clustered in the lower montane savannah in the same elevation range as Quinua.

2. What is more impressive about Quinua irrigation is its parsimonious use of a limited amount of water. Because of the vertical series of environmental zones, each with different conditions, water goes at successive times to different places to be used for different purposes, and each region benefits according to its requirements in a most economical dovetailing of functions.

3. Since the ecological zones of mountain environments are very similar in different areas of the world, irrigation in other highland areas may have ecological functions analagous to those in Quinua. This may indeed be the case in the Teotihuacán valley in Mexico (Barbara Price, personal communication). The extent of the similarities, of course, must be determined by further empirical research. Such research is indeed required for other areas of Peru. Since the moisture variable is not a constant in mountain environments, however, we may find significant differences as a result of differing rainfall patterns. Differences will also result from different types of soils and cultigens.

4. The irrigation system of Quinua is small scale. The same is true for other contemporary irrigation systems in the Ayacucho valley located near Quinua and the city of Ayacucho. Even in the Rio Chacco, at the bottom of the Ayacucho valley, small diversion dams and canals are used. It appears that large dams are not required to utilize river water for irrigation. A diversion dam similar to that in the Lurin Sayoc barrio of Quinua may serve instead.

5. The fact that irrigation water is distributed only at certain times by political authorities and that water is frequently stolen, is of interest with respect to certain controversies over the Wittfogel-Steward hypothesis. It has frequently been assumed that irrigation itself causes despotic and centralized political control. The data from Quinua do not support this conception. In Quinua, water is distributed primarily on the basis of customary procedure. Even during the formal water distribution of the yaku patacha, the political officials simply legitimize acknowledged altitude rules of water distribution. This does diminish conflict at a time of critical water need, but is not essential, as witness the present distribution of water by the people themselves in Lurin Sayoc. Moreover, it is the individual's responsibility to get the water to his fields. There are no formal sanctions against water stealing. I suggest that similar patterns of informal distribution can occur in much larger irrigation systems (Mitchell 1973b). Under such circumstances centralization of power is not

inevitable—even when, as in Quinua, political officials organize the cleaning of the canals.

6. The data from Quinua illuminate the water needs of the archeological site of Huari. Huari, the urban center of one of the largest Andean empires, flourished between A.D. 600 and 750. The present archeological site is located in the lower montane thorn steppe of Quinua. At the present time, irrigation does not extend to Huari because of insufficient water; consequently, only a narrow range of crops can be grown there. If the climate was similar in the past, more extensive irrigation would have been necessary to grow a broad range of crops in the vicinity of the city. An urban center, of course, could have developed such an irrigation system.[7] On the other hand, the city may have been built in the lower montane thorn steppe precisely because it is an unproductive area. The city would thus occupy a minor agricultural area, but would be strategically placed between two important productive zones: the lower montane savannah and the alluvial valley. Both areas, relieved of population pressures, could be devoted entirely to agriculture with small-scale irrigation, and could supply the city with its agricultural produce. The city itself would thus only require an aqueduct for domestic water, rather than large-scale irrigation for agriculture.

7. Finally, the evidence from Quinua suggests that the hydraulic hypothesis of Wittfogel and Steward only partially explains the evolution of the large, bureaucratic state in the Central Highlands. It is true that the irrigation system of Quinua is very significant in the organization of the community and that such patterns appear to be widespread throughout the highlands of Peru. Nonetheless, these irrigation systems, if contemporary evidence is any indication, are too small and localized to account for the origins of political despotism and states larger than the local community. This would certainly be true for the development of Huari, if my inferences about the nature of Huari irrigation are correct. Irrigation, then, appears to be significant in the evolution of the local community but not the large, complex state and empire in this area. The role of irrigation on the desert coast is another—and separate—question (cf. Mosley 1974, 1975). In the highlands, at least, it is probable that other factors such as long-distance trade (Mitchell 1973b; Rathje 1972) or dense populations, environmental circumscription, and warfare (Carneiro 1970) are responsible for the more complex political evolution beyond the local community.

Notes

*This paper is a somewhat expanded and slightly revised version of a paper that first appeared in the *American Anthropologist* 78: (1976) under the title "Irrigation and Community in the Central Peruvian Highlands." The research was undertaken in

1966–1967 and the summers of 1973 and 1974. I am grateful to the Foreign Area Fellowship Program and the Monmouth College Grant-in-Aid Committee for their financial help. Dean Arnold, Glenn King, Hugo Nutini, Barbara Price, Thomas Schorr, Arthur Tuden, and the late John P. Gillin commented on earlier drafts of this paper. I also wish to thank participants in the Columbia University Ecology Seminar for their comments. R. T. Zuidema graciously provided me with his data from the Rio Pampas area of Ayacucho. I want to thank my research assistants and *compadres* in Quinua, particularly Mamerto Sanchez, Guillermo Aparicio, Adrian Pariona, and Benjamin Chavez. Dennis Lewis prepared the maps. I am especially thankful to my wife Daphna, with whom I have developed many of my ideas.

1. These strata correspond with what elsewhere in the Andes are referred to as *mestizos* and Indians. These terms are inappropriate for Quinua, so that "townsmen" and "peasants" (or "rural folk") are used instead (Mitchell 1974a).

2. Quinuenos explain this concomitant decrease of moisture with decrease in altitude in terms of the soil. They say that the soil is sandier at lower altitudes. This soil retains less moisture than that at higher altitudes, which contains more clay.

3. My discussion of these zones is based on Arnold's (1975) analysis of Tosi's classification for Peru. The English terms for these zones are derived from Holdridge (1947), which formed the basis of Tosi's work.

4. Murra (1960: 395) has also noted the use of irrigation to raise the upper limit of maize cultivation in pre-Columbian Peru.

5. The *varayoc* are rural political officials who were once common throughout the Peruvian Andes. They are usually identified with Indian social status and are used by townsmen to enforce and complete decisions of the town officials. In addition, they also fulfill ceremonial and political functions, such as the distribution of irrigation water, for the peasants themselves. Largely because of their identification with Indian status, they are disappearing in much of Peru.

6. In Quinua the irrigation canals are called either *yarqa* or *cequia*. The latter term is a corruption of the Spanish *acequia* (irrigation canal). Only some educated townsmen use the term acequia. The use of cequia in confusing, since its pronunciation is similar to the Spanish *sequia* (drought), an ambiguity which occurs in the literature (Arguedas 1964: 243; Morris et al. 1968: 251).

7. It is interesting to note in this regard that informants report the existence of a stone irrigation canal going to Huari from Lake Yanaqucha located in the mountains behind the village of Huamanguilla. I did not see the canal, but it is reported to be in a considerable state of disrepair and is not used at the present time.