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THE RESOURCE BASE OF THE ANDEAN CIVILIZATIONS

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ABSTRACT

The understanding of the prehistoric Andean cultures has shifted noticeably in recent decades, attributing to them higher levels of achievement, both in qualitative and quantitative terms. One of the central elements in the re-evaluation is the realization that a strong economic base, including agricultural production, was in existence from at least 2000 years before the present. This paper brings together some of the newer evidence, to show that the local base was even stronger than is currently acknowledged by scientists working in disparate specialisms. We focus on the pre-Inca, Tiwanaku state which centred on the Lake Titicaca basin.

STAGES OF UNDERSTANDING

Early modern visitors to the high Andes posited that the Tiwanaku culture was one of limited scale, and its centre, the city of Tiwanaku, merely a cremonial site with a tiny resident population. This was the position taken by Wendell Bennett (1934), the leading North American worker on the area in the 1930s and 1940s.

A more modern position was adopted by writers such as Lanning (1962), who regarded the Lake Titicaca basin as having true cities rather than just ceremonial centres from about 2000 years ago. This was also the position taken by Posnansky (1945) on the basis of his very extensive studies of the Tiwanaku site. There was a permanent and substantial population, whose estimated size has grown from one generation of archaeologists to another and is thought now to be over 100,000 persons. This idea is accepted by modern Bolivian archaeologists (Sangines 1995), who also regard Tiwanaku as not an isolated centre, but the head of a whole urban hierarchy. This kind of structure of urban life, for Gordon Childe, required a strong agricultural base to supply the cities with a constant and large flow of foodstuffs. The nature of the agricultural basis for such a large and permanent population is problematic, and the object of this paper. Tiwanaku became capital of an extensive empire, covering some 600,000 square kilometres and maintained its position not for a short period but from the time of first expansion in the 8th century, for some 400 years until collapse some time just before 1200 AD (Sangines pp. 28-29). Prior to that, substantial city-based regional kingdoms had emerged over the first millenium BC in the area around Lake Titicaca (Kolata, 1993, Ch. 4).

Current explanations for the ability to maintain the population of large cities in the now bleak and inhospitable altiplano, focus mainly on the access to the varied territories of the empire, and in particular to the different resources available at different ecological levels, possible because of the close proximity of high mountains tempperate zones, and subtropical areas. The model of the simultaneous exploitation of a number of ecological levels, by groups which periodically migrate between zones, or by outer colonies from the homeland, comes from John Murra, whose 1972 paper, reprinted in the collection printed in 1975 (Murra 1975, Chapter 3), entitled *El control vertical de un maximo de pisos ecologicos en la economia de las sociedades andinas,* was very widely acknowledged and followed by most economic archaeologists in subsequent writings on the prehistoric. Andean mountain civilizations. Browman (1984) adopts a variant of this model, the Altiplano mode, to assert that the access to outer resources was through a trading network and urban hierarchy; rather than active occupation of outer zones by the home population or a group of it. But his emphasis continues on the need for wide-ranging linkages to outer zones with different resources.

Murra's model, based on extensive work for his Ph. D. in the 1950s and subsequent study, is of fundamental importance to our understanding of Andean use of resources, but it should not be used indiscriminately to explain the whole of economic life in the Andes. There are several points to be made: first, the model is partly to do with the economic interlinking and movement of goods between different ecological niches in the mountain environment, but it also concerns colonization and the establishment of territorial rights, a process that must have been a central aim in the periods of empire expansion for the Inca empire. In the outer territories, colonists from the centre were used to exploit the new resources. It is not certain that this model was applicable for Tiwanaku, or that it expanded territorially as did the Inca empire. Some evidence is that it remained a highland kingdom (Browman 1984).

Secondly, the movement of goods in to the centre from the outer ecological niches was predominantly not of basic food stuffs, but sumptuary goods feeding the more advanced needs of a high civilization. Coca, peppers, timber and wooden products, and cotton, were the luxury items from the Yungas. There was a shorter distance movement, to the high lands for the crops of potatoes or oca, or for animal pasture, and downslope to warmer valleys for maize growing, but these were movements within one day or overnight. Even in the case of maize, grown preferentially in the valley lands at 200-3000 metres, this was not a major staple crop, but one associated with religious ceremonies and the redistributional powers of the kings and leaders, and in all probability the maize lands were in the hands of the state. Maize was not really an autochthonous crop, but an import, associated with power and with those who held it (Murra 1975 a).

Relations between the main demographic and power base in the high mountains, and the outer areas, were thus something like those described by Karl Polanyi (Polanyi *et. al.*, 1957) for the early empires generally; a selfsufficient land area, with external links to outer areas solely for luxury items on which the empire did not really depend for survival.

It should also be noted that Murra makes no quantitative estimate of the proportion of food or raw material supplies which was to be obtained from the colonized areas, compared to that produced in the highland cores. A large movement of bulky commodities would have required an enormous effort expended in transport because of the mountain terrain, and this huge effort is in fact suggested, by Alan Kolata (1982, 1989), relying on the large herds of llamas for transport. Kolata himself does not detail in any quantitative terms how many llamas would be needed for transport, and seems to have been uncertain as to whether this idea is a full explanation for the sustenance of the highland population, as he also rehearses the idea of climate change, and the possibility of a better agricultural climate in the past.

Another point, made by Knapp (1991, p. 11), is that there is no necessary rationality in the behaviour pattern of Andean farmers, so that an appeal to the use of different ecological niches as the most rational pattern is not secure. The rationality may be thought to lie in the risk reduction through diversification of crops, but the farmer might then look for diversification within his home area rather than expansion out into other climatic zones. Rationality in using up the spare time available to the farmers, who might work in one zone, and then move to another rather than stay idle for some of the year, is also adduced as the main reason for movement between multiple niches (Golte 1987), but there is no indication in the Andes, that farmers would give up free time, to be used for ceremonies, visits to friends, or fiestas, for the sake of greater production.

AN ALTERNATIVE VIEW

There has been a growing level of understanding about the technology and nutritional value of the altiplano agricultural system, and collectively, the evidence now is that this system was highly productive and able to support a large population. We may focus here on two aspects; one of these is the raised field system, and the other is the nutritional value of some traditional crops.

RAISED FIELDS

Raised fields are found very widely in the Americas, and have been traced both in lowland and upland environments. In the highlands, they appear in flat or very gently sloping land, and typically form a pattern of sets or bundles of 10 or 20 ridges alternating with broad ditches, with a wavelength from crest to crest of 3-5 metres, although in some areas they are far wider, forming field platforms. They are open ended, having no enclosure at either end such as might serve to retain or keep out water. The height from ditch to ridge is often very slight, but reconstructions show that it was originally a metre or more.

One of the key areas for these raised fields, with still in the 1950s an area of over 100,000 acres, is that around Lake Titicaca. The original area before loss to modern plough agriculture may have been twice this amount, to judge from the suitable areas in the pampas of Taraco and Ilave, where intensive farming is likely to have erased all trace of the ridges (Smith, Denevan and Hamilton 1968). In Spanish, the fields are called *camellones,* in quechua *waru waru.* As they were probably developed by the Aymara peoples under the Tiwanaku empire, it seems appropriate to use the aymara term *suka kollus* form them.

The interpretation of these fields has changed over the years. Smith *et al.,* could only hazard very tentative conclusions about their function, and saw them as means of reclaiming marsh land, and as a technique for avoiding temporary floods from lake or rain, but were uncertain about their use for organized irrigation, and thought water conservation in dry periods would be a major feature. Thermal functions in maintaining the ridges frost free were seen as secondary. Lennon (1983) follows these authors in arguing for a water conservation function, but also a drainage function to judge from the detail patterns. The review of preColumbian agriculture by Smith (1987) also emphasizes the drainage function, as well as the increased soil depth achieved through ridging, and mentions thermal effects as a secondary matter.

By this time however, Ryder and Knapp (1983), moved towards another emphasis, based on their study of raised fields in Ecuador. The thermal protection provided by the ridges at an altitude (2855 metres) where strong diurnal variation in temperature was typical and there was a frost liability throughout the year, was seen as critical. Experimental work with actual raised fields and thermometers showed the role of these in raising temperature more than 1 degree C., largely due to the creation of a line of higher air temperatures over the (water filled) ditches. Because of this, it was necessary to have narrow ridges and to protect the plants with ditches on both sides. An explanation for the peculiarly narrow ridges is thus given, as well as an explanation for the lack of organized patterns such as would be needed for irrigation or for drainage. Ryder and Knapp's experiments have been followed by other experiments in Peru at high levels, and temperature differences as much as 2.5 degrees C. found, providing a powerful frost control (Sattaur 1988). The most detailed studies were made by Ortloff (1989), including measurements of the soil temperature as well as the air temperature and that of the water in the ditches. The latter could be as much as 10-15 degrees F. higher than the outside air temperature on cold nights.

The temperature function is of course not the sole one of the suka kollus. They also managed to maintain high fertility of the soil. Partly this was due to their formation through the piling up of soil from the ditches to bury vegetation and gibe a deep rich top soil on the mounds. Partly it was due to periodic replenishments of this soil with aquatic plants and sediment enriched by manure from animals such as ducks and fish which occupied the ditches, in the ditch cleaning exercises. Experiment in modern times (Kolata 1993, Ch. 6 pp. 183-90) show there is a rapid colonization of the ditches by plants and if encouraged, by fishes. The water system would also give protection against droughts and floods, as predicted by the earlier students of the system.

The experiments on production levels go beyond academic exercises; they involved native farmers from the northern, Peruvian side of Lake Titicaca, under the guidance of Clark Erickson of the University of Illinois, from 1981, growing potatoes, quinua, and cañihua, traditional upland crops, and achieving crop yields 4-8 times as large as those normally produced on flat fields. Potato yield levels of 10.6 tonnes per hectare here may be compared with regional averages of between 1.6 and 6 tonnes (Garaycochea, 1987). In a separate project on raised fields with potatoes, on the southern, Bolivian side of the lake, organized from 1986 with local people by the University of Chicago, the *Proyecto Wilajawira* (Kolata 1989), comparable differences were found. In the 1987-88 growing season, one of intense frosts around L. Titicaca, the yield difference between standard plots and those in raised fields set up under Kolata (Kolata 1993) was 2.4 tonnes per hectare, against 42 tonnes per hectare, or 21 tonnes per hectare when the areas occupied by the ditches are excluded, roughly half of the total. These Bolivian results are even more extreme than in Peru, but come from a slightly lower and less frost prone region, and may also relate to modest differences in cultivation technique (Kolata 1993, p. 198). A further benefit of the frost-proofing of the farming system, for potatoes as for quinua, ulluco, oca, and other crops, is the possibility of double cropping which has also been done successfully in the raised fields. The improved climatic conditions allow a more rapid maturation of the crops and in most years will permit double crops.

This feature is of great significance in the understanding of the ancient food supply system for the high civilizations of the Andes. Some students of the area had concluded that the ancient systems were irrelevant to present day altiplano conditions, because of climate change, or geological events such as volcanic ash deposition, but the contributions of the teams with Erickson and Kolata have shown the current relevance of the system.

Raised fields are of course not the whole story of farming technology in the Andes; irrigation and terracing systems were complementary to the raised fields, and in the L. Titicaca zone were adjacent to them, on the inmediately ground (Donkin, 1979, p. 121).

NUTRITIONAL VALUE OF CROPS

The second half of the food resource story concerns the high nutrition value and special adaptation to the altiplano, of some of the traditional crops. Attention focuses especially on the pseudo-cereals, plants not from the grass family but yielding large volumes of cereal-like seeds. These species include the chenopods or goosefoot family, and the amaranthus family.

Several species of Amaranth were domesticated in the Americas, and in the Andes the species used was *Amaranthus caudatus.* Locally known as *kiwicha,* it grows successfully in relatively poor conditions of soil and bright sunlight, and has a high protein content of 15-18%, including lysine, a protein normally only obtainable from animal protein (Sauer 1995, Sattaur, 1988a). Today, it is scarcely of importance in the Andes, though still grown as a vegetable garden crop by rural people, at altitudes around 3000 metres, alongside such crops as maize.

Amongst the chenopods, quinua *(Chenopodium quinua)* and cañihua *(Chenopodium pallidicauli)* are both of importance. These also have a very high protein content, 14-18% (Galwey 1995), and are high in the complex proteins, lysine and methionine. Their calorific value is also high because of a strong fat content, though they cannot be used to make bread like wheat because of a lack of gluten. As with the amaranths, these crops have been reduced to a very limited area, and are grown in small peasant farms and back gardens, and to poor soils on marginal areas which they tolerate well. Given the survival in such poor conditions of this crop, its extension onto better soils might show a high productivity. Cañihua, in particular, is used as a grain and fodder crop for animals, at altitudes over 4000 metres, where other crops cannot survive. This crop starts to grow at temperatures of -3 degrees Centigrade, as opposed to requirements of around 6 degrees for most middle latitude crops (Sattaur, 1988a). This is a vital characteristic in the frost prone highlands.

Both the amaranth and chenopods seem to have been domesticated in the southern Andes, where there are the first and most varied records (Sauer 1995, Galwey 1995). It seems reasonable to suppose that they were extensively used in the Tiwanaku area. According to Browman (1984), they were domesticated, along with beans, lupins, potatoes and the tuber group, in Tiwanaku by 1000 BC. The chenopods and amaranths do not exhaust the list of useful plants which have declined in use in the Andes. A form of lupin, *Lupinus mutabilis,* or tarwi in quechua, has a different kind of role, being a legume which can enrich soils or prevent their degeneration under nitrogen using crops such as maize. This plant also contains alkaloids that repel insects, and can take up phosphorus under conditions where other plants cannot do so. It has a high protein content, of 46-48%, along with high oil content, comparable to soya beans. Tubers suited to the high altiplano other than potato include ollucu *(ollucus tuberosum)* again has a protein content, at 10-15%, much higher than the 2% level of potatoes, and must have been a valuable protein addition to ancient diets. Mashua *(tropaeolum tuberosum)* is resistant to frost and continues growing down to 0 degrees Centigrade.

None of this commentary is to insinuate that Tiwanaku did not utilize the animal population. Herding, in this part of the world, is likely to have anticipated agriculture, and domestication of the camelids, both llama and alpaca, is dated to 7000 BC (Browman 1984). In the early centuries, the herds are likely to have been used for their meat, but with later development of civilization and of agriculture, they became more valued for their wool and for transport.

THE FOOD RESOURCE

It is now clear that a large population could be supported on the Titicaca altiplano with local food supplies of good quality and quantity. If we accept current ideas about the size of the city of Tiwanaku, about 100,000, and add in further urban populations in the basin area of perhaps 30,000, plus a dispersed rural population of about 250,000 (Kolata 1993, p. 205), there is no shortage of food to support this human group. Kolata uses conservative estimates of the land available for raised fields, at about 19,000 hectares, and calculates the total crop from this area based on 75% use, and double cropping of the land. This gives enough food in calorific terms, for a population of between 570,000 and 1,111,500 people, depending on whether we use the data from the Peruvian or the Bolivian side of the lake for yields. Neither of these figures was approached by the calculated population of 380,000 at the peak of Tiwanaku times. If it is allowed that in fact many raised fields existed outside the area where they can still be detected, then the production potential grows much further, and there is still less difficulty in accounting for a sizeable urban population, fed from rural surpluses in the Titicaca basin.

CONCLUSIONS

Individually, none of these findings is revolutionary, nor enough to form an opinion about the food resource of the Andean civilizations. Collectively however, they constitute an important basis for rethinking the resource base of these civilizations. We must remember that the understanding of the *suka kollus* has been delayed or distorted by our understanding of the role of raised fields in other areas, where irrigation or drainage are dominant roles. Protein content of vegetable foods is also little understood in the western, European based civilizations, where protein has always been predominantly from animal sources. Another factor hindering an appreciation of the ancient foods and the ancient technologies, is that some of them were dismissed, or actively discouraged, by the Spanish invaders of the 16 th century. Amaranths, for example, were seen to be used in religious ceremonies and their use discouraged, both in·Mexico and in the Andes. For want of understanding of the role of the raised fields, these were abandoned by the Spanish whose home experience was in terms of irrigation and for whom these structures were irrelevant. It may be added that in any case, the massive loss of population due to European diseases such as measles and smallpox meant that the dense population needed for managing an intensive farming system was no longer to be found.

Some of the technology was probably lost centuries before the advent of the Spanish, in the interval between 1100 AD and 1450. About 1100 AD or a little earlier, the whole southern altiplano was affected by a major long term drought, which eliminated the elaborate farming system, and along with it, the power of the Tiwanaku state. When the Inca state overran the region in the 15th century, the ancient arts had largely been lost and forgotten, and were not later recovered by the Spanish.

Today, the experiments with the old technology and species have proven their value. This does not however mean that they will necessarily form the basis for a rural revival in countries such as Bolivia or Peru. Just as the Green Revolution did not live up to expectations in the 1960s and 1970s, so now the rediscovery of ancient knowledge provides no guarantee of its use. Instead, it will depend on a thoroughgoing reappraisal of rural priorities, with attention to land tenure, education, the provision of infrastructure, pricing systems and markets, which will allow small farmers themselves to reappraise the prehistoric systems. In Peru and Bolivia today, indigenist movements have encouraged some adoption of traditional crops, but these actions will lead to failure unless accompanied by an integrated, locally based programme for rural development. One of the nearest approaches to this has been with the Cusichaca Trust, whose activities began in 1978, in an area near Ollantaytambo, under the leadership of Dr. Ann Kendall, and including infrastructural works to recover old water systems, soil conservation, kitchen gardens, solar power systems, and the improvem, ent of living conditions and sanitation in the homes. Few government schemes have this broad approach.

What is not evident is a movement from grassroots, led by local people and administered by them, to reintroduce the ancient technology. Foreign archaeologists, or outside development agencies, are unlikely to have permanent effects.

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