Chapter 12
Managing Mayhem: Conflict, Environment, and Subsistence in the Andean Late Intermediate Period, Puno, Peru

BrieAnna S. Langlie and Elizabeth N. Arkush

Extant archaeological and ethnohistoric research indicates that warfare profoundly shaped the trajectory of life in the Lake Titicaca Basin, Peru, during the Late Intermediate Period (LIP, 1100–1450 C.E.) (Arkush 2011; Hyslop 1976; Julien 1983; Stanish 2003; Tschopik 1946) (Fig. 12.1). Regional surveys show that populations strategically relocated their settlements to defensive hilltop forts in response to the political perils of the time. While the unstable climate and dry environment in this region has always presented difficulties for farmers (Erickson 2000; Erickson and Balée 2006), a prolonged drought and new social tensions likely amplified subsistence stresses for LIP peoples (Arkush 2005; Bird et al. 2011; Frye 1997; Thompson et al. 1985). We broaden the discussion of agropastoral risk management to consider both social and environmental pressures that affected peoples' decisions about food production during the LIP in the Titicaca Basin.

Inter-annual fluctuations in the environment caused by climate changes can lead to crop failure, food shortages, and even starvation among human populations. Traditionally, research on agropastoral risk management has focused on strategies developed by farmers that mitigate the hazards caused by these probabilistic fluctuations (Adams and Mortimore 1997; Augustine 2010; Browman 1987, 1997; Gallant 1991; Halstead 1990; Howden et al. 2007; Marston 2011; O'Shea 1989). This literature focuses primarily on how present and past agropastoralists adapt to the local natural environment, without consideration of the political landscape of an era. In contrast, recent research has highlighted the effects of social

B.S. Langlie (✉)
Washington University in St. Louis, St. Louis, USA
e-mail: blanglie@wustl.edu

E.N. Arkush (✉)
University of Pittsburgh, Pittsburgh, USA
e-mail: arkush@pitt.edu

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realities, such as warfare, on food procurement and nutritive quality (Ferguson 2006; LeBlanc 2006; LeBlanc and Register 2003; Milner et al. 1991; Otterbein 1999; Zori and Brant 2012; see also VanDerwarker and Wilson, this volume). Following current usage in anthropology, warfare is defined as a state of hostility between politically autonomous social groups involving armed, potentially lethal conflict and acts of destruction (Ferguson 1984; Milner 1999; Webster 1998). Notably, warfare and environmental stress can produce a feedback loop observed in contemporary and ancient times because repeated crop failures and food shortages brought on by inter-annual climate variance can lead to increased social tensions and warfare (Allen 2008; Lape and Chao 2008; Nel and Righarts 2008; Zhang et al. 2007). At the same time defensive nucleation results in people employing agricultural strategies that exacerbate environmental stress (Kowalewski 2006; Netting 1973, 1974).

Here, we examine how social and environmental pressures articulated, creating a context for trade-offs seen in ancient peoples' economic choices. Furthermore, we propose a methodology to measure these trade-offs. Because of the flexibility inherent in agropastoral subsistence strategies (Browman 1987), Andean populations were able to adapt to either warfare or environmental variability; however, different strategies would be chosen depending on which source of risk was prioritized. We posit that by observing the combination of subsistence adaptations implemented by ancient agropastoralists, archaeologists can pinpoint the perceived importance of each of these hazards in the past.

Even in times of peace, agriculture has been a risky undertaking in the central Andes Mountains of South America since its adoption in the region. *Altiplano* farmers have coped with chronic cold temperatures, unpredictable annual rainfall, and nutrient poor soils (Erickson 2000; Erickson and Balée 2006) by devising three primary strategies to reduce the possibility of inter-annual food shortages. First, several hardy, frost-resistant species of indigenous grains and hundreds of varieties of tubers were domesticated and cultivated in the region (Hastorf 2008; Pearsall 2008; Piperno and Pearsall 1998). Remains of these plants have been documented in archaeological contexts during earlier periods in the Titicaca Basin (Browman 1989; Bruno 2008; Rumold 2011; Whitehead 2007; Wright et al. 2003). Second, plant cultivation is complemented by camelid pastoralism (llamas [*Lama glama*] and alpacas [*Vicugna pacos*]), which provides a direct source of food and dung, the latter used to amend barren soils. Third, ancient farmers increased the productivity of soils by engineering the landscape; they constructed raised fields, sunken gardens, and terraced hillsides (Bandy 2005; Diaz Zeballos and Velálsquez Coaquira 1992; Erickson 1992, 1993, 2000; Flores Ochoa 1987; Janusek and Kolata 2004; Kolata and Ortloff 1996; Smith et al. 1968).

Yet even with these ingenious solutions, agropastoral subsistence strategies would have been particularly challenging in the Late Intermediate Period. Several lines of regional paleoclimatological evidence indicate a prolonged drought led to diminution in lake levels, particularly during the early part of the LIP (Abbott et al. 1997; Baker et al. 2009; Binford et al. 1997; Bird et al. 2011; Calaway 2005; Melice and Roucou 1998; Thompson et al. 1985; Thompson et al. 1986;

Thompson et al. 1998). These climate changes would have affected water availability for humans, livestock, crops, and wild vegetation in the region. At the same time, the threat of conflict drove warring LIP ethnic groups to resettle in defensive hilltop forts (Arkush 2005, 2011; Julien 1983; Stanish 2003; Tschopik 1946). Warfare may have intensified toward the end of the LIP, as Arkush (2011) found that most fortresses date from 1300 to 1450 C.E. These hillforts often contained dense populations living on marginal lands. As a result, warfare in the Titicaca Basin surely caused hardships that fundamentally structured economic choices (Arkush 2011).

Recent archaeological research at Ayawiri, one of the largest fortresses in the western Titicaca Basin, has allowed us to investigate how risk management strategies were implemented during a period of social conflict and environmental fluctuation. Ayawiri is located on a hilltop west of Lake Titicaca at an altitude of 4100 masl (see Fig. 12.1). Radiocarbon dates for its LIP occupation fall within the range of cal. 1275–1500 C.E. This fortified site covers over 13 hectares of the

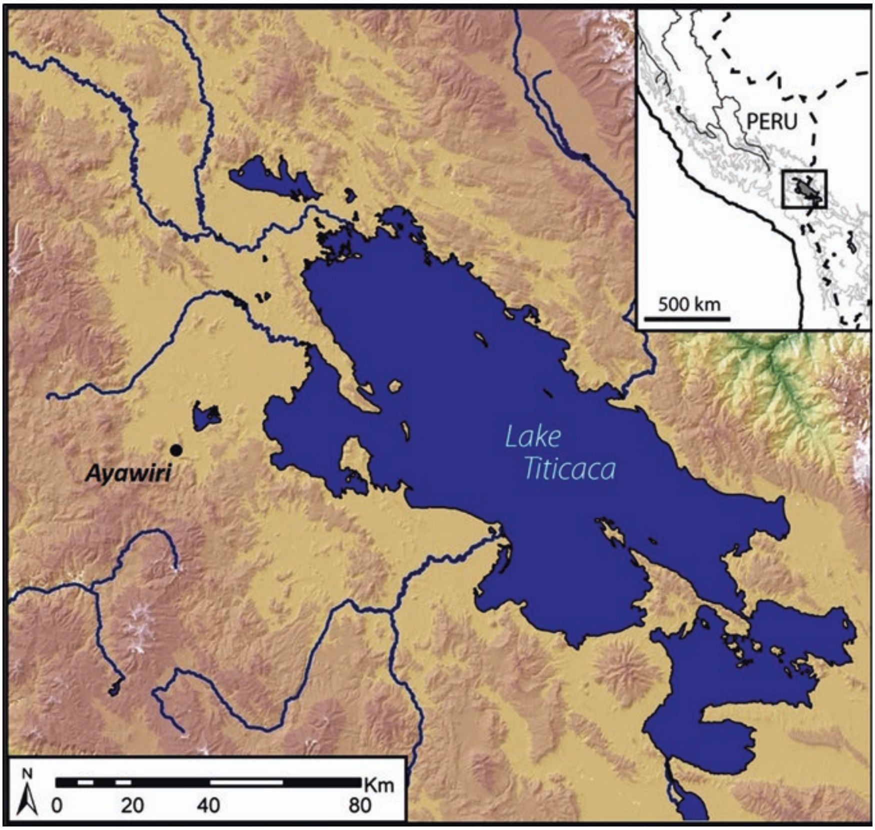

Fig. 12.1 Map of the Lake Titicaca Basin (*dot* indicates the location of the site Ayawiri)

southern portion of a flat mesa (Fig. 12.2). Three stacked-stone defensive walls measuring approximately 1.8 m high and 2 m thick protect the northern approach to the site, and a stacked stone wall encircles the rest of the habitation area. The protected area of the site south of the defensive walls includes about 120-stone wall-enclosed compounds, within which over 670 houses and 450 small storage structures have been identified (Arkush 2011). The mesa upon which Ayawiri was constructed is surrounded by steep hillsides for most of the west, south, and east sides. In prehistory, farmers carved these steep hillsides into viable agricultural terraces.

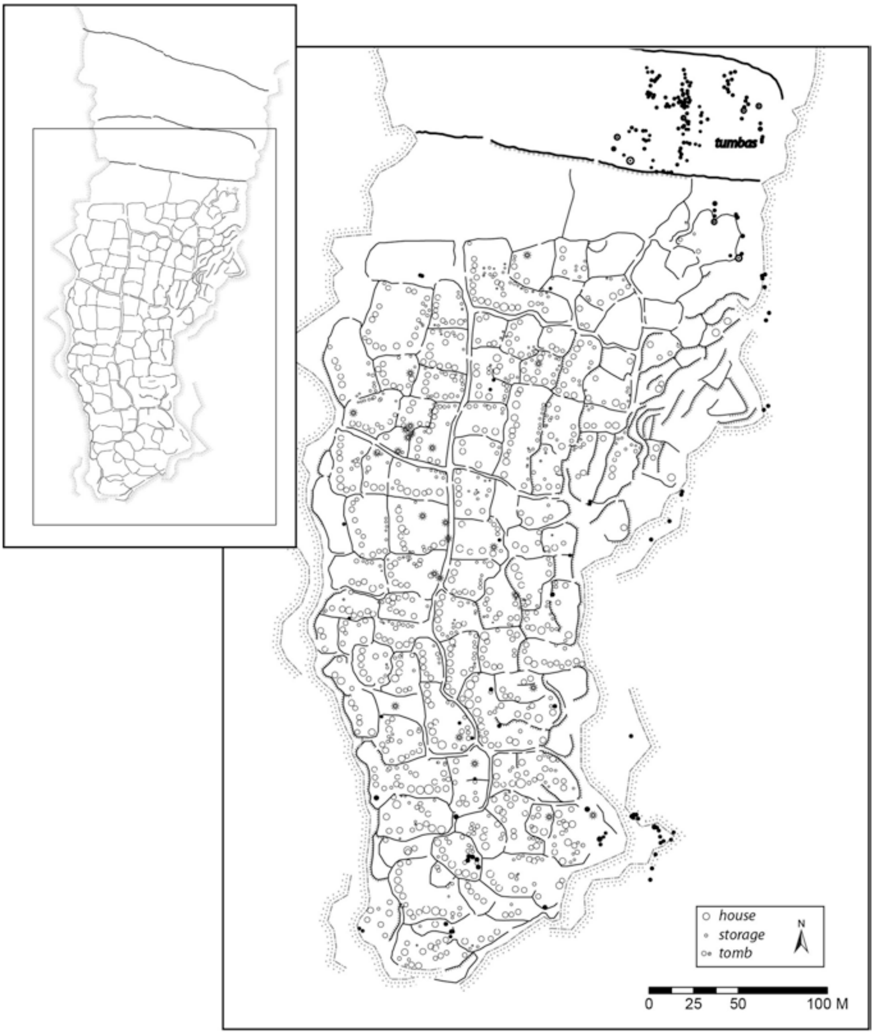

Fig. 12.2 Map of the fortified habitation area at Ayawiri

The territory surrounding Ayawiri is located in the Andean ecozones of *suni* and *puna* (Pulgar Vidal 1946), and is dominated by shrubs and grasslands. Within this territory, we have identified three distinct *ecotopes*, or the smallest ecologically relevant units on the landscape (Troll 1950) (Fig. 12.3). First, flanking the site, agricultural terraces, which are still farmed today, contain shrub plants and crop weed companions when not in cultivation. Indigenous crops grown on the terraces today and probably in prehistory include quinoa (*Chenopodium quinoa*), and tubers such as oca (*Oxalis tuberosa*) and potatoes (*Solanum tuberosum*). Second, to the east of the site, there is a valley that is partially flooded in the rainy season and has very low agricultural potential today due to the high salinity of the soil, although relic fields in the eastern part indicate a far area of the valley was cultivated in the distant past. This valley is composed of predominantly of bunch grasses (e.g., *Stipa ichu*). Third, to the south and west of Ayawiri, there is another valley with a year-round river that is also abundant in bunch grasses. Parts of this river channel into a rich swampy *bofedal*, used as a pasture for herd animals today. This *bofedal* is rich in lacustrine and riverine plants that thrive in wetland areas, such as sedges (Cyperaceae).

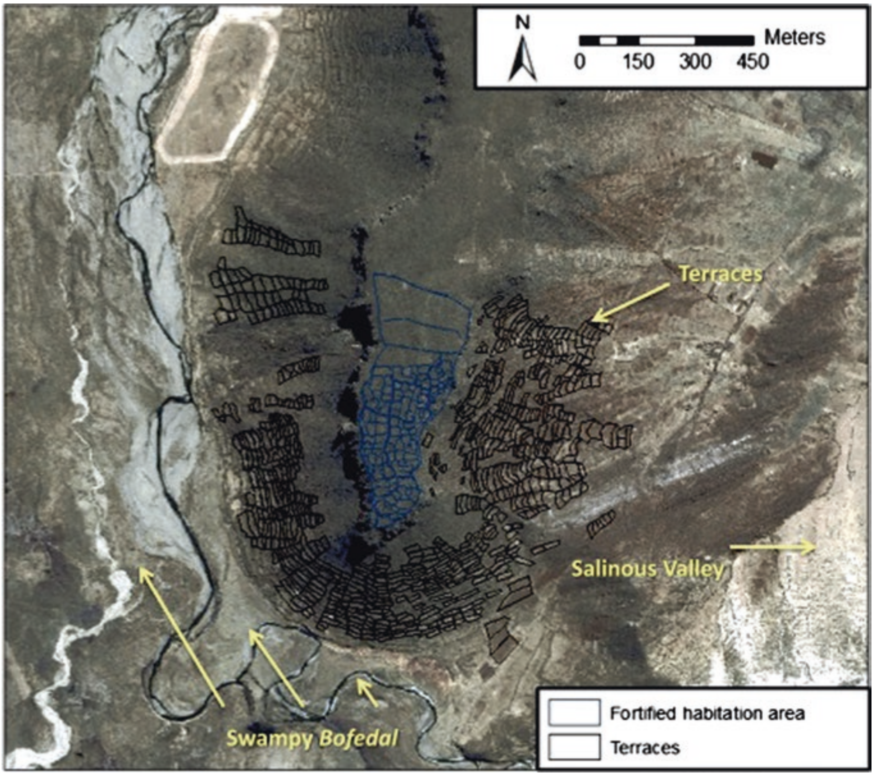

Fig. 12.3 Map of the ecotopes surrounding Ayawiri

From 2009 to 2014, Proyecto Machu Llaqta, directed by Arkush, carried out research at the habitation area at Ayawiri. We have conducted architectural mapping and intensive excavations, and Langlie conducted macrobotanical analyses of recovered plant remains. With these materials, we aim to clarify the trade-offs that the ancient people of Ayawiri made in managing different kinds of agropastoral risks.

12.1 A Model for Managing Risk at Ayawiri

In constructing a model for risk management at Ayawiri, we distinguish among three kinds of interrelated risks: (1) *environmental stress* caused by climatic variability; (2) *intra-group stress* caused by tensions within a community; and (3) *inter-group stress* caused by conflict between communities or enemies. In reviewing ethnographic and archaeological literature about agropastoralism, we found that strategies adapted to cope with environmental stress are qualitatively different than those adapted to deal with inter- and intra-group stresses. Thus, we propose that it is possible to measure ancient farmers' perceptions of these stresses in the past by identifying which strategies they chose to mitigate risks. We begin this discussion by outlining these three types of risk.

Environmental Stress: In the frost-prone and drought-prone Andean *altiplano*, perturbations in the climate such as a prolonged drought would have a specific influence on subsistence strategies. Ayawiri residents would have needed to mitigate the impact that environmental stress potentially had on inter-annual variability in the food supply. Farmers coud have dealt with inter-annual variability logistically in terms of crop management and field management, and socially by sharing foodstuffs within and between communities.

Intra-group Stress: Defensive nucleation into large towns, like Ayawiri, created new health problems of crowding, sanitation, and pressure on local resources, as indicated in several archaeological studies from North America (e.g., Cobb and Steadman 2012; Emerson 2007; Milner 2007), and generated new intra-group tensions among community members and factions (Birch 2013; Johnson 1982; Kowalewski 2006). These tensions could have been mitigated through practices that build group cohesion, such as collective ceremonies, and conformity in the choices of households and individuals. This new social environment could also have affected the ways in which a community organized food storage, processing, and consumption choices.

Inter-group Stress: The threat of warfare drove resettlement to defensive hilltop fortresses, often on marginal lands. This choice of location affected food production strategies. Specific cropping schemes, field locations, and camelid grazing areas could be adjusted to a context of violent conflict if the threat were severe. For example, planting crops and grazing camelids near the site would reduce exposure to enemy attack by reducing time spent outside fortifications (Milner et al. 1991; see also Kennett et al. and VanDerwarker and Wilson, this volume).

How can we assess the impact of these stresses on the lives of prehistoric populations? Drawing on ethnography, traditional ecological knowledge, historical data, and comparative archaeology, we propose a model to assess the trade-offs between environmental stress, intra-group stress, and inter-group stress (Table 12.1). This model is specific to agropastoralism in the *altiplano*, but has

Table 12.1 Choices Ayawiri residents may have made to cope with environmental, inter-group, and intra-group stress

Strategy		Effects on:		
		Environmental stress	Inter-group risk of attack	Intra-group stress
Field location	*Field fragmentation*	↓ risk of crop failure	↑ farmers' risk of attack and crop raiding	↓ competition between neighbors' claims to nearby fields
	Reliance on nearby field	↑ risk of crop failure and depletes soil nutrients	↓ risk of attach because farmers remain closer to fort	↑ competition between neighbors' claims to nearby fields
Grazing strategy	*Extensive grazing on wild plant stands*	↓ risk of crop failure	↑ Camelid exposure to theft	↓ social tensions sparked by camelids grazing on neighbors' cultivated fields
	Grazing in fields and on crop plants	↑ risk of crop failure	↓ Camelid exposure to theft	↑ social tensions sparked by camelids grazing on neighbors' cultivated fields
Types of foods consumed	*Diverse diet*	↓ risk that harvest will fail	↑ risk of exposure to attack because traversing diverse ecologies	None
	Constrained diet	↑ risk that harvest will fail	↓ risk of exposure to attack because traversing diverse ecologies	None
Settlement pattern	*Fissioning into small settlements*	↓ stress on local resources	↑ risk and exposure to attack	↓ social tensions
	Nucleation	↑ stress on local resources	↓ risk and exposure to attack	↑ social tensions
Storage and consumption	*Communal pooled storage and/or consumption*	Evens out and ↓ risk among households	None	??
	Privatized storage and/or consumption	↑ risk to a household's inter-annual food supply	None	↓ social tensions

the potential to be adapted elsewhere. We target several behaviors that are sensitive to these risks and stresses: choice of field location, grazing strategies, types of foods, settlement patterns, and storage and consumption practices. Settlement patterns and storage and consumption practices can be gleaned from survey and excavation data. Decisions regarding field locations, grazing strategies, and types of crops grown can be assessed using data gathered from analyses of macrobotanical remains recovered from the habitation area of the site, and through comparing these data with ecotope analysis of the landscape surrounding Ayawiri. Unless the context of charred plant remains is clear (i.e., burned food in a storage structure), most macrobotanical evidence in this project yields data potentially related to human diet, types of crops cultivated, camelid grazing, and the natural environment. This is because, in addition to periodic cooking accidents, charred seeds excavated from Ayawiri represent routine dung burning. Particularly in xerophytic environments where trees are rare, and at high altitudes where lower oxygen levels are insufficient to stoke wood fires, several archaeobotanists have shown that small carbonized herbaceous seeds recovered from various contexts likely entered the archaeological record through dung burned as fuel (Hastorf and Wright 1998; Klinge and Fall 2010; Miller 1984, 1997; Miller and Gleason 1994; Miller and Smart 1984; Spengler et al. 2013). In the Andes, camelid dung fires explain the herbaceous weedy seed signature of many archaeobotanical samples (Hastorf and Wright 1998; Pearsall 1989). Because camelid dung has been a preferred fuel source for fires in the Andes, archaeobotanical remains preserve the digested remnants of grazing (Hastorf and Wright 1998; Miller and Smart 1984). We compare these remains to the ecotope signatures surrounding Ayawiri to assess locations where ancient agropastoralists grazed their herds (Spengler et al. 2013). These analyses allows us to identify risk management strategies chosen by Ayawiri residents during the LIP.

12.1.1 Field Location

Regarding environmental stress, farmers recognize that microenvironmental differences in soil quality or climate mean that they never know whether a specific crop or variety will prosper in any given year (Baksh and Johnson 1990). Ethnographic and ethnohistoric sources have noted that agropastoralists deal with this issue by cultivating fields in various locations, a practice known as field fragmentation. In the Andean context, field fragmentation appears as a form of spatial diversification that capitalizes on diverse microenvironmental zones to hedge against local climate variability (Browman 1987; Bruno 2011; Chibnik 1990; Goland 1993; Marston 2011; McCloskey 1976; Stone and Downum 1999). Simultaneously farming in multiple ecotopes, such as locating fields in wetlands, at low elevations, and on hillsides, takes advantage of natural microclimates (Browman 1987; Bruno 2011; Marston 2011). Where water is already scarce, field fragmentation would have increased the probability of crop success, particularly during periods of drought (Stone and Downum 1999). If farmers were foddering or grazing their animals on crops, then field fragmentation would also provide food security for livestock.

Additionally, we postulate that field fragmentation might result in decreased competition between families over claims to nearby fields, therein minimally reducing intra-group stress. However, for the residents of Ayawiri, spatially extensive field fragmentation would have heightened inter-group stresses by increasing time spent outside of defended zones rendering farmers more susceptible to enemy attack (see also VanDerwarker and Wilson, this volume). Furthermore, faraway fields would be left unattended and exposed to possible crop theft or crop damage by enemies (Netting 1973).

Under similar conditions to the social situation at Ayawiri, modern warring populations in west Africa intensified agriculture adjacent to areas of settlement nucleation, and farmers abandoned fields near contested frontiers to reduce exposure to inter-group violence (Netting 1973, 1974). Similarly, archaeologists of North America have found that Pre-Columbian warring peoples' diets were constrained due to "feelings of insecurity resulting in excessive caution when conducting subsistence practices" (Milner et al. 1991, p. 590; see also VanDerwarker and Wilson, this volume). If inter-group tensions were high and violence was a perceived risk to Ayawiri farmers, then we would expect them to intensify agriculture in the ecotope nearest the site. In doing so, intensification near the site would reduce the risk of attack by other groups because farmers can readily retreat to a defensive position. Nevertheless, intensifying production near the site often causes an increase in environmental stress by degrading soil fertility, thereby resulting in a subsequent decline in yields over time (Boserup 1965); additionally, this strategy could increase intra-group tension through competing claims to nearby fields.

At Ayawiri, intensification near the site would have taken place on the terraced hillsides that flank the fortress. Survey of the agricultural terraces near the site recovered LIP ceramics from surface contexts. Based on these ceramics and proximity to the site, we posit that if LIP Ayawiri residents abandoned frontier zones and intensified agricultural production near the site, they would have done so on the adjacent terraces. Macrobotanical data yield evidence regarding field location and grazing strategies. Specifically, abundant and diverse macrobotanical remains that grow in multiple ecotopes would point to an extensive agropastoral land-use strategy, while a low abundance of plant remains from riverine and the valley-bottom ecotopes would point to probable agricultural intensification on the terraces.

12.1.2 Grazing Strategies

Like field location, peoples' choices regarding grazing and foddering herd animals would have been made with sensitivity to both environmental and social stresses. In other parts of the world, if the environment does not allow farmers to produce sufficient yields to meet the demands of human subsistence, then fields and crops are reserved for human consumption, while domesticated animals are grazed extensively or foddered on wild plants (Boserup 1965; Marston 2011). Extensively grazing animals might also decrease intra-group tensions sparked by grazing on their neighbors' field crops. Additionally, extensive grazing would expose livestock to possible raids. Nevertheless, it is worth noting that in comparison with agricultural field fragmentation, grazing on wild stands requires fewer people to be exposed to possible attack outside of defensive hillforts. Depending on the size of the herd, often only a single person needs to accompany the camelid herd to pasture, an inference based on our observations in the region today.

While Miller (1996, p. 524) notes that humans likely consumed some of the wild taxa found in archaeological contexts where dung was also burned, she contends that "most of the actual specimens of these taxa became charred through the burning of dung as fuel." With this taphonomic understanding that charred herbaceous seeds are "*primarily* fuel remains" we are propelled to ask more nuanced questions of macrobotanical data (Miller 1996, p. 527). Thus, analysis of macrobotanical remains from Ayawiri elicits information about the diet, and ranging behaviors of ancient camelid herds.

Following a method detailed by Marston (2011), we query the macrobotanical data to better understand landscape use by Ayawiri pastoralists. Based on information derived from modern Andean camelid foraging studies, we know that modern alpaca and llama herds in the Andes eat a diverse and broad diet (Bryant and Farfan 1984; Flannery et al. 1989). Andean camelids can consume an array of forage plants and cultigens (Bonavia 2008). Furthermore, among Andean farmers, it is a common practice to share cultivars with herd animals (Hastorf and Wright 1998). In this study, an abundance of crop and companion weed plant remains would indicate an intensive land-use strategy where farmers grazed their herds on agricultural fields and/or shared their food with camelids, whereas wild and riverine plant remains would indicate an extensive herding strategy or human land-use pattern. Abundant and ubiquitous crop, weed, and herbaceous macrobotanical remains would be indicative of a mixed strategy of intensive agriculture in the terraced fields and extensive grazing/foddering, indicating that farmers made choices to balance risks posed by both environmental stress and intra-group conflict.

12.1.3 Types of Foods

Social and environmental factors affect choices about the varieties of crops grown and types of animal protein consumed. For example, diversification among agropastoralists hedges against the risk of failure of any one crop or loss of herd animals due to climatic forces (e.g., frost or drought) or disease (e.g., nematodes or animal sickness) through the production of multiple agropastoral products with different resistances and different rates of maturation (Browman 1987; Marston 2011). By employing a diverse economic strategy, agropastoralists can readily make seasonal, annual, or inter-annual shifts in time spent herding or farming in order to account for environmental fluctuations as well as social situations. However, inter-group conflict can affect a community's access to fields in various ecotopes, grazing areas, and hunting grounds. For instance, based on bioarchaeological data, Milner et al. (1991) inferred that prehistoric warfare in North America actually decreased the types of plants in local diets because peoples' daily activities were constrained; VanDerwarker and Wilson's presentation of plant data (this volume) from this same region essentially confirms Milner's conclusion.

To assess how social and environmental stress affected the diversity and types of food grown, we examine macrobotanical data for evidence of either a diverse or constrained diet. In combination with our preliminary impressions of the excavated faunal assemblage, we are able to establish whether inhabitants were consuming crop plants, grazing extensively, and hunting wild animals from various ecotopes.

12.1.4 Settlement Patterns

The way that a group settles on the landscape is largely dependent on social or environmental factors. For example, nucleation for defensive purposes is a common response to the threat of inter-group conflict (Arkush 2011; Haas 1989; Keeley et al. 2007; LeBlanc 1999; Nelson 2000), whereas a dispersed settlement pattern ensures that each family group has sufficient land to produce food (Boserup 1965). A nucleated settlement pattern not only places pressure on nearby lands, it can also increase intra-group stress. While an extensive settlement strategy reduces competition over resources between neighbors, nucleation brings many families together into densely packed settlements (LeBlanc 2000; Plog and Solometo 1997). As settlements grow, it is reasonable to expect that the site's inhabitants experience challenges to public health and an increase in social tensions. How did these intra-group stresses articulate with environmental risk and the risk of attack in the past? One classic solution to intra-group stress *and* environmental pressures—fissioning—would have directly increased the risk of enemy attack on these hillfort communities.

To understand residents' choices about settlement organization at Ayawiri, we assess the environmental context of the site location, in addition to the external and internal architecture of the site. Proximity to natural resources lends insight into whether the site was chosen to cope with environmental pressures of such a large population, or whether residents chose the location for its natural defenses. Furthermore, the organization of both household and communal space at the site can lend insight into how residents managed and assuaged intra-group tensions. For instance, civic architecture and public space are often interpreted as architectural constructions that bring residents together and potentially mediate intra-group tensions in cases of nucleation or rapid settlement growth (Cohen 2010;

Pluckhahn 2010; Rodning 2013). Creating such space for collective ritual is one way a defensible, densely packed community could choose to lessen intra-group stress.

12.1.5 Storage and Consumption Practices

Specific storage and consumption practices are often regarded as risk management strategies chosen to minimize inter-annual food shortages (Winterhalder 1990). Storage of agricultural surplus guards against food shortages due to variable crop yields caused by climatic fluctuations, especially in places like the *altiplano* where the seasons dictate that farmers can only plant and harvest a single annual crop (Low 1990; Marston 2011; Winterhalder et al. 1999). Communal storage or intra-group food sharing ensures no single household will suffer in case of individual agricultural loss (Davies and Bennett 2007; Kaplan et al. 1990). Thus, people might have engaged in risk pooling—food sharing, feasting, and/or communal storage—in order to minimize the damage that crop failure wrought on any particular family or kin group. However, this strategy requires cooperation and might not be possible if intra-group tensions and mistrust were strong. In the absence of food sharing, household surplus accumulation could have elevated intra-group stress as some households aggregated stores and others did not, making inequalities apparent. However, if stores were hidden, this may have mitigated intra-group hostilities (DeBoer 1988; Zori and Brant 2012).

Various archaeological indicators at Ayawiri point to how residents carried out storage and consumption during the LIP. The location and size of storage architecture indicate whether surplus was stored at a household or communal level. We look at evidence of cooking and processing to pinpoint how and where these activities were carried out. Finally, evidence regarding the nature of feasting can indicate whether food sharing was common among Ayawiri residents. These indicators shed light on the degree to which food sharing strategies were chosen to cope with environmental and/or social stresses.

To summarize, agropastoralists make calculated trade-offs in crafting subsistence strategies and in choosing and building their settlements. The benefit of engaging in any one risk mitigation strategy may or may not be offset by an equivalent cost. For example, choosing to live in a nucleated settlement may only slightly increase stress on the surrounding environment, while at the same time substantially decreasing the possibility that residents will suffer from enemy raiding. By individually assessing each strategy chosen by farmers in prehistory, we gain insight, not into a perfectly rational set of decisions, but into how farmers *perceived* environmental and social stress in their time. Placed within a paradox of trade-offs, the residents at Ayawiri were forced to develop a specific combination of subsistence strategies adapted to their perceptions of risks stemming from environmental stress, intra-group stress, and inter-group stress.

12.2 Macrobotanical Results

Macrobotanical remains were recovered during excavations from hearths, structure floors, and patios. Most macrobotanical samples were collected as 10-liter soil samples (unless features were smaller in volume) and subsequently floated using a modified SMAP-style flotation machine. While analysis is ongoing, Langlie has thus far completed analysis of 49 macrobotanical samples from 426 liters of soil. In these samples, 10,430 macrobotanical specimens have been identified, of which 9894 are seeds, 536 fragments are wood larger than 2.0 mm, and 27 fragments are charred fragments of dung (Table 12.2). These specimens represent 12 types of botanical remains, including two domesticates: chenopod (*Chenopodium* spp.) seeds and fruits, and tubers.

To analyze macrobotanical remains, we employ two commonly used quantitative indices: standardized density and ubiquity, the latter expressed as percentage presence. These measures are used to identify important plants in the assemblage. Density is the measure of the sum of the specimens of a taxon divided by liters of soil floated (Miller 1988). Ubiquity is a measure of presence of a taxon that is measured by adding the total number of samples a taxon is present in, dividing it by the total number of samples analyzed, and multiplying by 100 to obtain a percentage (Popper 1988). Ubiquity allows us to partially mitigate issues of preservation and recovery in this study by disregarding absolute counts. We assess the

Table 12.2 Ayawiri paleoethnobotanical results

	Raw counts (N)	Standardized density (N/l of soil)	Ubiquity (%)
Crop plant remains			
Chenopodium spp.	9215	21.6	96
Tuber fragments	194	0.45	24
Crop companion weedy plant remains			
Fabaceae	58	0.14	37
Relbunium sp.	20	0.05	16
Rubiaceae	5	0.01	12
Cactaceae	25	0.06	6
Malvaceae	86	0.2	49
Verbena sp.	1	<0.01	4
Riverine and lacustrine plant remains			
Cyperaceae	16	0.04	18
Herbaceous plant remains			
Poaceae	272	0.64	63
Plantago sp.	2	<0.01	4
Fuel			
Wood	536	1.26	73
Dung	27	0.06	8

relative importance of these plants in the economy at Ayawiri by comparing ubiquity values to other paleoethnobotanical studies from the *altiplano* dating to earlier time periods (Table 12.3).

12.2.1 Crop Plants

Chenopod fruits and seeds compose the vast majority of this assemblage ($n = 9215$). At least two species of chenopods were domesticated in the Andes: quinoa and *kañawa* (*Chenopodium pallidicaule*). Numerous subspecies (mostly weeds) grow in the region today. The standardized density of chenopods in this assemblage is almost identical to other *altiplano* paleoethnobotanical studies (see Table 12.3). Notably, fruits from this study appear to be domesticated species based on their comparatively large diameter, thin testa (seed coat), and truncate margin configurations (see Bruno 2006; Smith 1984).

Fragments of plant storage tissue called parenchyma in this assemblage represent tubers, which continue to be grown on the adjacent terraces today. One particular ancient specimen has a distinct eye or axillary bud and leaf scar, which indicate the recovered tissue is a potato. Additionally, excavations in 2012 uncovered seven morphologically intact and completely charred potatoes. Several stem and root tubers were domesticated in the Andes, including the potato, oca, mashwa (*Tropaeolum tuberosum*), ulluco (*Ullucus tuberosus*), and maca (*Lepidium meyenii*) (Flores et al. 2003; Pearsall 2008). The starchy content and preparation method (e.g., boiling and mashing) of tubers means that parenchyma rarely preserves in the archaeological record (Pearsall 2000). This taphonomic consideration likely contributes to the low density of tuber remains in the Ayawiri samples. Additionally, preservation issues probably contributed to the variability in the ubiquity of parenchyma recovered from other sites in the region (see Table 12.3).

12.2.2 Crop Companion Weedy Plants

We identified a group of plant seeds often considered weeds in the region that commonly thrive in disturbed *altiplano* soils such as enriched agricultural fields (Fabaceae, Malvaceae, *Relbunium* sp., Rubiacaeae, and Verbenaceae) (see Bruno 2006). Additionally, a few cactus (Cactaceae) seeds were identified. Langlie noted that cactus plants thrive today throughout the residential area of the site and on the agriculture terraces. Generally, weedy plants recovered from Ayawiri were less ubiquitous than those found at other *altiplano* sites (see Table 12.3).

Table 12.3 Ubiquity values (expressed as percentage presence) derived from comparative paleoethnobotanical studies conducted in the *altiplano* region

Site name	Ayawiri	Chiripa	Kala Uyuni	KCH 11, 21, and 56	Tiwanaku	Tiwanaku	Tiwanaku
Period name and date ranges	Late intermediate (C.E. 1100–1450)	Formative (1500–100 B.C.E)	Formative (1500 B.C.E–C.E. 200)	Late formative (200 B.C.E–C.E. 200	Late formative 1 & 2 (200 B.C.E–C.E. 500)	Middle Horizon (Tiwanaku IV C.E. 500–800)	Middle Horizon (Tiwanaku V C.E. 800–1150)
Number of samples	$N = 49$	$N = 560$[a]	$N = 213$[b]	$N = 21$[c]	$N = 24$[d]	$N = 113$[d]	$N = 204$[d]
Crop plant remains							
Chenopodium spp.	96	99	94/98*	76	96	99	92
Tuber fragments	24	67	92	81	16	6	3
Maize	0	0	0.4	0	20	43	24
Crop companion weedy plant remains							
Fabaceae	37	59	92	48	**	**	**
Relbunium sp.	16	42	71	0	**	**	**
Rubiaceae	12	0.18	51	0	**	**	**
Cactaceae	6	23	10	57	**	**	**
Malvaceae	49	93	97	76	**	**	**
Verbena sp.	4	37		0	**	**	**
Riverine and lacustrine plant remains							
Cyperaceae	18	64	91	76	**	**	**

(continued)

Table 12.3 (continued)

Site name	Ayawiri	Chiripa	Kala Uyuni	KCH 11, 21, and 56	Tiwanaku	Tiwanaku	Tiwanaku
Herbaceous plant remains							
Poaceae	63	92	98	67	40	57	26
Plantago sp.	4	4	11	10	**	**	**
Other							
Wood	73	79	99	86	80	91	88
Dung	8	13	8	24	88	98	91

*Includes *Chenopodium quinoa* and *Chenopodium* spp., respectively

**Authors lumped these taxa into a single weedy category

[a]Data from Whitehead (2007)
[b]Data from Bruno (2008)
[c]Data from Langlie (2011)
[d]Data from Wright et al. (2003)

12.2.3 Riverine Plants

One distinct aquatic plant type identified thrives in moist soil near stands of water is Cyperaceae, also known as sedges. Only a few sedge seeds were identified. In the *altiplano*, a perennial aquatic sedge locally known as *totora* (*Schoenoplectus californicus*) is intensively cultivated in the modern era and this practice likely extends back into antiquity (Banack et al. 2004; Orlove 1991). The white juicy rhizome located at the base of the *totora* plant is commonly consumed as food (Browman 1989; Bruno 2008), and the stalk can also be used as thatching for roofing material, boats, mats, tools, cordage, and animal fodder (Browman 1989; Orlove 1991; Whitehead 2007). Based only on the seed morphology, archaeobotanists in the Andes are currently unable to differentiate sedge seeds to species; however, Bruno (2008, p. 233) notes that Cyperaceae seeds recovered from sites in the region probably derive from one of three different genera (*Schoenoplectus* sp., *Carex* spp., or *Scirpus* spp.). Cyperaceae seeds are often common and abundant in macrobotanical assemblages in the region; however, we identified only 16 seeds from this family. The ubiquity value of Cyperaceae seeds found at Ayawiri is appreciably lower than at other archaeological sites in the region (see Table 12.3).

12.2.4 Herbaceous Plants

Additionally, two herbaceous seed types were identified that grow in most ecotopes throughout the *altiplano*: Poaceae (grass seeds) and *Plantago* sp. (the plantain family). At least four types of grass seeds were distinguished in samples; however, at least 85 species of grass grow in the region today (Whitehead 2007). For centuries, *altiplano* grasses have been used for animal forage, fodder, basketry, and building construction as thatching and roofing material (Bruno 2008; Whitehead 2007). The ubiquity of grass seeds found in samples at Ayawiri is comparable to that recovered from Tiwanaku, but markedly lower than at other sites (see Table 12.3).

We infer that cultivated crop plants were an essential component of the economy at Ayawiri, as indicated by the abundance of both crop plants and companion weed plants. Based on comparative ubiquity values, crops were just as important to the diet of Ayawiri residents as they were during earlier time periods in the *altiplano*. Due to the intensive nature of chenopod and tuber cultivation, Ayawiri farmers likely spent much of their time in their cultivated fields. Growing these plants would have required farmers to invest a considerable amount of time tilling soil, sowing seeds, tending fields, and harvesting mature crops. As none of the identified crop plants require large amounts of water, we propose that inhabitants grew their crops on the nearby terraces.

12.2.5 Fuel Plants

Charred wood fragments were found in many of the Ayawiri samples. Today, the landscape surrounding the site is almost completely devoid of trees except for a couple *keñua* (*Polylepis* spp.) trees growing near the base of the terrace complex. These trees are knotty and soft, which makes them poor candidates for building materials. On the other hand, woody shrubs predominate in the region and are common on agricultural terrace margins, on the steep hillsides, and on the top of the mesa just north of Ayawiri. These shrubs were likely used as a complementary fuel source in prehistory throughout the region (Bruno 2008). As many of the woody specimens in our assemblage are small twigs, residents of Ayawiri likely stoked their fires with the branches of dried woody shrubs. Based on the comparable ubiquities of wood recovered from Ayawiri and other sites in the region (see Table 12.3), we suggest residents of the site were using shrubs for fuel in a similar manner as in people from earlier periods.

We also found charred fragments of dung and small herbaceous seeds indicative of dung burning in many of the Ayawiri samples. Criteria outlined by Miller (1996) and Spengler et al. (2013) confirm that macrobotanical remains recovered from the site partly derive from dung burned as fuel: (1) Alternative fuel is rare and insufficient in the *altiplano*; (2) based on the zooarchaeological analysis residents possessed herd animals (specifically llamas) that produced suitable dung for burning; (3) we found burned fragments of dung, and herbaceous seeds were ubiquitous; (4) many seeds were poorly preserved or fragmented, likely as a result of mastication or digestion; (5) many seed assemblages were mixed and heterogeneous; (6) all samples analyzed were recovered from domestic use or refuse areas rather than storage contexts (no samples from discrete storage contexts were included in this analysis); and (7) there is an ethnographic history of dung used for fuel in the region. Today, dung is still used by residents living near Ayawiri and throughout the Andes to fuel cooking and warming fires. Sillar (2000) notes that in the Cuzco region, potters still prefer dung for ceramic production because it provides more even burning. Lastly, (8) there is a long archaeological history of dung fuel use throughout the *altiplano*. Browman (1989), Bruno (2008), and Whitehead (2006, 2007) have all identified charred camelid dung from Formative Period archaeobotanical samples recovered from sites located on the southern shores of Lake Titicaca. Evidence of dung fuel use was pervasive at nearby Tiwanaku, where it was found in various cultural contexts (Hastorf and Wright 1998; Wright et al. 2003). These archaeological data provide evidence that dung has a long history of use as fuel in the broader Titicaca region.

Preliminary zooarchaeological analysis of animal bones recovered during excavations from the site indicates that camelids represented a significant portion of the Ayawiri economy, whereas lacustrine and riverine animals such as aquatic birds and fish are poorly represented in the assemblage (Aimee Plourde 2014, personal communication). Considering these findings alongside the abundant remains of crop plants and companion weed plants, we posit that Ayawiri residents and their herd animals were dependent on both agriculturally and pastorally produced foods. This diet seems somewhat narrow, particularly for camelids. For humans, chenopods and tubers dominated the diet, whereas camelids only consumed companion weedy species and possibly crops, with relatively little pasturing in the *bofedal* even though it is quite close.

These data also allow us to identify ecotopes where residents grazed their camelid herds. Based on the abundance of crop and companion weed plants, our data indicate Ayawiri camelids were primarily grazed intensively in cultivated fields, probably in terraces adjacent to site. However, residents occasionally took their herds to graze in riverine or lacustrine ecotopes as indicated by the identification of a small amount of wetland-adapted plant species. Compared to Formative Period sites in the *altiplano,* the low incidence of Cyperaceae plants indicates herds rarely grazed in riverine or lacustrine ecotopes. These data point to a constrained grazing strategy during the LIP.

12.3 Settlement and Architectural Results

The site location and the layout of Ayawiri also offer insight into the choices made by its inhabitants. Survey and excavation data reveal that Ayawiri housed a large and dense population that aggregated at the site in the latter part of the LIP. Birch (2013) argues that in cases of settlement aggregation, site architecture is particularly indicative of how integration was accomplished and how interactions were fostered or discouraged; for instance, plazas or public ritual facilities might aid in the integration of communities and the construction of cosmic order, while distinct residential sectors could help to maintain separate social units within the site. At Ayawiri, there is a very marked pattern of residential separation and individuation that is much clearer than that found at other, smaller hillforts in the northwest Titicaca Basin. As we discuss below, people carried out most public and private activities, including food processing and preparation, within segregated compounds. A central north–south causeway and smaller intersecting streets divide the site into smaller sectors, and channel traffic so that residents of the same sector would have crossed paths more frequently; these sectors may also have been related to social group identities. What about community integration? There is no ceremonial or civic architecture aside from tombs, although open spaces between the defensive walls might have served as gathering spaces. It is also possible to imagine communal activities that would have left no physical trace. Nevertheless, we cannot point to any central integrative facilities, such as the platform and court complexes typical of Titicaca Basin centers in earlier periods, which were designed to bring residents together or allow for the ritual mediation of social tensions. Most tombs at Ayawiri are placed within cemeteries, and these places may have hosted periodic collective rituals. However, since there are several cemeteries at the site, and several distinct tomb clusters in the largest cemetery, such rituals likely emphasized identities related to descent groups (real or fictive) rather than a unified, collective Ayawiri identity.

Walled residential compounds are quite uniform across the site. They include houses and storage structures surrounding a central open patio (Fig. 12.4). Houses are circular structures with compacted use floors that contained ceramic, lithic, and bone artifacts. Houses are usually placed on the south and west side of compounds, often on a somewhat elevated fill level or a low platform. Where doorways are identifiable, they face out into the center of the compound. A good deal of food preparation took place inside houses. Twelve out of nineteen houses we have excavated to date had clay ovens, which are oval- or pear-shaped and about 30–40 cm wide (Fig. 12.5). They appeared to have supported a cooking vessel on top, while a fire burned in the hollow chamber inside. Houses with ovens are typically associated with grinding stones, cooking vessels, and faunal remains on floors, often right next to the oven, so these were clearly spaces for food preparation. (Grinding stones are also typically found in the patio spaces, so some food preparation took place in the open.) Because not all houses had ovens, we assume a *household* often corresponded to more than one structure: perhaps each nuclear

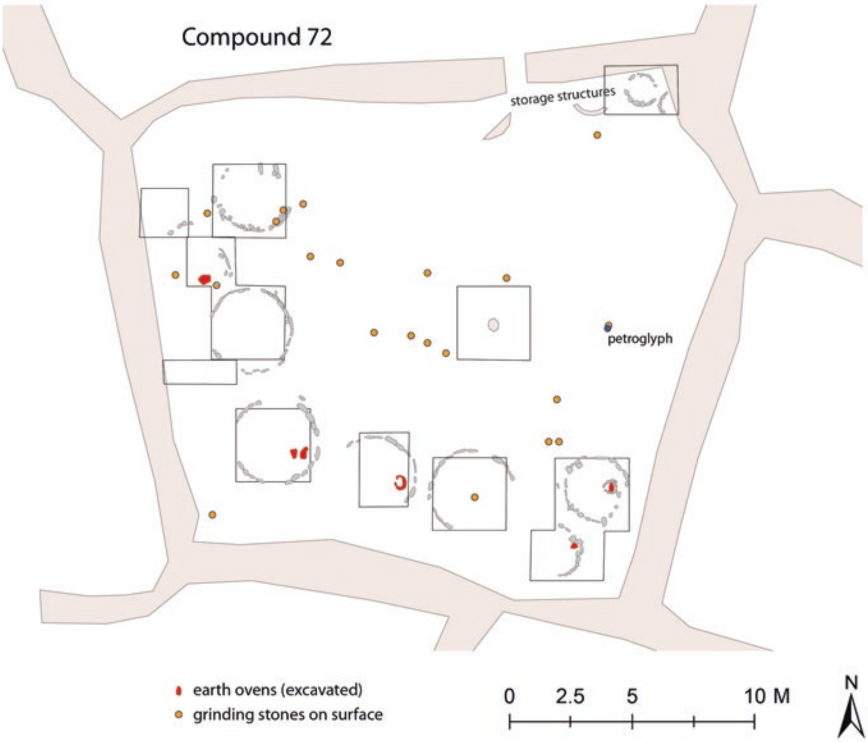

Fig. 12.4 Map of a typical compound at Ayawiri, with storage structures located in the northeast area and domestic structures that open onto the patio

Fig. 12.5 Example of an excavated clay hearth found at Ayawiri

family used from one to three structures on average. Compounds have between one and 19 large structures, with most ranging from two to eight structures, suggesting one or a few related families shared a compound.

In addition, residential compounds also have small circular storage structures, usually located on the north and east sides of the compound. Typically, these consist of a circle of larger rocks retaining an interior of loose rock rubble, creating a low platform apparently designed for drainage and perhaps some ventilation (Fig. 12.6). We infer that residents stored crops or dried meat (*charki*) on these aerated small platforms to prevent moisture and rot; a perishable superstructure may have protected the contents, as suggested by de la Vega (1990). Very similar storage structures are attested at the Inca site of Huanuco Pampa (Barnes 2012). Although no storage pits defined by stone lining or differential color or compaction were identified inside houses during excavations at Ayawiri, we did find a charred cache of potatoes and quinoa in a small pit dug into the soft fill below the floor of a structure. This pit would have been missed entirely if it were not for the charring and careful recovery of macrobotanical remains using flotation. Thus, it is possible that other small, informal and clandestine storage pits that we did not detect were placed inside structures. There is no good evidence for pooled storage. All storage structures are located in residential compounds, and if they can serve as an index of staple wealth, then wealth varied considerably across the site.

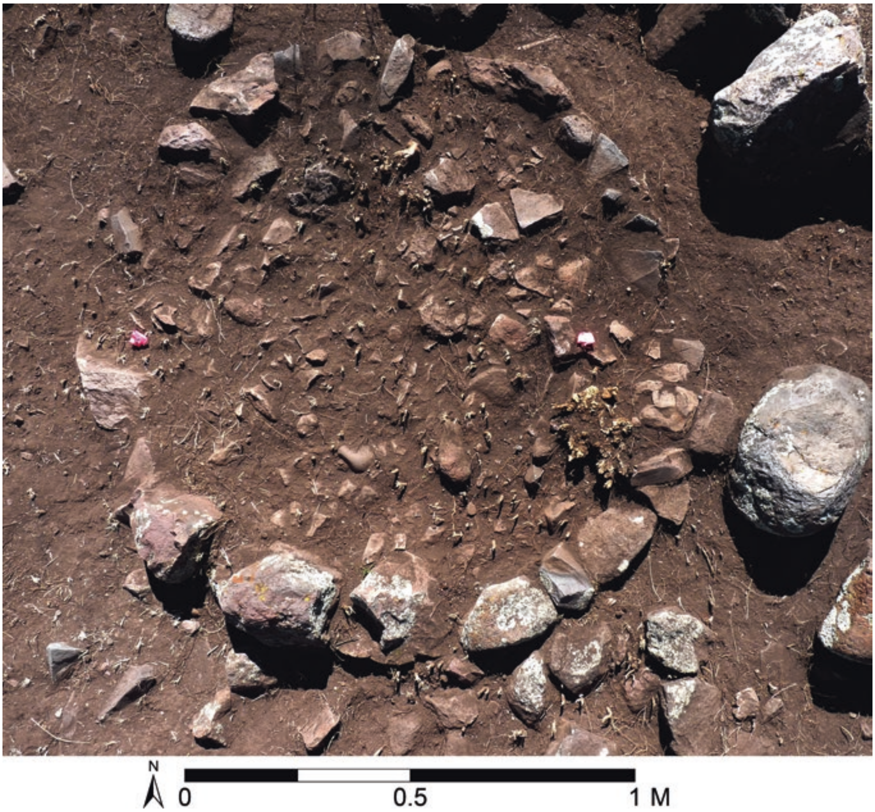

Fig. 12.6 Example of excavated storage structure consisting of a circle of larger rocks retaining an interior of loose rock rubble, creating a low platform

These data indicate that daily activities relating to food preparation and storage were segregated—they were kept within a family or kin group defined by residential compound walls. We are still in the process of assessing pooled consumption—feasting—but it is better evidenced in the earlier occupation of the site, during the Late Formative Period, than in the LIP based on the recovery of large dumps of faunal remains and ceramics during the former period. However, even if food preparation and consumption were not socially inclusive activities, they would have been public knowledge. Stored food was kept in freestanding external structures that were visible and could be counted. Because the central causeway and most intersecting alleys are raised above ground level, as people passed through the site they could look down into their neighbors' residential compounds—especially adjoining compounds—and witness storage structures and food-related activities. In addition, anyone living in an internal compound not abutting an alley would have had to pass daily through the domestic space of another group (perhaps their relatives) and would have seen evidence of their neighbors' activities and accumulated staple wealth. So a great deal of social life was observable, notwithstanding the careful demarcation of space with compound walls. Considerable similarities in the artifact assemblages and spatial layout of different compounds indicate pervasive community norms and practices, although some status differences between compounds were made visible through differences in the architecture of houses and compound walls. Our general sense is that of a site organized around conformity, fairly rigid social expectations, and segregation into kin groups.

To summarize, as with other large LIP hillforts in the region, the hilltop location, the size of the site, and the defensive nature of the walls indicate a settlement strategy that prioritized defense. Living in such a large, densely packed settlement on an inaccessible landform would have afforded residents significant protection from inter-group conflict. Furthermore, such a large population living in one area would lead to increased environmental stress such as diminished availability of local natural resources and decreased soil fertility due to intensified farming practices. At the same time, nucleation would have elevated intra-group tensions over personal space and access to resources. At Ayawiri, we do not see clear evidence for a spatial organization designed to mediate these tensions by building a closely integrated and cohesive community that engaged in many communal activities. The organization of space for living, cooking, storage, and ceremony indicates Ayawiri's residents managed their affairs separately, at the household or compound level.

12.4 Discussion

The natural environment of the *altiplano* presents persistent difficulties for agropastoralists, and paleoclimatological data indicate an extended drought that probably increased environmental stress during the LIP. However, the abundant crop remains from Ayawiri demonstrate that farmers were able to effectively grow crops during this time period, likely on the terraces adjacent to the fortress. Terrace agriculture represents a sustainable strategy that addresses some of the persistent environmental issues of the *altiplano* in that it guards against erosion, thus maintaining soil fertility, moistens the fields by capturing rainwater runoff, and protects plants from frosts that commonly occur in the region (Cook 1925; Dick et al. 1994; Inbar and Llerena 2000; Treacy 1989). Terraces in the Titicaca Basin (and at Ayawiri specifically) are primarily rain-fed, whereas raised fields and sunken gardens rely on groundwater. Based on the macrobotanical crop remains and the proximity of the terraces to the site, we infer there was sufficient rainwater for Ayawiri farmers to carry out terrace agriculture during the LIP occupation of the site.

For the LIP Ayawiri people, the environment was also sufficiently stable to fodder camelids in fields. Additionally, the environment was predictable enough during the LIP occupation of Ayawiri so that farmers could grow different types of domesticated plants.[1]

Evidence of a constrained use of the landscape for farming and herding indicates Ayawiri residents chose to live and work close to the site for the protection afforded by the defensive hillfort and nucleated population. Farming and grazing intensively on nearby terraces to calorically support such a large population at Ayawiri during the LIP probably increased environmental stress on the landscape surrounding the site. For example, fallow periods were probably decreased to grow more crops near the site, decreasing soil fertility. However, the choice to intensify agriculture reduced inter-group stress and the threat of attack on people and on the food supply. More specifically, intensifying agriculture and grazing near the site: decreased the likelihood Ayawiri residents' crops would be raided in their fields (see also VanDerwarker and Wilson, this volume, for a similar argument); reduced the susceptibility of camelid theft while grazing; and decreased the possibility of violent or contentious encounters between members of enemy groups, by nucleating and creating a buffer zone of empty land little used for farming or grazing between enemy territories. Yet all the while, intra-group stresses would have been exacerbated within the Ayawiri community by increasing competition for terrace hillslope fields among families at the site, and increasing competition for grazing rights within those fields.

Hence, our data indicate that Ayawiri's residents did not prioritize the alleviation of social tensions above other needs. This is apparent at the most basic level in their choice to relocate to a nucleated hillfort, indicating that the perceived threat of enemy attack ultimately influenced their decisions more than intra-group friction. That is, LIP peoples were willing to accept a certain level of intra-group stress in order to be part of a large defensive community. Residents dealt with intra-group social relations in specific ways between households. Based on the architectural layout of residential compounds and storage structures, they were more interested in maintaining internal divisions and separate identities than in pooling risk to mitigate environmental stress or relieve tensions over the unequal accumulation of food stores within the community. They built their community so that social activities, including those related to foodways, were segregated within small kin groups but visible to many others, potentially provoking jealousy and gossip, and enforcing conformity to social expectations. While community cooperation was essential to the construction and maintenance of terraced fields and defensive walls, effort was not directed into civic architecture built to assuage intra-community relations.

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[1]Notably, a diversity index in the *altiplano* is difficult to ascertain based on macrobotanicals alone. Since tubers rarely preserved in their entirety, microbotanical analysis such as starch and phytolith techniques are often necessary to identify the diversity in crop plants grown and used in the region in prehistory (e.g., Logan et al. 2013; Rumold 2011).

12.5 Conclusion

In this model of agropastoral risk management, we consider both the environmental and social drivers affecting decisions about food production. While this model is honed to nuances of agropastoralism in the *altiplano*, it has the potential to be adapted and utilized elsewhere. With this in mind, even when environmental stress is an important driver, social responses are culturally negotiated, as clearly seen in this case study at Ayawiri. While paleoclimate records provide complementary information about the past environment, they do not reveal how humans responded to climatic fluctuations. We believe that it is important to try and focus on the emic context under which subsistence decisions were made, especially within a time of warfare. Just as in the present era, farmers do not always make perfectly rational choices. Rather, they react to their perception of the world around them. In envisioning risk management strategies in this way, even in times of relative social calm, past perceptions of social stress and climatic variability among agropastoralists can be measured.

In conclusion, Ayawiri residents overwhelmingly considered warfare between communities to be the preeminent risk factor during the LIP. Based on the paleoenvironmental data, several researchers have proposed drought and subsequent agricultural crises precipitated warfare during the LIP throughout the Andes (Nielsen 2001, 2002; Seltzer and Hastorf 1990; Torres-Rouff and Costa Junqueira 2006), but in terms of subsistence strategies our findings indicate that people at Ayawiri reacted more robustly to inter-group stress. This outcome is not what we would expect if environmental stress were the primary driver of human action. Basically, every choice made by residents of Ayawiri prioritized reducing the chances of violent conflict at the expense of increasing environmental risks and local social tensions. Hence, our data shed light on the severity of Titicaca Basin warfare as perceived by its inhabitants in the LIP. Ultimately, we suggest that a hostile social environment has the potential to powerfully shape the subsistence choices of ancient and modern peoples.

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