19. Cultural and environmental change in the Cuzco region of Peru: rural development implications of combined archaeological and palaeoecological evidence

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Resumen

La información de la arqueología junto con la paleoecología del valle de Patacancha en el Perú da una imagen de la historia cultural y del medio ambiente de la zona. Actualmente esta información apoya obras de restauración de los andenes incaicos y pre-incaicos en este valle y otros. El lago de Marcacocha (a 3356 metros de altura, 12km desde Ollantaytambo) está completamente rodeado por andenes. El estudio de un núcleo de sedimentos orgánicos de 6.3 metros de profundidad esclarece algunos 4000 años de cambio en la vegetación y en la agricultura. También hay evidencia importante de la reducción del bosque antes de esta época. Cada 40 años de los últimos 1000 años han sido examinados; contra la erosión del suelo los habitantes del pasado plantaron árboles. Las excavaciones de Juchuy Aya Orqo, cerca del lago, han proporcionado evidencia por estructuras, entierros, fogones, cerámica, huesos y restos de vegetales quemados. Así hemos ampliado la imagen arqueológica de los andenes, edificios y otra infraestructura y hemos demostrado las estrategias de las sociedades prehispánicas en el desarrollo agrícola de la región. Hoy muchos retos de la agricultura local se asemejan a los del pasado. Un buen número de sistemas prehispánicos ha sobrevivido. Los datos arqueológicos y paleoecológicos traen la base cultural y técnica de una perspectiva para hacer revivir tanto la agricultura que los recursos en esta región.

Introduction

Agriculture in the high Andes has always been challenging due to the risks of soil erosion, marked climatic changes and seismic activity. Inaccessibility and social/political uncertainty have added to the difficulties. The landscape bears evidence of the ways in which civilizations have dealt with these problems over the last millennium in the form of diverse terrace systems, irrigation canals and buildings for food storage. Present-day population distribution, and mechanisms of exchange between kinship groups living in different agro-ecological zones also reflect survival strategies developed over several millennia - the last thousand years in particular. Rural development initiatives, which learn from these traditional strategies and exploit ancient agricultural infrastructure, have proven successful in the Cuzco region of Peru (Kendall 1982; 1997).

Archaeological investigations in the Cuzco region (e.g. Kendall 1991a) have recently been complemented by palaeoecological work to reconstruct vegetation and environmental history over four millennia (Chepstow-Lusty *et al* 1996; 1997). This work focused on a lake sediment core from Marcacocha in the Patacancha valley near Ollantaytambo, an area of extensive recent archaeological work by the Cusichaca Trust (Kendall 1998) (figs 1 and 2). The combined approach has helped to cast light on questions of the relationship between cultural and environmental change in the region's past societies.

The integration of archaeological and palaeoecological evidence from the infilled lake of Marcacocha and local areas has raised the question of whether there is evidence that past civilizations used corrective environmental strategies successfully. There is certainly evidence in the landscape of terracing and irrigation works, which mitigate against soil erosion and drought. Arboreal pollen in the lake sediment reveals a possible indication of woodland management and soil conservation from AD 1100 (Chepstow-Lusty & Winfield 2000). This is supported by archaeological evidence in that one of the main tree species, *Alnus acuminata* (*aliso*) was used in the roofs and lintels of the early Inka buildings at the nearby site of Pumamarca Fort (Kendall 1998: 66). This has afforded a tantalizing glimpse of how people responded to local environmental conditions and climatic change, and even redressed the ecological damage caused by previous inhabitants.

Active management of the landscape by past societies for environmental and cultural reasons is often postulated but rarely satisfactorily documented. The

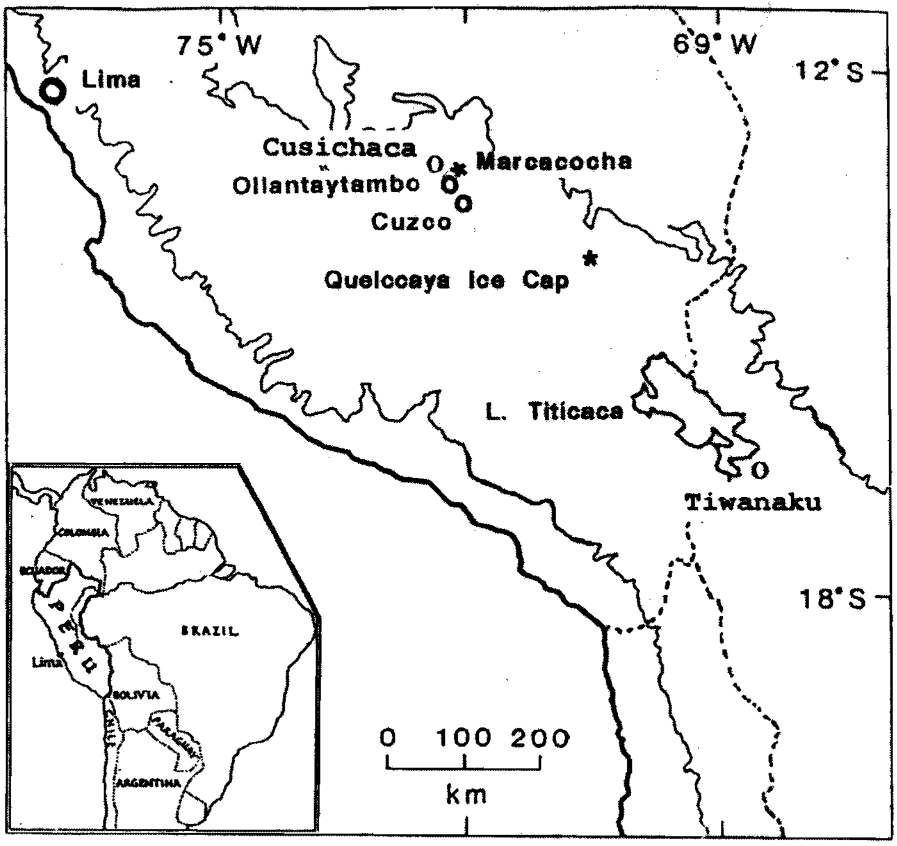

Figure 1. Map of principal sites mentioned in the text.

work described here begins to overcome this deficiency, and attempts to relate the findings to the modern context. Parallels can be drawn between the warm climatic epoch and the growing population prevailing at the time of pre-Hispanic landscape modification, as well as present day challenges of demographic and climate change. To some extent the cultural processes and environmental pressures which shaped the landscape up to 500 years ago are in evidence today, as are traditional agricultural practices and beliefs. This paper explores the relevance of the infrastructural and cultural inheritance from Inka and pre-Inka people to rural development initiatives in the Andes.

Cultural change and environmental modifications in the Ollantaytambo region

Environmental change and over-exploitation of resources have been investigated and proposed as contributing factors in the collapse of New World civilizations: Tiwanaku by protracted drought around Lake Titicaca at AD 1050 (e.g. Binford *et al* 1997) and the Maya during the Terminal Classic Period *c.* AD 800-900 (Culbert 1973), in which a series of droughts may also be implicated (e.g. Hodell *et al* 1995; Curtis *et al* 1996). The collapse of the Inka and Aztec civilizations appears to have had little association with climatic or environmental change, and can be very much attributed to the conquest by the Spanish. The imposition of a new social order and colonial exploitation, accompanied by the spread of Old World diseases and depopulation (Diamond 1997; Cook 1981), devastated Inka civilization and traditional belief systems (Wachtel 1971). There is a growing body of evidence concerning Inka and pre-Inka modifications of their landscape in response to cultural and environmental changes. In its final stage the Inka Empire stretched from southern Colombia to the River Maule in Chile (AD 1440-1532). Population estimates range from 16 to 30 million inhabitants, over half of whom lived in the Peruvian and Bolivian highlands (Earls 1991). By the early 16th century the Inkas had introduced their agricultural systems wherever most suitable throughout their Empire. Terracing appears to have been part of a fully developed economic strategy for food security – especially the production of maize. This was culturally reinforced through their agricultural calendar and centralized administration (Falk-Moore 1958: 17-47; Wachtel 1973: 59-79; Rostworowski 1988: 61-71 and 126-135).

The Patacancha Project (1987 - 1997), carried out by the Cusichaca Trust (CT), focused its archaeological studies (and rural development work) in the Patacancha river valley, a tributary of the Urubamba River with its confluence below the major Inka settlement of Ollantaytambo (Kendall 1997; 1998). Between 1993 and 1996 excavations concentrated on the local area surrounding the infilled lake of Marcacocha, 12 km from Ollantaytambo (figs 2 and 3). Marcacocha is surrounded by Inka and pre-Inka terracing, archaeological sites and roads, the earliest dating from the first millennium BC. The whole valley landscape is visibly dominated by Inka/pre-Inka features dating

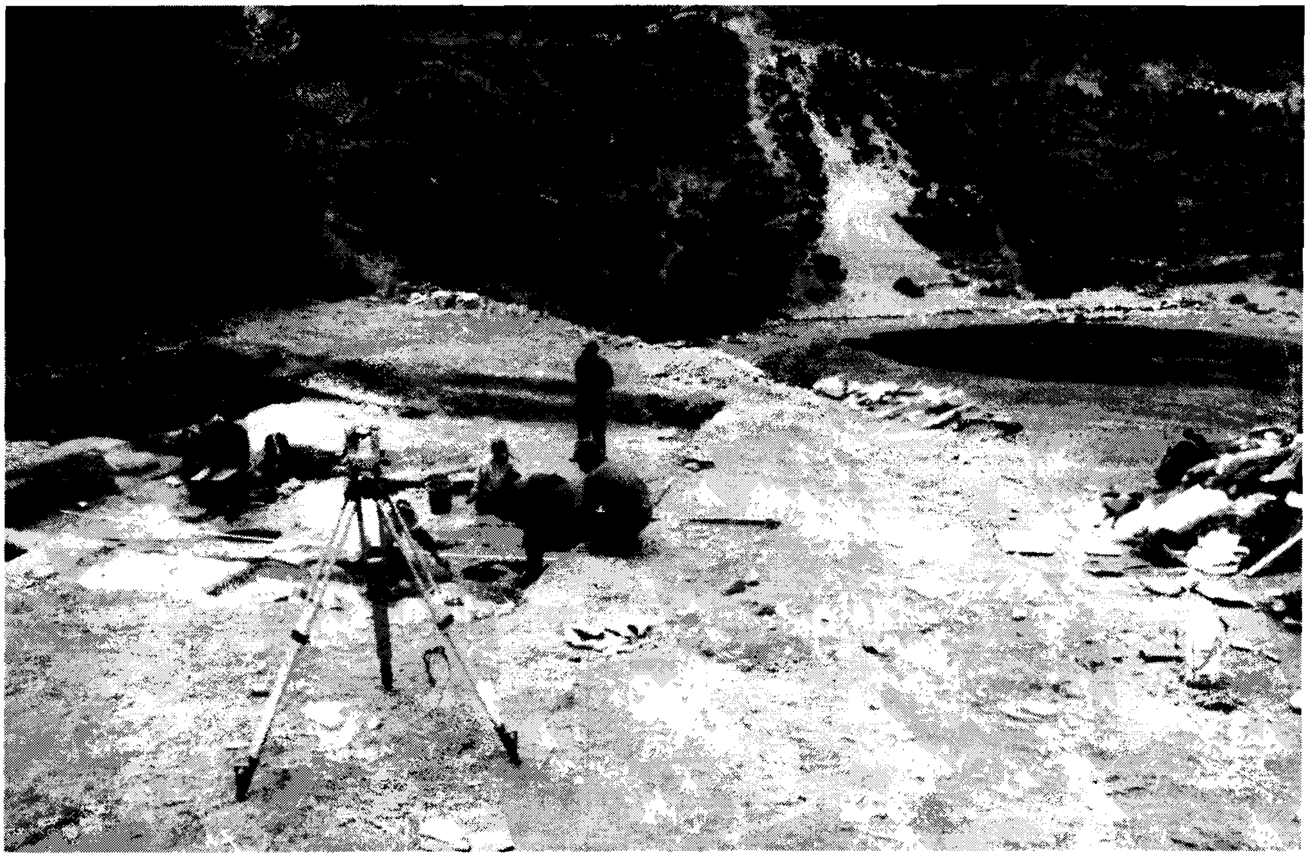

Figure 2. Archaeological excavation in the Patacancha Valley at Juchuy Aya Orqo in 1996, with the infilled lake of Marcacocha (40m diameter) in the background, 12km north of Ollantaytambo. Photograph: Cusichaca Trust (CT)

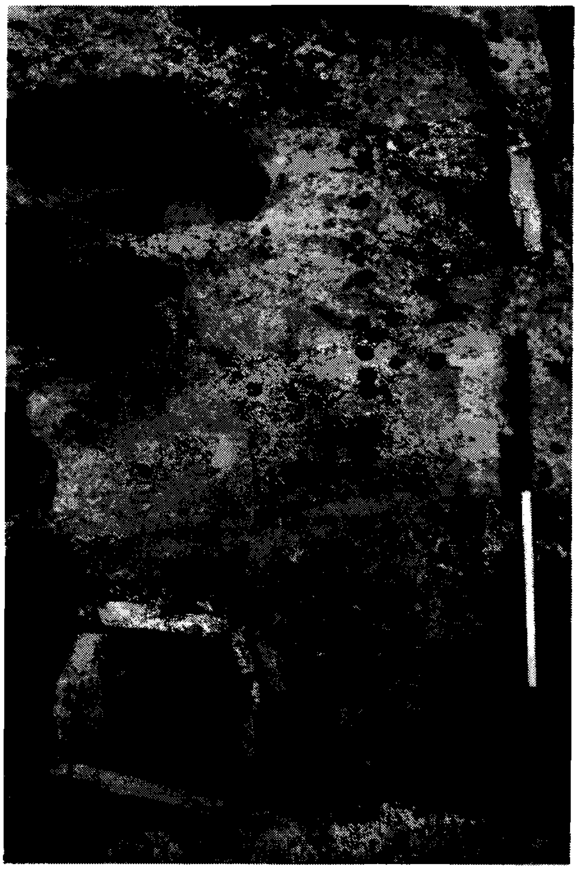

Figure 3. Excavation at Juchuy Aya Orqo: pre-Inka structures with wooden superstructure, stone-lined hearth and burial pits. Photograph: CT

Figure 4. One of the few large *aliso* (*Alnus acuminata*) specimens growing along the Patacancha River, chopped down in 1996. Photograph: CT

from late in the first millennium AD. In addition to residential buildings, forts, grain and potato stores, there are extensive walled terracing systems of bench terraces, with canals for irrigation, and high slope field systems of rudimentary terraces without irrigation (figs 5 and 6). Archaeological work has documented the extent and nature of this pre-Hispanic agricultural infrastructure (Kendall 1991b: 14; 1998). Sedimentological and palaeoecological analysis has provided proxy evidence that terracing and probably tree planting were actively used as responses to soil erosion, after AD 1100. Terracing certainly proved productive in the Ollantaytambo District: Kendall (1991b: 28) estimated almost 2,400ha of Inka and late pre-Inka terraces, perhaps supporting 100,000 non-local people. At this time, based on the evidence of surface remains at settlements, the local population is estimated not to have exceeded 8000. Whereas pre-Inka people used landscape modification for soil conservation and agricultural reasons, the Inkas appear to have also used it as part of a strategy for food security at a time of empire building, population growth and redistribution.

Since Andean people had no written language, direct environmental information is limited to the accounts of the Spanish chroniclers, together with pre-Colombian decorative and pictorial scenes on artefacts such as textiles, pottery, and Colonial *keros*. An indirect record of human impact and changes in vegetation and climate can be gained by analysing samples of pollen, macrofossils and charcoal from lake sediments. In the Cuzco region and the Andes in general, there are many lakes, which are potentially suitable for palaeoecological analysis. Marcacocha is at 3356m altitude, on the ecological transition between the lower valley *quechua* zone and the mid valley *suni* zone. As the area is near the centre of Inka political control and an area of intense pre-Hispanic agricultural development (Table 2, p. 197), it is an ideal site for the combination of archaeological and palaeoecological research.

Early periods up to and including the Middle Horizon

Prehistoric agricultural systems were first introduced in the southern Peruvian Andes over 4000 years ago, with rain-fed terracing systems in the mountains and irrigation on the coast. The transition to irrigated highland terraces was made later (Brooks 1998). In the case of the local Ollantaytambo context there is no secure evidence of very early terracing. No irrigated terraces have been confirmed prior to the end of the first millennium AD. The region's extensive archaeological remains have revealed the cultural history of the wider district (Kendall 1988; 1991a; 1991b; 1996; 1998), but there are frequently relative dating difficulties concerning the study of the first millennium AD, in the late Early Intermediate Period (Table 1, p. 196). This is especially problematical in the case of some continuing 'formative' pottery types from the Chanapata series. There is also very limited evidence for human occupation during this period and into the Middle Horizon Period. Pollen and sediment analysis from Marcacocha has provided significant proxy environmental data to help clarify the reason. Samples were examined at an interval equivalent to 40 years resolution for the last 1000 years and a variable resolution for the preceding 3000 years (fig. 7). Continuous palaeoecological evidence combined with discontinuous archaeological data and site information offers a much more satisfactory method of investigation of cultural change than either approach in isolation.

The sediment record indicates that before 2000 BC the landscape was already deforested and dominated by agriculture, with a high abundance of grasses presumably used for camelid pasture. Crops in the family Chenopodiaceae, such as quinua *(Chenopodium quinoa)* were important for over 2000 years, until AD 100, when its use sharply diminishes. This agricultural period from 2200 BC until AD 100 was also a time of frequent soil erosion events, and initially characterized by a high abundance of Ambrosia pollen in the sediment core. Ambrosia *(Ambrosia arborescens)* is a small shrub used to some extent today in stabilizing the high slope field systems (rudimentary terraces) (Tupayachi Herrera 1993), and also colonizes disturbed soils. In the Patacancha Valley over 685ha of these small banked-up terraces exist (over 3200ha in the whole Ollantaytambo District), see Table 2 (Kendall 1991b: 12-14). Once used for fallow cultivation, some are still in use today. Ambrosia presumably filled a similar role in reducing soil erosion in the past (Chepstow-Lusty *et al* 1998). Marked fluctuations of inorganic material within the highly organic lake sediments suggest the early systems for preventing soil erosion were much less effective compared to the more substantial terraces developed later.

From AD 100, agricultural indicators declined during an abrupt sustained cold period, and there is little evidence of soil erosion caused by human activities or natural events in this period until *c.* AD 700 after the start of the Middle Horizon Period (see Table 1). This is confirmed by the archaeological record in which there are limited data in the region for early to mid phases of Middle Horizon Period occupation. The main Middle Horizon Period (Wari), which flourished in Cuzco, is represented locally by few artefacts, mainly of imports of Qotacalle ware. Another Cuzco regional style at the end of the Middle Horizon is characterized by ware W70 (Cusichaca Trust's coded pottery type), an import also from the Lucre area south of Cuzco. This marks the beginning of renewed occupation around the Marcacocha Lake, on the ridge top of Hatun Aya Orqo (a strategic position), heralding an increase in the number of occupation sites near the end of the first millennium AD with associated irrigated terracing, for example at Hatun Aya Orqo.

In the area north-west of Cuzco, along the River Urubamba and its tributaries such as the Patacancha Valley, pre-Inka W70 and W45 pottery types predominate in the transition between the Middle Horizon Period and the Late Intermediate Period. These types are associated with oval and circular building forms respectively. Four main building types were documented at Hatun Aya Orqo, where small terraces define the early parts of the site, and a stone-

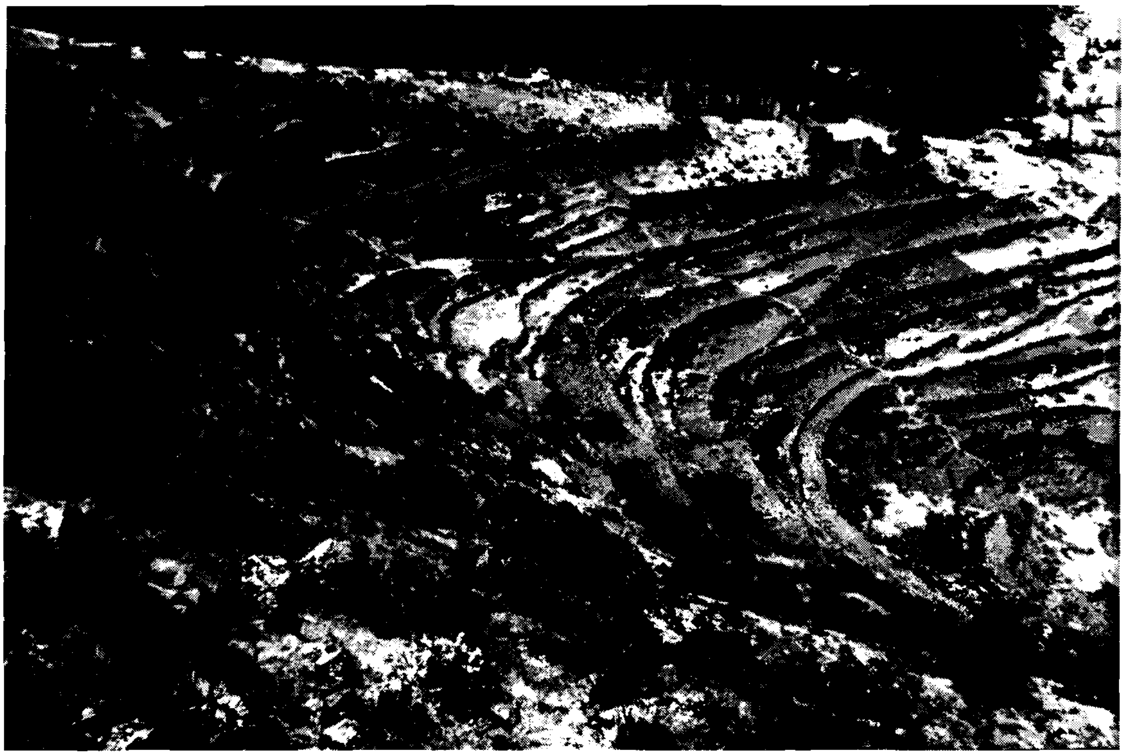

Figure 5. Inka fort at Pumamarca, dominating irrigated Late Intermediate Period terracing (c. AD 1250), Patacancha Valley. Photograph: CT

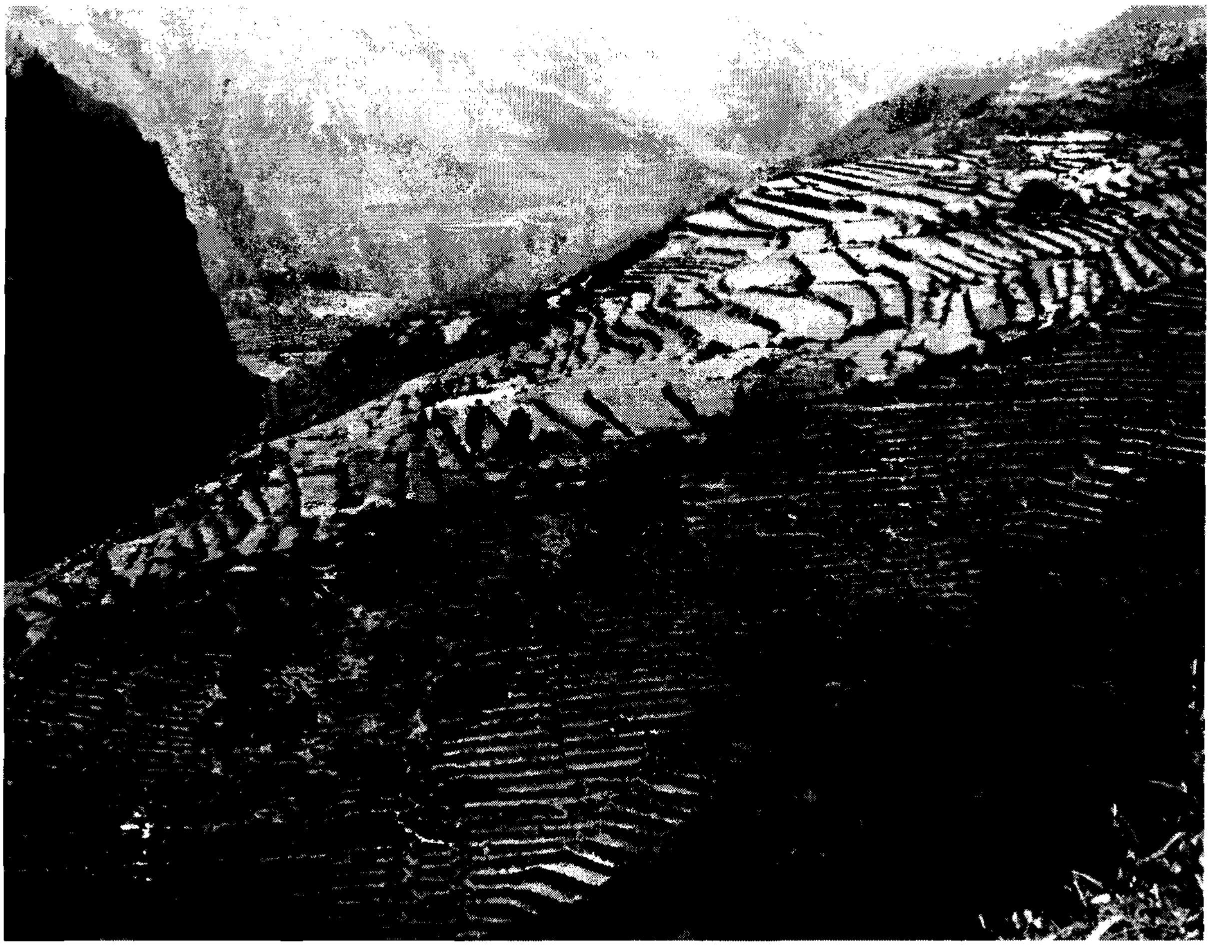

Figure 6. Inka terracing at Choquebamba, Patacancha Valley. Photograph: CT

lined canal brought water to the site just prior to or by the beginning of the Late Intermediate Period. The final phase is represented by Inka architectural forms, showing early or provincial features. On the opposite side of the Patacancha Valley, the classic Inka architectural style is found beside the Inka road. This is characteristic of the Late Horizon Period occupation after AD 1400. In total, seven building phases (from AD 1050 to the Spanish Conquest) were identified down-valley from Marcacocha to Pumamarca and Lomadas.

Excavations on the Juchuy Aya Orqo promontory, adjacent to the infilled lake at Marcacocha (figs 2 and 3) showed habitation, artefacts and carbonized remains, as well as numerous burial grounds. A few samples have been radiocarbon dated, confirming the broad chronology. Artefacts, particularly pottery, provide the evidence for a series of cultures from the first millennium BC (Early Horizon Period) to the sixteenth-century AD (Late Horizon Period), with one crucial discontinuity from the mid-Early Intermediate Period to nearly the end of the Middle Horizon Period (Table 1).

The historical reconstruction, and integration of archaeological and palaeoecological findings from the key lakeside site on the promontory of Juchuy Aya Orqo is now being undertaken. This will be enhanced by the results of ongoing archaeobotanical work undertaken by Emily Dean at Berkeley, California. Preliminary results of the excavations are available as follows. Nearly 2000 archaeological contexts were excavated at Juchuy Aya Orqo in an area of 25.8 square metres. Features included: various sequences of clay floors (37 in total); surfaces with evidence of fire use, including hearths of 18 different forms and 27 structures some of whose floors were delimited by stones or adobes and in some cases wood. There was a large number of post holes (373) associated with mud plastering construction techniques. Thirty-three burials were also found. The excavation confirmed the potential importance of the area for reconstructing the economy, ecology, architecture, funerary rituals, pottery and textiles throughout a long sequence of occupations. In the initial archaeobotanical analysis of five representative soil samples, carbonized remains of *Zea mays* (maize), *Chenopodium* (quinua, related crops and associated weeds), *Amaranthus,* Gramineae (grasses) and Leguminoseae (legumes) were obtained using on-site flotation techniques. Fragments of various wood types were also found, as well as evidence of root crops. These finds indicate that maize and quinua were probably the predominant cultigens in the valley. It was noteworthy that a high proportion of the maize came from contexts that contained burials and had signs of sprouting. Dean (personal communication) has suggested that this may indicate the consumption of *chicha* (maize beer). Carbonized wood was found in all of the samples, and very few contained fragments of carbonized excrement, suggesting that wood was the predominant fuel.

Late periods: the Late Intermediate Period to Late Horizon

Evidence of increasing temperatures and reduced precipitation after this period from the Quelccaya ice core (Thompson *et al* 1985) indicates that drought may have been a major factor in the collapse of the Tiwanaku civilization at AD 1050 (Binford *et al* 1997). However this sudden collapse conflicts with the archaeological evidence of Erickson (1999; 2000). In the Patacancha Valley, the large number of sites characteristic of the Late Intermediate Period suggests that the local population increased dramatically. This demographic increase, which was accompanied by irrigated terracing, suggests a positive strategy for responding to drier climatic conditions. From AD 1100, trees were able to recolonize and the arboreal pollen signal in the sediment core is dominated by *aliso (Alnus acuminata),* which favours degraded soils (fig. 4). Chepstow-Lusty and Winfield (2000) speculate that *aliso* was deliberately grown as part of a strategy to recuperate land severely eroded by previous societies prior to AD 100 and in the period AD 700-1100. Kendall (1996: 133) has sampled *aliso* lintels and beams in architectural remains at the nearby Pumamarca Fort, obtaining a series of radiocarbon dates up to the Spanish conquest. It was also noted that *c.* AD 1400 the Inka began using *chachacoma (Escallonia resinosa),* a harder wood, in their buildings.

Why should the warmer period have been a period of rejuvenation in the Ollantaytambo region, whereas it may have marked the end of the nearby Tiwanaku civilization at Lake Titicaca? One major difference between these regions may have been that water was available in the Cuzco area as meltwater from the mountains, whereas the Tiwanaku people were largely dependent on rainwater replenishing the water sources used to irrigate their raised field systems. It is probably at this time period that the Inka legend originates of the founding of Cuzco. Recent collation of excavation data linking early Inka architectural and pottery styles (Kendall 1996: 152) suggests an earlier date for the emergence and initial regional expansion of the Inkas than that assigned previously of *c.* AD 1250 (see also Bauer 1992). Rowe (1944) suggested that the Late Intermediate Period pottery style called 'Killke', predominant in Cuzco and its surrounding area, was prevalent from AD 1250 and coincided with the early Inka occupation of Cuzco. Dwyer (1971) showed Killke pottery to originate earlier, from an estimated date of AD 900 to 1000. The first wares of classic Inka pottery are associated with pre-classic Inka architecture in Juchuy Cusco and Pumamarca (Kendall 1996). The Cuzco Killke pottery style (defined in the Cusichaca Trust's projects as closest to ware W45) pre-dates any known Inka pottery types. W45 was found in a layer in the Patacancha Valley at Lomadas *over* the occupation horizon, which included W70 potsherds, and mixed together in other contexts (Kendall 1996). The Killke pottery is now generally estimated as starting at c. AD 1000, through a combination of radiocarbon dates obtained from a wide variety of Cuzco sites and material samples (Dwyer 1971; Kendall 1996: 153; Bauer 1992: 82), but it continues into the fifteenth

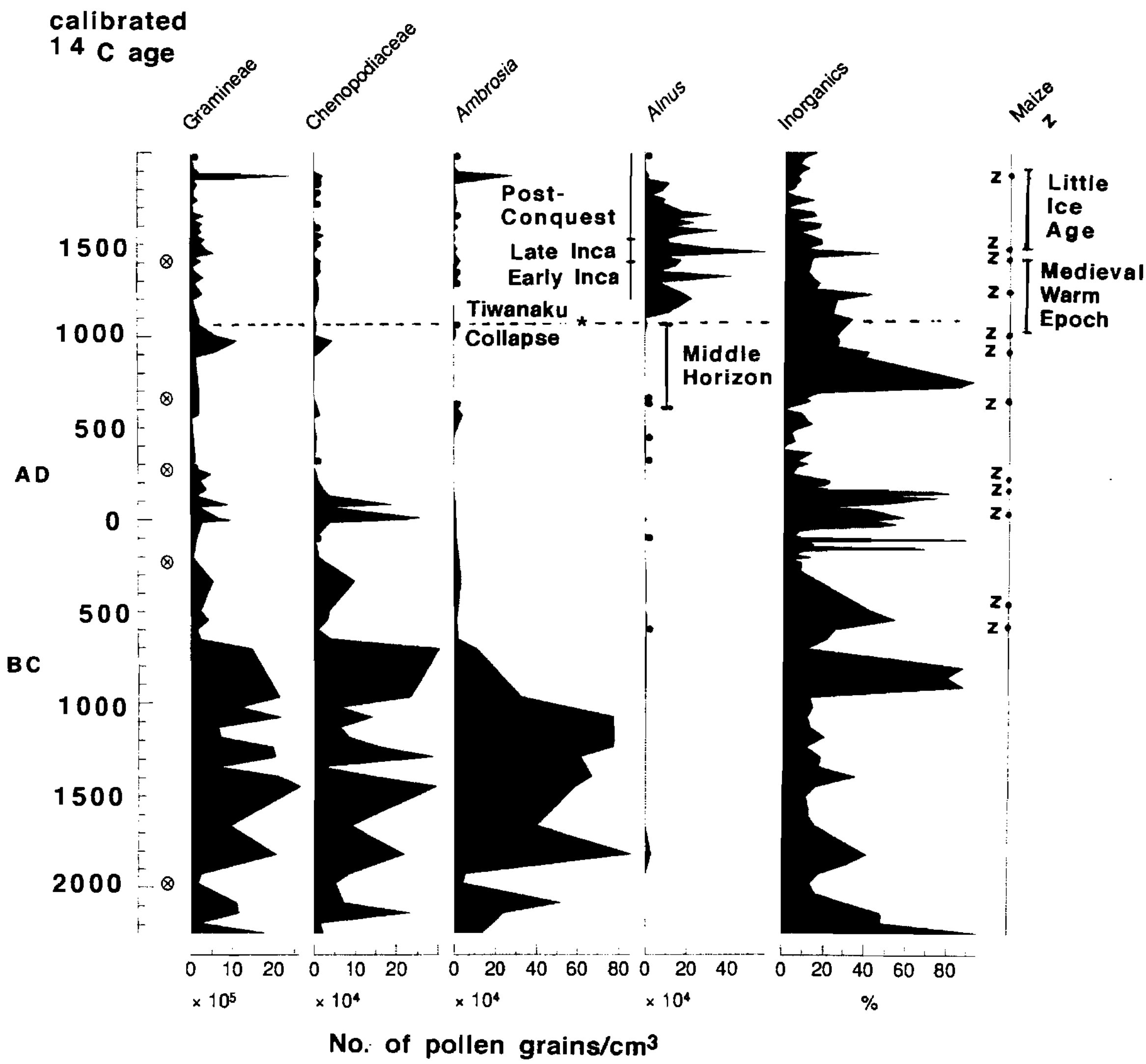

Figure 7. Pollen concentration diagram of four selected taxa from the infilled lake of Marcacocha. The re-appearance of *Alnus* (*aliso*) at c. AD 1050, representing most of the tree signal, is the first sign of tree re-colonization in the 4000-year record in a deforested, agricultural landscape. The inorganic record is a possible proxy for the erosional history in the catchment. Other events, including the Medieval Warm Epoch and the collapse of the Tiwanaku civilization, are also shown. The shaded circles indicate the calibrated radiocaron dates. The presence of rare maize (*Zea mays*)pollen grains are indicated by 'z', notably beginning after the decline of several significant Andean crops within the family Chenopodiaceae, such as *Chenopodium quinoa* (quinua), and associated weeds such as the shrub *Ambrosia arborescens* (*altamisa*), a possible indicator of soil erosion.

century, overlapping with the onset of the late Inka expansion, Late Horizon *c.* AD 1440. The results of the Cusichaca Trust's archaeological investigations show three stages in the Inka presence in this part of Peru. It appears first to emanate from the Lucre Basin, and then subsequently from the Cuzco Basin (Table 1).

Archaeological data and a multi-disciplinary dating programme are required to build up further the chronology outlined above. An over dependence on surface collections of pottery and small-scale excavations has held back progress in constructing such chronologies. Although excavation is the essential tool for proving associations, the use of archaeological relationships between walls of surface buildings, as well as evidence of their modification through time, can also be used for the relative dating of building phases, combined with information from distinctive architectural styles.

In the latter part of the Late Intermediate Period, under the early Inka state *c.* AD 1300, the most sophisticated development of highland terrace systems with stone-built irrigation canals took place. This is particularly in evidence in the Patacancha Valley. Here, as elsewhere, such systems effectively rebuilt the landscape and stabilized soil erosion. This is supported by the decline of inorganic sediments in the lake at this time. Relationships between settlement distribution and concentrations of agricultural infrastructure suggest that modest-sized terraces, constructed against the gradient, were mostly present from AD 1050-1300. Occasional areas of low, flat platforms were built closer to occupation sites (bench terraces). Subsequently, with wider expansion of the Inka state from Cuzco, more substantial terrace systems of bench terraces (e.g. at Choquebamba in the Patacancha Valley (Kendall 1997) and Ollantaytambo) were built throughout the Andes during the Empire. These were constructed with 1m of rubble in the base (often over clayey soil and sometimes with an introduced clay lining), overlain with gravel and then at least 1m of introduced soil. These platforms were supported by inclined stone walls, often with two faces and a clayey content in their lower courses. To provide good drainage, they were backed with a lining of gravel. Stone conduits distributed water from the main contour-following canal to a system of secondary, steep gradient canals. The varying gradient of these canals was accommodated by complex hydraulic detailing, as can be seen at Choquepuquio and Pisac. By this time maize appears to have replaced quinua as the major crop.

Although the warm period (AD 1000-1490), commonly referred to as the 'Medieval Warm Epoch', may have been favourable for the natural regeneration of *aliso*, it is possible that this excellent agro-forestry tree was actively managed to fulfil the same purpose in the past as it does today, that is as a source of fuel, to stabilize soils and for building. The agricultural infrastructure fell into disuse after the Spanish Conquest with the subsequent rapid population reduction. Forest cover gradually declined to satisfy the high demands of the Spanish for firewood, timber and smelting (Ansión 1986), the situation being exacerbated by the Little Ice Age (AD 1490-1880), recorded in the Quelccaya ice core (Thompson *et al* 1986). Without the Inka environmental laws governing the use of resources, including forests (Garcilaso 1966 [1613]: 241-50, 271, 325-8, 394), deforestation proceeded rapidly. Presently over-exploitation and availability of wood resources is a serious problem amongst even the remotest of communities (fig. 4).

A Cusichaca Trust study of extant *Queñua (Polylepis)* woods in the mid-Patacancha Valley (Olazabal, 1997) revealed that this resource for firewood was declining rapidly; present woods would disappear in fifteen years if no corrective reforestation was introduced. In its rural development work the Cusichaca Trust has sought to support planting with native trees, but the long-term uptake is insufficient to reverse the overall trend of deforestation (Walsh, 1999: 30-33). As we are entering a warmer epoch, as the result of global warming, historical evidence supports the case for reforestation. Similarly, there are lessons to be learned concerning soil erosion prevention if food production and security in the region are to be increased. The most impressive and productive solution is undeniably to rehabilitate irrigated Inka bench terraces. While the Cusichaca Trust can show this is technically possible and appropriate, socio-economic studies are required before it can be ascertained whether wide-scale rehabilitation would be socially feasible and economically viable.

Earth, land, water and culture

The succession of cultures can be read in the landscape of terracing and irrigation patterns. This transformation of the landscape, sculpted with curvilinear and rectilinear forms of terraces, irrigated by stone-built canals, was widely effected by the Inkas and their immediate predecessors. These systems created both dramatic patterns, as well as making powerful cultural statements. Similar landscape modifications were made in other areas by highland civilizations such as the Tiwanaku and the Wari. However, Inka/pre-Inka transformation of their environment is particularly sophisticated and relevant to the present day.

When Meyers (1998) describes the landscape as being sculpted into a cultural expression of relationships with the natural environment, we are made aware of the overall permanence and importance of the mountain and its features. Its resources, particularly water, find cultural forms as they are adapted to (and by) Andean culture. For instance, Inka religious ideology is expressed through concepts of social organization, which can be argued to derive from the need to control the mountain hydrological system. The Inkas used myths, symbolism and rituals relating to the environment to enforce the social structure needed efficiently to exploit a catchment area of inter-related ecological zones with their different resources (Murra 1972; Zuidema 1977, 1989). This finds expression in socio-religious rituals such as sacrifices. The recent mummy finds of children and young adults in mountain-top burials bear testimony to the practice of the *capac hucha* ritual, a very restricted child sacrifice practised by the Inkas, on the snowy peaks of mountains whose melt-water was channelled into local irrigation systems (Reinhard 1996). The connection between sacrifices and water rituals is also recorded in the ethnohistorical records. Acts of mountain worship are still practised by Andean communities today, for example the acknowledgement of the *apu*s (mountain gods) with libations.

There is no doubt that the Inkas set about pre-designing their irrigation projects on a total catchment area basis. Earlier systems were often incorporated into the new designs. Large stones sculpted to illustrate or commemorate such schemes are to be found *in situ* demonstrating irrigation project designs. Examples such as the Sayhuite stone of Abancay are known throughout the former Empire, as far as Argentina's southern *puna* (see Podestá and Olivera, this volume). Along the Vilcanota-Urubamba drainage, the main valley and every tributary has at least one major irrigation canal, contouring each valley side (Kendall 1991b: 12-17).

Taking the Patacancha Valley as an example of the development of an irrigation system, the early stone-built canal system terminating at Hatun Aya Orqo (described above) could have been fed later by longer supplementary canals connecting streams high on the valley's western side. Another early canal reached Pumamarca from the Yurakmayo side valley. This was superceded in Inka times by a canal from 3850m altitude, near the top of the side valley, with a total length of 5.8km; it supplied water to the fort at Pumamarca and the major Inka terrace system at Choquebamba (figs 5 and 6). The canal had three major secondary drop structures over high gradients, each several hundred metres long, to distribute water to the terraces. The terrace system has an area of approximately 90ha, and comprises three recognizably distinctive phases of construction. On the eastern valley side, three stone-built canals can be seen following contours on the mountainside at different heights. The uppermost canal is the most extensive, and took water as far as Juchuy Poques, a small promontory site occupied from the Middle Horizon Period until the Spanish Conquest. It also irrigated small terraces and high slope field systems *en route,* and crossed the valley ridge into the adjacent valley.

Traditional Andean social organization, typically involving relations between *hanan* (upper) and *hurin* (lower) *ayllu*s (social groups), determined rights and irrigation, land distribution and settlement patterns. The link between the social and physical ordering of the environment finds its best known expression in the ceque system recorded in Spanish ethnohistory by Cobo in 1653, and studied by Zuidema (1989: 455-487).

The past, present and the future — the role of rural development

The outcome of this study, using this integrated archaeological/palaeoecological approach, is not solely of academic interest. Viewed on a wider scale it appears that, from AD 1100, the inhabitants of the Patacancha Valley, challenged by dry periods, successfully managed their landscape and rectified much of the earlier environmental damage. They combined the practice of agro-forestry, terracing and irrigation, thus allowing for the growth of populations in both rural and urban zones. In the modern context of increasing population and a warmer climate it is particularly appropriate to revitalize past strategies and restore existing infrastructure.

Two ways of incorporating this valuable information into 'grass roots' rural development programmes have been implemented by the Cusichaca Trust. The first is to restore valuable agricultural infrastructure, that is the actual canals and terraces, using traditional technology (Huaman Miranda, 1991; Kendall 1982; 1997). At Cusichaca, terraces which were previously sown once every seven to twelve years are now cultivated twice or even three times annually, resulting in a tenfold production increase or more. In the Patacancha Valley, where 160ha of terracing and associated irrigation have been restored, similar productivity gains are expected (Walsh 1999). The second is to understand and incorporate cultural practices and technologies which have survived from pre-Hispanic society into initiatives. These can improve health, nutrition and livelihoods today. All these approaches are similarly incorporated in the Cusichaca Trust's third ongoing development project in Peru, at Pampachiri in the Apurimac region.

From where does the impetus come to transform landscapes and promote rural development as an investment for the future? It is rooted in the past. The Inkas developed the existing terraced agriculture for food security, first for their State and then for the Empire. They appear to have taken the Andean traditions and spiritual attitudes and used them to bolster their productive and administrative aims. Their futuristic landscapes were to serve a practical purpose, but were dressed up in all the regalia of earlier traditions exploited for increasing food production, power and prestige.

Presently, we see continuities not only in Andean traditions and technology, but are experiencing a similar climatic phenomenon as recorded *c.* 1000 years ago in the palaeoecological record. There is increasing evidence that the Little Ice Age (1490-1880), which followed the Medieval Warm Epoch (*c.* AD 1000-1490), has been replaced again by a warming climate, due to rising atmospheric carbon dioxide concentrations. This is expected to cause shifts in agro-ecological zones, coupled with greater climatic extremity, both of which threaten food security around the world. This is a global concern, and a priority issue in rural development today. Locally, a warming climate could mean a renewed increase in the range and productivity of highland terraced irrigation agriculture. In the Andean context of vertical agro-ecological zoning, climate is critical for the range of viable agriculture.

Working with Andean farmers for over twenty six years through its rural development work, the Cusichaca Trust has gained a solid understanding of the contemporary challenges, opportunities, and the place of traditional infrastructure and practices in Andean culture. In the 1990s, the Peruvian government has taken a renewed interest in the economic development of its highland regions, with major programmes of road building, electrification and social services. By learning from the ecological and cultural legacy of the pre-Hispanic civilizations, we can contribute a vision of a sustainable way forward for rural development, which may be more appropriate to local conditions than many modern agricultural strategies. There is now an urgent need to carry out further research in this field at new locations characterized by ancient infrastructure, such as in the Apurimac and Ayacucho regions as well as in the Cuzco region, so that the lessons for rural development can be widened in their applicability. At the same time successful development must also be the outcome of current socio-economic justification and conditions. In the past, environmental changes have stimulated appropriate responses but these have been to fulfill demographic needs. The next step must be to bring together the traditional benefits with those of the developed world and its demands. Sustainable development must evaluate the role and importance of ancient agricultural infrastructure and value the Andean environment to maintain it into the future.

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TABLE 1. Chronology and associated styles/cultures for the last three millennia in the Cuzco region

Period	Styles / cultures
Initial	Marcavalle in Cuzco BC 1200 – 800
Early Horizon	Chanapata BC 800 – 300
	Pacallamocco pottery
Early Intermediate	Not formally clarified in Cuzco *c.* BC 300 – AD 600
	Represented at first by a continuation of Chanapata-derived pottery
	Other painted styles are reported in Canaraccay and elsewhere
Middle Horizon	Wari Occupation in Cuzco AD 600 – 900
	Qotacalle pottery (according to Rowe (1944), but may start earlier)
	Pottery ware W-70 appears late
Late Intermediate	Killke style in Cuzco AD 1000 – 1450: Pottery ware W45
	Early Inka in Cuzco by *c.* AD 1200 – 1400
	Classic pottery wares and incipient Inka state
Transitional	Inka state *c.* AD 1400
	Classic architectural style
Late Horizon	Late Inka
	Imperial Inka beyond Cuzco AD 1450 – 1534

Table 2. An evaluation of the area under cultivation in pre-Hispanic times (by zones in hectares): Urubamba (Vilcanota) Valley (source: Kendall 1991b). E= estimated

	Patacancha Valley	Confluence area	Piri Valley	Confluence area	Tanccac Piscaycucho	Cachiccata Paron	Sillque (including confluence)	Cusichaca & Huallancay (including confluence)	Salapunco Totontoy	Totals	Potential Annual Harvests	Potential Land annually uUnder cultivation
Pre-Inka terraces	209.0E	11.8	35.2	24.2	91.6	137.9	46.2	226.8E	-	782.91E		
Inka terraces	169.4	266.7	75.4	111.2 (94.8)	337.2 170.8	110.1	262.5	134.4	65.0	1531.9		
Total of terraces with irrigation	378.4 +	278.5	110.6 +	135.4	599.6	248.0	308.7	361.2	65.0	2485.6	(x2)	= 4971.2
High slope field systems	685.0 (150.0)		328.5 +	136.7	545.0	458.4	257.0	561.7	80.0	3202.3	(-70%)	= 960.0
Total of land Under cultivation	1213.4 +	278.5	439.1 +	272.1	1144.6	706.4	565.7	922.9	145.0	5687.9		5931.9