PART A

PROSPECTS AND POTENTIALS OF ANDEAN DOMESTIC CAMELIDS IN HIGH MOUNTAIN ECOSYSTEMS: THE ANDEAN EXPERIENCE

Andean Camelids as Part of the Andean Highland Agroecosystem

Evolution of Andean Agroecosystems

Amerindian man arrived in the Andean Region from the northern part of the continent in successive migratory waves around 15,000 to 20,000 years ago. The subsistence strategy of this early settler was based on hunting and gathering, with a concentration on lamoids, cervids, and rodents. Whether these primitive hunters had a transhumant pattern with an oscillatory highland-lowland movement pattern or a rather upland sedentary settlement pattern is still a matter of controversy among contemporary archaeologists.

Whatever the case, over a 10,000 year period, increased dependency on lamoid and rodent (*Cavia porcellus L.*) hunting and highland tuber and chenopod collection led to a gradual simultaneous process of plant and animal domestication. The archaeological records confirm domestication of the *llama* and *alpaca* by 4,000 B.C. (for further information on camelid evolution and domestication please refer to Part B of this document).

The Andean traditional subsistence system is strongly based on a highly developed pattern of diversification of resource exploitation. A strategy for simultaneous exploitation of as many resources as possible along the dramatically differentiated altitudinal levels has being pointed out as the cultural "ideal" of the Andean indigenous households (Troll 1935 and Murra 1972). This so-called "vertical ecology" orientation of productive activities refers to both domesticated and wild biotic resources, as well as to other non-renewable resources (salt and minerals). It is certainly related to the agropastoral character of the traditional subsistence strategies.

The Andean traditional peasant society, principally oriented to assure security and self-sufficiency in a harsh and unpredictable environment, organises its productive activities through a strategy oriented to diversify as much as possible. Households located in deep valleys will, traditionally, have direct access to each soil and microclimatic condition through an extremely fractioned pattern of land ownership, comprised of as many altitudinal levels as possible. Only grazing lands located between the snow line (somewhere around 5,000masl) and the uppermost limits of cultivation (4,000 to 4,200masl) tend to be communally owned. In several regions, indigenous communities lost their pasturelands as a result of the encroachment of large ranches (*haciendas*) which were initially granted to Spanish conquerors (*conquistadores*) during the colonial period (1530s through 1820s). Some large landholdings were also consolidated or developed as privately-owned properties during the first century of contemporary republican history.

The uppermost agricultural belt (with its lowermost limit at between 3,800 to 4,000masl) is usually devoted to the cultivation of native varieties of "bitter" potatoes (*papa luki*) grown for preparation of *chuño*, a storable freeze-dried product, the Andean chenopods -- *quinoa* and *cañihua* (*Chenopodium quinoa* and *C. cañihua* respectively) and, more recently, wheat and barley. In this area, land is usually farmed once every six years and then left fallow. During the resting period, the land is open for grazing, thus enriching its soil with animal dung. Because of high altitude conditions, dung decomposition is slow and its contribution to soil fertility persists over many years.

Right under this uppermost agricultural production zone lies the most important food production belt of the Andes: the areas used for Andean tuber crops, principally potatoes, represented by many cultivars - of which close to 15,000 have been identified by the International Potato Centre- grown as a monocrop or with other Andean tuber crops; such as *ocas* (*Oxalis tuberosa*), *ollucos* or *lisas* (*Ollucus tuberosus*), *mashua* or *izaño* (*Tropaeolum tuberosum*). Potatoes in their many varieties are, however, the Andean staple. Other important crops at this level are broad beans (*Vicia faba*) of European origin, *tarhui* or *chocho* (*Lupinus* sp.), and vegetables of European origin (cabbage, carrots). The lowermost limit of this production zone is marked by the uppermost limit of maize (around 3,200masl). From there on below, native varieties of corn dominate the predominantly sloping landscape. Many of these areas have been carefully terraced. Corn is also the main crop on the flat bottom lands.

Traditionally corn and Andean squashes (*cucurbits*) are also grown in association with beans (*Phaseolus* sp.). Other crops usually grown in association with maize are *yacón* (*Polymnia sonchifolia*), *racacha* or *virraca* (*Racacia xhanthorriza*), and *mauka* (*Mirabilis expansa*).

As we descend into the tropical humid, lowland valleys along the eastern slope of the Central Andes, the sacred coca plant (*Erythroxylon coca*) became the main crop for farming on rather unappropriate lands. Coca leaves (nowadays a perverted commodity due to the illicit demand for cocaine, one of its fourteen alkaloids), traditionally chewed for its energetic properties, in addition to being a mild stimulant like betel nut, played a critical role in the pre-Columbian non-monetary economy. Coca leaves used in old style non-monetary barter and trade operated as a *cuasi* (coin) and played a crucial role in articulating different production zones. It was also important for traditional medicine and religious rituals.

During the last five decades the traditional subsistence strategies -- already under stress and in the process of transformation since Spanish colonisation -- underwent substantial changes as a result of several factors. Above all, the pressures of a market economy, the new demand for agricultural products from growing urban centres, the introduction of new crops and farming technologies (many of which proved inappropriate, inefficient, or, furthermore, disruptive) brought many changes into the system. In addition, policies unfavourable to farmers, and principally conceived to favour urban dwellers, and induced modernisation in the cities triggered rural to urban migration. Despite persistent population growth rates (depending on the country, from 2 to 3% in the cities and from 3 to 5% in the countryside), migration into coastal towns and cities, as well as into colonisation fronts in the eastern Amazonian lowlands, has prompted rural depopulation, farm abandonment, and a steady productivity drop. The most hard hit amongst subsistence strategies has been traditional farming, unable to meet cash demands and incapable of facilitating farmers with access to modernisation (schools, health, and communication systems).

The Place of Camelids in the Andean Agroecosystem and in Andean Culture

Since their domestication along with plants, camelids have played a critical role in the Andean agroecosystem. In the cold Andean highlands, as well as along parts of the Pacific Coast, the *alpaca* is the most important source of wool. The *llama*, also a secondary provider of wool, has become a most efficient pack animal, enabling the transportation of goods over long distances. As still occurs today in traditional villages, both species were a very important source of manure for agriculture, which also served as fuel in the high treeless *puna* environment. Although meat has always been considered of secondary importance in the Andean diet, salted and freeze-dried camelid meat is an eventual but important source of high quality protein.

Camelid bones provide the prime matter for work utensils and beautifully crafted items, while sinews are turned into thongs. Camelid lard, in addition to acknowledged health properties in the rich Andean medical lore, still plays an important role in religious rituals. Camelid foetuses, resulting from natural abortion -- a common trait in SACs (South American Camelids) are sold in rural markets and are widely

used in fertility rites. Similarly, stone formations in the SAC digestive system--*bezoares*-- are considered to be charms and are believed to have magical properties.

Finally, and not the least important, SACs have always been an abundant source of images and concepts in the rich and metaphorical Andean ancestral mythology. Herders state that *"we take care of our animals and they take care of us"* (Palacios 1977), showing the strong interdependence between animals and humans. Peasants believe that *pachamama* (mother earth) gave SACs to men as a loan, and that the future of humanity depends on the proper conservation of herds. They believe lamoids originated in the underworld and came out from water springs. At the end of the world they will all return to those sacred springs. A sign that the end of the world is approaching, they say, will be the depletion of the *alpaca*.

Myth and rite also play an important role in enhancing animal fertility through propitiatory ceremonies that are part of the activities associated with mating and with controlling herd size through animal sacrifice during the dry season.

The Andean Agroecosystem: Camelids and Energy Flow

Within the traditional subsistence strategy, domesticated camelids play a critical role. Their high and cold habitat has a limited net production of biomass. Despite the crucial domestication of plants for human consumption, these crops do not grow over the 4,300masl limit. So, firstly, as opposed to cattle and sheep, camelids do not compete for land with agricultural practices since they normally graze on pastures above the limits of agriculture, or on agricultural plots under fallow. Highland pastures high in cellulose, which cannot be directly utilised by men, are transformed into energy by SACs.

Secondly, SAC dung becomes an essential part of the agroecosystem through effective energy transfer from grazing areas into agricultural plots. This is accomplished either by allowing the animals to graze on lands in their fallow period, or by gathering by hand the dung naturally collected in "latrines" (see Part B), then transporting it on the backs of *llama* and spreading it by hand on the fields prior to ploughing.

Dry SAC dung (*taquia*) is an important cooking fuel at high altitudes where firewood is scarce or non-existent. Besides burning well, it has high heating properties. However, use of dung as fuel reduces the quota for increasing yields in agriculture, and, therefore, in a context of land shortage and low productivity, this traditional practice needs to be discouraged. However, in order to limit the use of dung as fuel, alternative sources of economic energy need to be provided. Currently, kerosene is a commonly used fuel in the Andes. However, its cost makes it inaccessible to the poorer strata of rural society. Reforestation with Andean native trees and shrubs with firewood potential has been promoted in some areas. However, the slow growth of plants at high altitude makes this an initially inefficient alternative. Nowadays, in highland villages, it is not uncommon to see small industrial activities (such as bakeries) relying on the intensive use of *taquia*, cheaply bought from landless herders.

Other alternative and innovative sources of energy in mountain environments need to be explored and promoted. The potential of solar and wind-generated energy is being explored in the Andes. Geothermal and hydroelectric power are also alternatives with significant potential in the Andes.

Transportation of goods on the backs of *llama* represents an efficient as well as a wise energy alternative to the use of motor vehicles, particularly costly when running on steep and winding roads. This is specially true when the beneficiary is basically a self-subsistence peasant agriculturalist with little or practically no access to cash. This became quite evident during the oil crisis of 1968 when fuel prices went up dramatically and *llama* caravans temporarily gained popularity once again in certain regions of the Central Andes. During the rainy season landslides blocked highland roads, also opening up opportunities for *llama* herders to provide their services at proper rates.

Each *llama* can carry around 25 to 30kg over distances of 20 to 25km daily, and a *llama* caravan may consist of 100 to 120 animals. A whole caravan can be handled by one or two persons. On their way they consume wild grasses and natural fodder, requiring no special feed. Furthermore, when they arrive at villages they are always welcomed. In addition to news and products for exchange, the corrals, which are gladly offered for overnight stays, are left with dung that can be used as manure and fuel by the owner of the resting place.

However, the *llama* can only carry non-perishable goods such as grain, potatoes, freeze-dried goods, fibre, and manufactured products. The mining industry has always been a major beneficiary of the traditional practice of transporting minerals by *llama*. On the other hand, short-lived products which easily decompose are not suggested for transportation over long journeys, despite the favourable cool to cold and dry conditions of the *Puna*.

The fibre market may also be analysed from the perspective of energy flow. In addition to providing an efficient means for energy conservation through its use for clothing, SAC wool has an attractive price in the market. In many cases, particularly in highland communities with little or no access to agricultural lands or off-farm employment opportunities, the wool market is the only source of cash. In these highland communities, cash is converted into much needed, additional food energy and other supplementary nutritional requirements (limited factors in the human, highland diet include iodine, which is obtained through consumption of dry sea kelp, certain vitamins, and calcium, most of which can be obtained through trade and barter or at the rural markets).

Although meat (from SACs) has never been a principal item in the daily diet, old animals are sacrificed for their meat, which, once dried out in the cold *(charqui),* becomes an important article for trade (see Part B for further information on SAC meat). In both fibre and meat, *llama* and *alpaca* have significant yields as exemplified in Table 1.

Table 1: Production Parameters in *Llama* and *Alpaca*

Species	*Llama*	*Alpaca*
Birthrate (%)	47.0	45.0
Mortality at birth (%)	25.0	30.0
Adult mortality (%)	8.0	10.0
Adult live weight (kg)	90.0	50.0
Carcase yield (%)	55.0	54.0
Extraction (%)	10.0	12.0
Fibre weight (kg)	2.0	1.6
Frequency of shearing (per year)	3.0	1.5

Source: Pre-identification Report, Regional Project on Sudamerican Camelids - FIDA, 1990.

SACs, as other forms of livestock in rural peasant society, function as capital accumulation and reserve, to be easily and readily convertible into cash when needed (see Part B).

Finally, it has been noted that reliance on children for herding tasks contributes significantly in an energy-efficient strategy for division of labour at high altitude. The efficiency of an agropastoral family is related to the number of children over six years old, the age after which they can take care of the animals (Brooke Thomas 1977).

Andean Camelids and European Farm Animals in Combined Herds

Early Impact of Introduction on Lamoid Populations. Introduction of cattle, sheep, horses, mules, and burros, as well as of other European farm animals, took place soon after the Spanish conquest (1530s). In the very beginning the local Amerindian population regarded the newcomers with amazement and fear. Early colonial history has recorded that initially the local population thought that the horse and the mounted soldiers were one whole being. Equally, the zest for gold and silver on the part of the *conquistadores*, in association with the metal mouthbit fitted on to horses, made some think that these animals fed on precious metals.

Although the colonisers promptly acknowledged the attributes of the Andean "lambs of the earth", as they generically referred to cameloids, the new settlers valued above all the farm animals that had roots in hispanic culture. The horse was perceived as an indispensable beast for mounted travel as well as a symbol of power and dominance. Along with horses came mules and burros. Cattle for milk and its derivates, as well as for meat, were also introduced early on. Oxen came along with the cultivation of wheat and barley (Spanish settlers would not eat maize or potatoes, initially considered "food for Indians", favouring products to which they were familiar). The introduction of a new farming technology, the oxen-driven plough, to the horror of the natives, left to the animals the sacred duty of ploughing mother earth (*pachamama*), previously done directly by men with the traditional Andean foot-plough (*chakitaclla*).

All these, but particularly the horse, required cultivated fodder. For the first time in Andean history, cultivated grasses were grown to feed animals, a previously inconceivable practice in the context of rather scarce agricultural land. Now, men and animals had to compete for land, a scarce commodity in the highlands.

Sheep and goats were introduced at about the same time. Both were prized for meat (although pigs were still the main source). However, sheep played an important role in the colonial textile home industries because of their prized pelts and hides used for, clothes, water bags, and storage vessels.

A little known fact is the introduction of north African camels, along with the introduction of the date palm and fig tree, to the Peruvian coastal deserts by the Spanish settlers. However, for unknown reasons, probably related to the Spaniards' lack of familiarity with this animal and to lack of proper management, Old World camels did not prosper and were neglected and allowed to stray off, becoming prey for escaped black slaves. The last camel in Peru is recorded in 1615 (Crosby 1972: 96).

Although there has not been much research on the initial impact of the new animals on the Andean highland agroecosystems, a substantial transformation had to take place to accommodate the newcomers in their new environment. In addition to the need for growing pastures, management of these new animals was not at all part of the herding tradition of the Andes, which specialised in easy-to-handle lamoids. Demarcation of grazing lands and delimiting them from agricultural plots required new and more restrictive arrangements by bordering the land with stone walls. The care required by the new animals meant additional investments of time as well as novel management technologies. These were all done at the expense of agriculture.

Another major impact of the introduction of farm animals from Europe, although it has not been thoroughly researched, was the introduction of new diseases. In contrast to lamoid defaecation habits,

which concentrate manure in "latrines", the new animals excrete at discretion, thus encouraging the spread of parasites. In addition, sheep seem to have been a major transmitter of several new sicknesses to lamoids, particularly scabies, severely decimating the population of Andean SACs (Bernabe Cobos 1964).

Finally, quite early on, the *conquistadores* noted that the newly introduced animals, from chicken to cattle, were affected by high altitude in terms of their reproduction rates. This was even noted in humans. Diminishing reproductive rates in animals and humans were dealt with by the seasonal movement of herds into the lower parts of the valleys, thus further affecting the best bottom valley agricultural lands. Additionally, it has been reported that the Spaniards also relied on the use of some Andean plants to enhance human and animal fertility. Indian communities in central highland Peru were taxed with a root crop called *maca* (*Lepidium meyenii*) believed to increase the fertility of animal and human populations at high altitudes.

Herding Lamoids with Cattle and Sheep. Despite the initial resistance to and awareness of some of the problems that the introduced animals brought, most of them gradually made their way into the traditional agropastoral economies of the high Andes. Some, such as the horse, never became important in indigenous highland communities due to politically symbolic associations with the *conquistadores*. Even today highland Indians rarely own horses.

On the other hand, sheep and cattle were gradually incorporated into the highland agropastoral ecosystem. Sheep adapted rather well, despite having lower productivity than lamoids. They provided wool in addition to meat, both of which found a market in urban centres where lamoid meat was, and still is, looked upon as undesirable "Indian food". Towards the 1830s, increased foreign demand for sheep wool facilitated the development of large sheep farms, mostly in the southern highlands of Peru (at that time the main wool-producing economies were southern Chile and Argentina). Paradoxically, the bundles in which this wool was exported were fastened with the longer fibres of *alpaca* and *llama*. These fibres attracted the attention of Titus Salt, a British importer. By 1850 the total export of *alpaca* fibre was getting close to that of sheep wool. Since then, the market has kept growing.

Bovines of European origin, although also less productive in terms of highland biomass conversion compared to lamoids, were also gradually adopted by the Andean peasants. Once again, the urban demand for meat and dairy products turned cattle into a worthwhile contribution to the rural economies. Milk was not at all attractive to Andean natives, who, as other non-dairy consumers around the world, have a lactose assimilation deficiency. However, as cheese, milk found its way into the peasant diet.

On the other hand, both sheep and cattle became important items of capitalisation. As opposed to lamoids, the new animals were readily marketable for cash in towns and cities. As a capital reserve they offered better convertibility than the denigrated SACs, identified with the poor Indian peasant.

The culturally-rooted Andean desire for risk minimisation through wide resource-base diversification best explains the increased acceptance of the new farm animals in highland peasant society. In accordance with this Andean ideal, a new resource is always welcomed; a cultural pattern which sometimes does not carefully assess the ultimate consequences. The Andes has many examples of favourable as well as unsound introductions and innovations.

Nowadays SAC herders on an average can be characterised as poly-pastoral. Although, among traditional herders, lamoids constitute the dominant species, depending on region and altitude, there is always a place for sheep and cattle. In the *Puna* it is quite common to run into mixed herds of lamoids and sheep. A few bovines are kept in corrals, though they sometimes graze along with the rest of the animals. On an average, the *alpaca* is dominant in mixed herds (from 30 to 120 *alpacas*) due to the value of its fibre. They are followed by ovines (10 to 80) and *llama* (5 to 50). As far as cattle are concerned, if any, two

or three cows and occasionally a bull are kept separate, although sometimes they can be seen grazing with the rest of the herd. Variations in the rates of mixed herd combinations occur from region to region. In northern Chile, for example, the *llama* predominates along with sheep (Gundermann 1984).

Handling a mixed herd is certainly more complicated than handling one of pure lamoids. The latter, even in large numbers, can be managed by one herder due to their docility and sheep, due to the habit of staying with their leader, require much more concentration. In many cases dogs are used to help with sheep. This presents a problem for SACs (as indicated in Part B). Finally, when bovines graze along with the rest of the mixed herd, they tend to be fastened with ropes to stones or poles to avoid straying.

Mixed herding, in addition to the sanitary risks indicated previously, may also affect the status of pastures. It has been noted that sheep-grazing patterns seriously affect the slow-growing highland pastures with short grass. Although not much research has been carried out on the effects of mixed herding, in comparison to pure lamoid herding, on pastures, because of the lower productivity of sheep at high altitudes (compared to SACs), a higher degree of overgrazing should result from the first option. Appropiate alternatives to mixed herding should be based on sound agrostological research and adequate rangeland and herd management. Each animal has also specific pasture preferences, a factor that should be taken into account in order to optimise the utilisation of highland prairies. Ensuring adequate balance in the consumption of different grasses is better in the long run than risking the degradation of pasturelands.

The relative significance of each one of the above-mentioned species, independent of herding arrangements, in two Central Andean countries, is exemplified in Table 2.

Table 2 : Bolivia and Peru: Relative National and Regional Proportions of Camelids in Relation to Other Ovines and Bovines

(1000 head)

Country	Prov.	Ovines	*Llamas*	*Alpacas*	Bovines	%Camel (1)
Peru	Ancash	828.7	960.0	576.0	225.0	0.15
	Huanuco	563.8	3.6	-----	134.0	0.51
	Pasco	555.3	21.5	2.1	87.2	3.50
	Junin	2015.3	68.9	9.6	213.0	3.40
	Huanca Velica	728.0	112.0	244.2	157.8	29.00
	Lima	493.7	32.0	32.5	250.0	8.00
	Ayacucho	597.6	89.0	137.7	200.5	22.00
	Apurimac	411.1	120.0	194.1	282.5	31.00
	Cusco	1744.4	150.0	345.6	347.0	19.00
	Puno	3008.1	314.4	1702.7	411.5	37.00
	Arequipa	258.8	122.0	294.3	186.4	48.00
	Moquegua	32.2	32.0	38.8	31.4	53.00
	Tacna	50.0	13.5	34.4	30.7	35.00
Total (1)		12509.1	1080.0	3037.0	3900.0	20.00
Bolivia	La Paz	2514.9	426.0	233.1	314.7	19.00
	Oruro	1949.5	739.8	86.0	39.0	29.00
	Potosi	2019.4	819.0	1.0	120.2	28.00
	Cachabamba	1149.5	37.2	4.1	285.4	3.00
Total (2)		8545.4	2000.5	324.3	5401.5	14.00

(1) Including *alpacas* and *llamas*
(2) Total includes populations from all departments
Source: FIDA 1990.