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Neo-environmental determinism and agrarian 'collapse' in Andean prehistory

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Introduction: neo-environmentalism in Andean archaeology

In early anthropology, environmental determinism was used to explain race, human demography, material culture, cultural variation and cultural change. As anthropological interpretation evolved, simplistic reductionist thinking was replaced with more complex socio-cultural explanations. Despite these theoretical advances, environmental determinism continues to be invoked to explain Andean prehistory. The rise and fall of Andean civilizations are 'mapped onto' sediment cores, pollen diagrams and ice cores and somehow this 'explains' cultural change. In the extreme incarnations of neo-environmental determinism, humans are considered passive pawns at the mercy of droughts and floods. I will evaluate a recent hypothesis proposed to explain the collapse of the Tiwanaku State and raised-field agriculture from a landscape perspective informed by a 'bottom-up approach' to Pre-Columbian farming systems, the ethnography of wetland peoples and insights from the New Ecology.

The collapse hypothesis

Andean archaeologists have long been infatuated with the idea that cultural change could be explained by climatic shifts in rainfall and temperature (e.g. Shimada *et al.* 1991; Cardich 1985). These ideas appear and disappear in regular cycles of about 20 years for the south central Andes. The 'collapse hypothesis' recently proposed by Kolata, Binford and Ortloff (Kolata 1993; Kolata 1996; Binford *et* al. 1997) for the collapse of the Tiwanaku civilization bears a striking resemblance to that proposed by Puleson (1976) for the explanation of the 'horizon/intermediate period' phenomena in Andean prehistory, and that proposed by Posnansky (1945) for the collapse of Tiwanaku. Since much of the world is still recovering from a major El Niño event, a critical examination of neo-environmental determinist explanation is relevant.

According to Kolata and colleagues (1997: 235), 'Environmental thresholds vary through time as climate changes, populations grow, cultures and their technologies evolve, and resources are depleted and substituted'. They define an environmental threshold as 'climatic extremes that limit the complexity of cultural development'. In this perspective (Binford *et al.* 1997: 246),

> "Human cultures adapt to changing environmental conditions within a range of normal variation. 'Nor-

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> mal' is usually defined by recent and short-time scales, rather than by long-term variability during which thresholds at environmental extremes can significantly affect cultural adaptability. In commonly defined normal periods, thresholds can be exceeded for short periods without seriously affecting a civilization. However, in the long term, lower frequency variation with larger amplitudes may exceed the limits of human adaptability."

According to the collapse hypothesis for Tiwanaku, the threshold was exceeded when 'chronic drought' conditions prevailed in the South Central Andes after AD 1150.

Kolata and colleagues have marshalled impressive evidence from the Quelccaya ice cores, sediment cores from Lake Titicaca, water budget modelling and archaeological excavations in raised fields. The scenario of Tiwanaku collapse can be summarized as follows: a drastic rainfall deficit beginning at AD 1150 caused a 'chronic drought' of 300 years. The water level of Lake Titicaca dropped between 12 and 17 m and much of the lake was reduced to a saline swamp surrounded by a bleak arid landscape. The raised-field system was abruptly abandoned because it became impossible to maintain due to drought conditions, higher labour costs and salinization. Because Tiwanaku's food production was based on intensive agriculture, the collapse of the regional raised-field system brought on the collapse of the Tiwanaku urban centre and state administration. Populations dispersed and migrated out of the region. According to Kolata and colleagues, this resulted in a total 'cultural collapse', plunging the Lake Titicaca basin into a post-Tiwanaku 'Dark Ages' lasting until the conquest of the region by the Inka in the late 15th century. A corollary to the 'collapse hypothesis' is that between AD 600 and 1100, climatic conditions were favourable to raised-field agriculture, thus Tiwanaku civilization flourished.

There are problems with the evidence for the drought. The AMS samples used to date the drought were freshwater snails and marsh reed seeds, possibly not the best class of organic material to date a drought. The sediment hiatuses, which presumably date the drought, range between AD 263 and 1323 and between AD 584 and 1461 (Abbott *et al.* 1997). It is obvious that the chronology of the drought is far from precise. Archaeological evidence shows that Tiwanaku's primary and secondary urban centres collapsed 100-200 years before the supposed onset of the drought (Kolata & Ortloff 1996: 196, table 8.3). Archaeological excavati in Koani Pampa and Huatta demonstrates that raised fields continued to be constructed and used at a regional scale for at least 300 years after the collapse of Tiwanaku (Seddon 1994; Erickson 1996; n.d.).

Climate change in the Lake Titicaca Basin and the new ecology

Kolata and colleagues assume that there is a 'normal' climate or set 'normal' range of climate variation for the Lake Titicaca basin. They use the lake-level records for this century and the precipitation records derived from the Quelccaya ice core as their baseline. Any long-term major deviation from this 'norm' is considered to exceed the 'environmental threshold'. Their model focuses only on declining precipitation and drop in lake levels over long periods, which they interpret as evidence of severe drought. They ignore the fact that periods of decrease in precipitation and lowering of lake levels are *always* followed by periods of increasing precipitation and rise of lake levels (Monheim 1963). In the historical record, these periods often resulted in massive floods around the lakeshore. Because of their focus on long-term trends, Kolata and colleague overlook the evidence for short-term episodes of 'excess' precipitation during the presumed 'chronic drought' that are clearly recorded in the Quelccaya ice records (Kolata & Ortloff 1996: figures 8.3-8.7).

The 'New Ecology' provides a more sophisticated perspective for understanding the dynamics of cultural landscapes than the traditional equilibrium and homeostasis model applied by Kolata and colleagues. Botkin (1990), a major proponent of the New Ecology, stresses that environments are dynamic and historically contingent. These insights overlap with the anthropological and historical approaches taken in the archaeology of landscapes and historical ecology (Ashmore & Knapp 1999; Bender 1998; Crumley 1994; Tilley 1994, Erickson 1993; n.d.). As Zimmerer notes (1994: 108),'the new ecology accents disequilibria, instability, and even chaotic fluctuations in biophysical environments, both "natural" and human-impacted', There is no 'normal' climate around which rainfall or temperature varies or changes. This perspective also incorporates long-term human

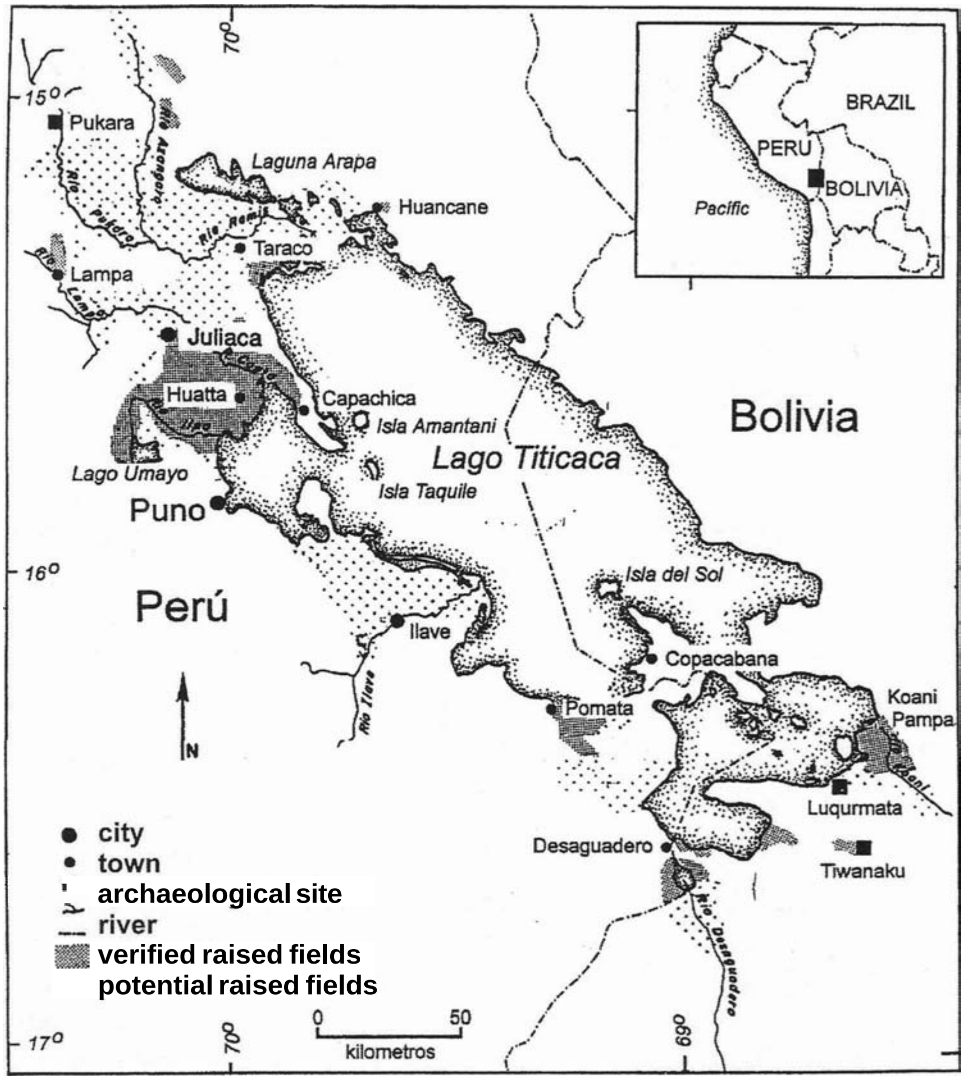

FIGURE 1. Map of the Lake Titicaca region showing locations of places referred to in the text.

activities as an important factor in the chaotic dynamics of landscapes. The usefulness of the concept of human adaptation to natural environments or 'a range of normal variation' of climate is called into question. In the Lake Titicaca region, human activities have transformed 'nature' into a totally anthropogenic landscape over a period of 9–10,000 years (Erickson in press). What is 'nature' or 'natural' in this context?

Human response to past and present climatic fluctuation

Lake Titicaca is located at 3800 m above sea level in the South Central Andes of present-day Bolivia and Peru (Dejoux and Iltis 1992) (FIGURE 1). Western-trained agronomists characterize the area as marginal for agriculture because of the high altitude, poor thin soils, frequent frosts, short growing season and irregular precipitation. Despite these environmental conditions, the lake region is one of the most densely populated rural areas in the Andes and has been for thousands of years. Aymara and Quechua, who make up the majority of the inhabitants, intensively farm an anthropogenic landscape inherited from the prehispanic inhabitants. These peoples transformed and managed the agricultural land and 'natural' resources through the establishment of raised fields, terraces, sunken gardens and other artificial landscape features.

If we accept that the environment of Lake Titicaca is characterized by disequilibria, instability and chaotic fluctuation, how do the Quechua and Aymara inhabitants past and present confront and thrive in climatic mayhem? One coping strategy is the creation, maintenance, and expansion of 'landscape capital' (Blaikie & Brookfield 1989). The walls, fields,

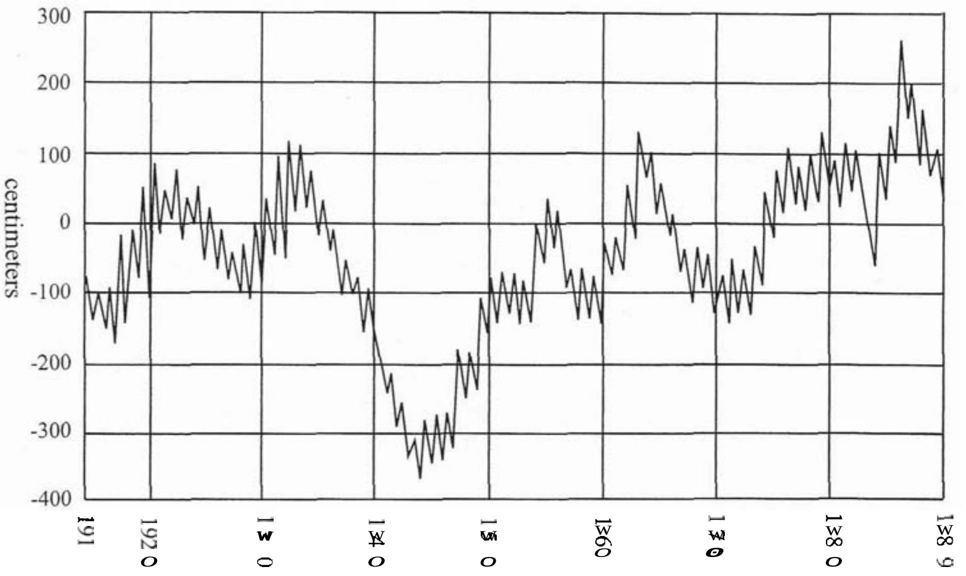

FIGURE 2. *Graph showing variation of the water levels of Lake Titicaca between 1914 and 1989 (adapted from Roche* et al. *1992: figure 10).*

canals, paths, settlement mounds, soil improvements and terraces created by hundreds of generations of earlier farming peoples are part of the inheritance that benefit their descendants (Erickson 1993; in press). A related strategy is the transformation of and expansion of 'natural resources' such as wetlands through cultural practices into anthropogenic resources that can be controlled and manipulated as the climate fluctuates (Nufiez 1986; Levieil & Orlove 1990). Andean peoples have developed numerous strategies such as field scattering, freeze-dry storage of surplus production, diversification of agro-pastoral systems and sectorial fallow to reduce agricultural risk (eg. Browrnan 1987; Morlon 1992). We might now even ask how much of the evidence for 'climate change' recorded in sediment, pollen, and ice cores is actually the result of human farming activities and anthropogenic impact on regional environment, rather than natural phenomena (Erickson in press)?

Historical and lake-level records document numerous short- and long-term droughts and floods (Monheim 1963; Dejoux & Iltis 1992). Records show the lake level has fluctuated 6.4 m in the past century (FIGURE 2). I personally witnessed the human response to a serious drought during the 1982–83 El Nifio and a record-breaking flood during 1985–86. In 1865-70 and 1942–45, communities of the Lake Titicaca region suffered through long periods of drought. There is evidence of droughts of 36 continuous years in the 17th century, 29 continuous years in the 18th century and 15 continuous years in this century (Monheim 1963). During 1860–65 and 1959–60, communities confronted serious inundation. Many of these historic droughts and floods are on a par with the so-called 'abnormal' climate phenomena recorded in the Quelccaya ice cores for the prehistoric period. The historical documents show that these climatic events caused hardships for the hundreds of thousands of inhabitants of the region. The droughts did not cause 'cultural collapse', mass permanent migration out of the basin, nor abandonment of agriculture.

How do native peoples who live around the Lake Titicaca respond to drought? A common result of drought is the lowering of the lake level. Because of the topography of the flat lake plain, a drop of 1 m can expose an estimated 200,000 ha of previously submerged lake bed (FIGURE 3). During the long droughts of the 1860s and the 1940s, enormous areas of lake bed became dry land. These areas have deep, organic-rich soil that is highly prized by local farming communities (FIGURE 4). My informants in Huatta eloquently spoke both of the horrors of long-term drought and the joy of farming these new lands. They described piles of threshed quinoa and potatoes as large as houses. Huatteños also told of how the communities who control lakeshore territories managed to become 'rich' during the droughts by selling the abundant surplus produced on newly exposed lake bed and renting those lands to those less fortunate.

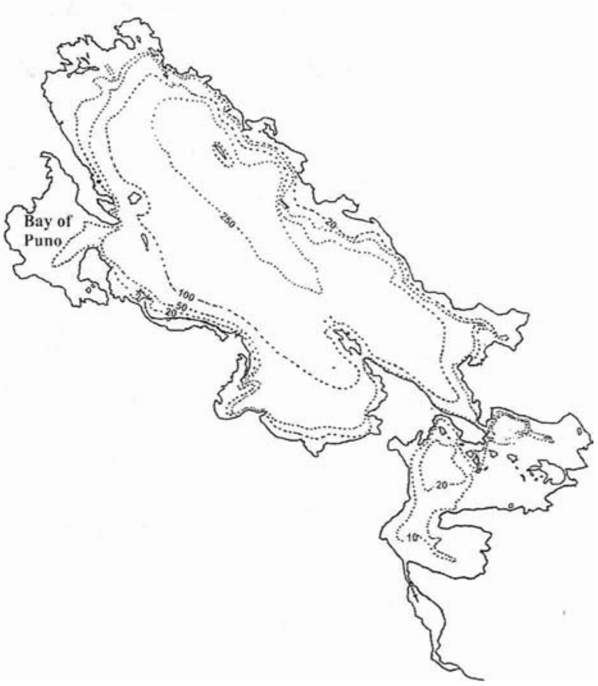

FIGURE **3.** *Bathymetric map of Lake Titicaca showing areas susceptible to changes in lake level (after Boulange & Aquize 1981).*

Historical records referring to the drought of 1890 are full of references to land disputes between indigenous communities over control of farmland exposed by receding lakeshores. Anthropologists have documented a number of strategies used by lakeshore farming and fishing communities to control and manage the wetland and lake resources (Nuñez 1984; Levieil & Orlove 1990). Lacustrine resources are physically marked, regularly patrolled and defended. In Huatta and Coata, individuals and communities have established mojones, visible markers of stone and sod, and long linear ditches to define the boundaries of these valuable farmlands that lie under water in most years (FIGURE 5). Another strategy is to establish households on the large earthen mounds, prehispanic settlements, clustered at the edge of and within the shallows of Lake Titicaca. Where no mounds exist, the Uru of Los Urus and Quechua of Huatta establish communities and gardens on floating islands made of totora reeds (FIGURE 6). This diverse strategy of wetland resource utilization has a 3,000-year history (Erickson 1993; 1996). The continuity of farming settlements on valley floors, seasonally flooded lake plain and natural and artificial islands in the lake is well-documented in the archaeological settlement surveys (Albarracin 1996; Albarracin & Mathews 1990; Graffam 1992; Erickson 1993; n.d.).

Mitigation of drought is one of the many of the benefits of raised-field technology. Our experiments demonstrate that water levels can be manipulated in the deep, wide canals between raised fields. The topography of raised fields and the dead-end nature of many canals provides an excellent means of capturing rainfall and preventing runoff during the growing season. The severe drought of 1983–84 provided an excellent test of raised-field agriculture.

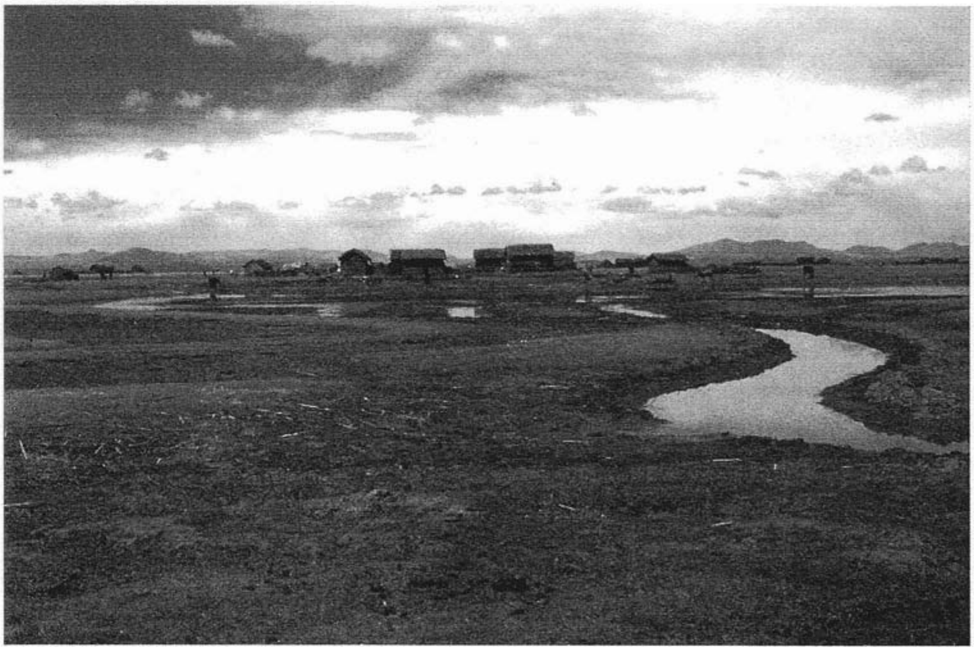

FIGURE 4. The dry lakebed near Huatta, Peru, exposed during the drought of 1982-83. Note the rich dark soils composed of rotting organic matter from the totora reed swamps.

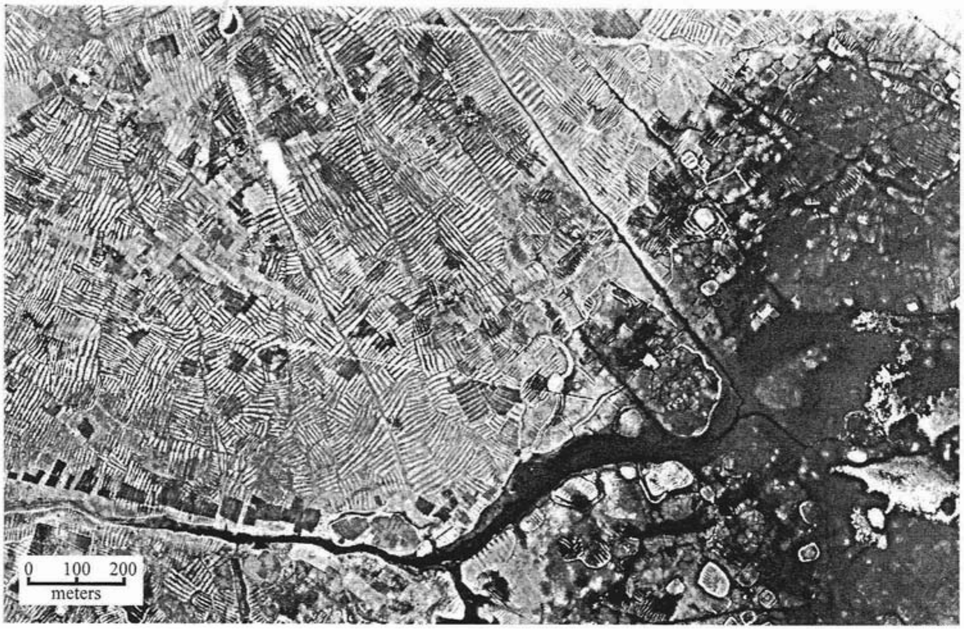

FIGURE 5. Precolumbian canals crossing raised fields near the lake shore in Huatta. The functions of these canals include channels for reed boat traffic, water management, and boundary markers for community fields (cultivated during droughts) and aquatic resources (exploited during 'normal' years).

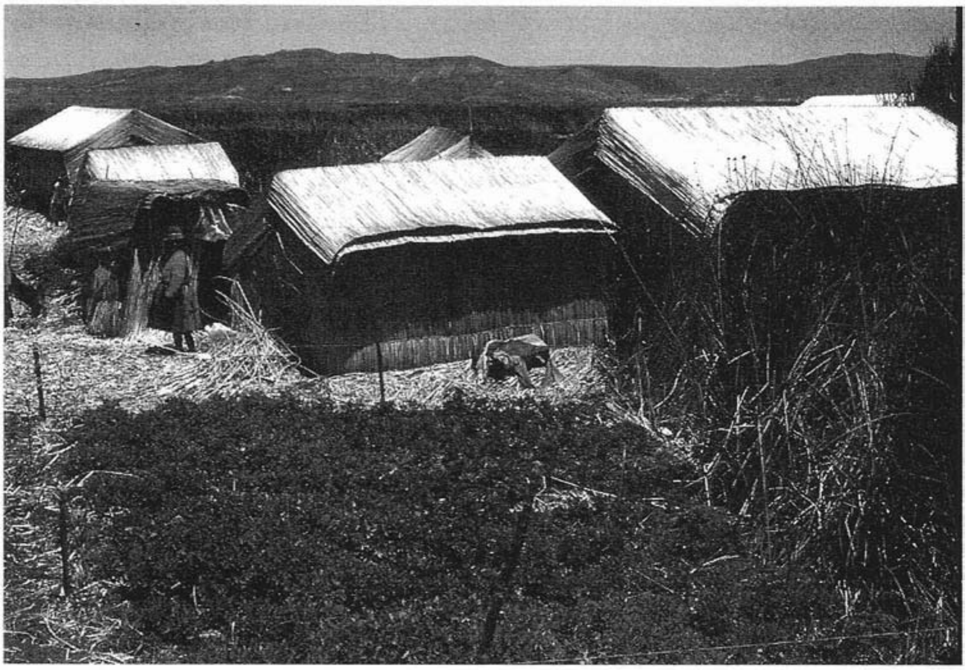

FIGURE 6. A 'floating island' of the Uru with potato gardens and residences in the totora reed marshes of the Bay of Puno, Peru. The platform is constructed of tons of totora reed grown by the Uru and their Aymara and Quechua neighbours.

Nearly all crops planted on the hill slopes in Huatta and surrounding communities failed while raised fields produced some of the only crops in the region.

What was the effect of long-term drought on prehispanic raised-field agriculture? The 120,000 ha of known raised fields are distributed in a variety of topographic locations. Aerial photographs taken during a period of low lake level in the 1970s clearly show the patterns of raised fields and canal networks that are under water during most 'normal' years (FIGURE 7). We mapped many of these raised-field features in Huatta during the drought of 1982–83. We are convinced that raised fields were not all in use at the same time due to the unpredictable climatic fluctuations. As lake levels rise and fall, prehispanic farmers moved accordingly to farm appropriate locations in the same way that Huatteño farmers do today. Some fields were apparently only used during periods of drought and others during times of flooding (depending on the topographic location).

Documents record the impact of the massive droughts of the 1860s and the 1940s on native peoples living near the lake. The Uru

FIGURE 7. *Aerial photograph of the dry lake bed near Huatta during the drought of the 1970s. The patterns of abandoned raised fields, boundary canals and Pre-Columbian occupation mounds.*

FIGURE 8. *The* pampa *of Huatta near Lake Titicaca during the flooding of 1986. Most of the modern households are located on prehispanic occupation mounds.*

rely heavily on the resources of the wetlands, in particular totora reed that is used to construct fishing boats and floating-island settlements. Both of these major droughts wiped out some 5 linear km of totora-reed swamps along the Desaguadero River and several square kilometres of reed swamps at the lake outlet near the town of Desaguadero. The Uru population dispersed during the climax of the drought, most moving in with their Aymara and Quechua neighbours. According to Monheim (1963), within a few years after the droughts ended, the Uru had not only moved back to their wetland homes, but had also re-established the entire totora-reed ecosystem. Totora reed is not a 'natural resource', but rather a aquatic crop that is planted and cultivated (Nuñez 1984; Monheim 1963; Levieil & Orlove 1990). The Uru construct literal 'floating gardens' where there is no dry land.

Droughts are always followed by periods of heavy rainfall (Monheim1963). This phenomenon, which regularly recharges the lake and aquifers, is ignored by Kolata and colleagues. These rains often result in serious flooding of the lake plain and have a substantial impact on farming communities. During the massive floods of 1985–86, some 20,000 people were temporarily left without homes and relocated on higher ground (FIGURE 8). Fields were inundated and crops were lost. Mud-brick and sod houses and corrals collapsed after floodwaters soaked their foundations. Farm families moved back to their home sites soon after the waters receded. Within a few years, most had re-established their homes on the rubble of their previous houses. The long history of building and rebuilding settlements is documented in the complex stratigraphy of the prehispanic settlement mounds on the lake plain. There are thousands of these mounds dispersed across the lake plains, and many are still occupied today.

Raised fields also mitigate flooding. During most years, the lake plain is too wet for non-raised-field agriculture. The raised platforms keep the crops from becoming waterlogged. Most of the experimental raised fields produced a harvest during the largest flood in recent history (1985–1986). Some fields were inundated; but farmers were able to harvest them before they flooded.

Conclusion

For farming communities past and present, the climate of the Lake Titicaca basin is risky, unpredictable and chaotic. Peoples inhabiting the lake region have developed a complex indigenous knowledge system that includes a sophisticated agricultural technology and elaborate social strategies to mitigate both short- and long-term climatic fluctuations. This knowledge has been worked out and fine-tuned by hundreds of generations of farmers. It has been passed down through daily practice and oral history from generation to generation. The Quechua, Aymara and Uru have inherited the legacy, as living practices and as a material record embedded in the landscape. Far from being static holdovers from the precolumbian past, the knowledge system and the landscape it transformed are dynamic and flexible. Historical records and ethnography provide rich information on actual human response to climatic fluctuation. Culture in the Lake Titicaca basin did not 'collapse' after the serious droughts and floods in recent history, nor did it 'collapse' in the post-Tiwanaku times. Pre-Columbian states and urban centres were ephemeral, rising and falling with some regularity in the Lake Titicaca Basin. The timing of these phenomena may relate to actual climatic fluctuations, although that would not be a satisfying or adequate anthropological explanation of prehispanic cultural change in the Andes. Farming communities and intensive agriculture did not disappear during the post-Tiwanaku periods. In fact, the archaeological record for rural settlement and intensive agriculture during this period demonstrates continuity and expansion.

The neo-environmental determinist position promoted by many Andean archaeologists views humans as passive and incapable of adapting to the long-term climatic change beyond some presumed environmental threshold. An archaeology of landscapes, combined with the insights of the New Ecology, provides a theoretically robust alternative. In this perspective, humans are considered active and dynamic agents who not only respond to the challenges of fluctuation of climatic in their environments, but also create, shape and transform those very environments. Archaeology, ethnohistory and ethnography have made many contributions to our understanding of the human element in the short- and long-term histories of dynamic environments of the Andes. More importantly, archaeology can shed light on rural lifeways and farming communities, the 'people without history'. The vast accumulated knowledge and abilities of these farmers are embedded in the cultural landscape of the Lake Titicaca basin.

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