Local Knowledge for Mountain Biodiversity Conservation at the Cajamarca Pilot Project in Perú

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1. INTRODUCTION

The Andes are a continuous mountain ecosystem that includes the territory of seven different South American countries, from Venezuela in the north to Argentina in the south. It extends over 2 million square kilometres, and it has an estimated population of about 20 million inhabitants. The land used for agriculture ranges from 1,500 to 4,200 m in elevation which gives rise to many different agro-ecological zones, particularly in the Central Andes (Colombia, Ecuador, Perú and Bolivia) where even tropical high mountain conditions are found. In the Andes, the more extensively populated area in the world is typically located above 3000 m elevation. Large cities, such Quito, Ecuador, and La Paz, Bolivia, have more than 1.5 million inhabitants each, and medium size cities like Huancayo, Cusco, and Puno in Perú and Oruro and Potosi in Bolivia have more than 100,000 habitants.

Agriculture in these mountains is possible because frost-resistant plants were domesticated to adapt to high altitude, such as the so-called "bitter potatoes" (*S. juzepzukii* and *S. curtilobum*), other "native" potatoes, the small Andean grain "cañihua" (*Chenopodium pallidicuale*) and the small highly nutritive root "maca" (*Lepidium meyenii*). The conservation of these crops has been possible only because the local communities have maintained their cultivation and use during the last few centuries. Also, at altitudes of 3,800 to 4600 m, two important ruminants, the llama and alpaca, were domesticated to produce meat, fibre, leather and manure and graze on more than 20 million ha of native pasture in Perú and Bolivia.

It is also important to remember that these areas have been utilized by humans over the past 10,000 years, and important cultures as the Tiahuanacu and Chavin, and finally, in the 11th century, the Incas, built up what was considered the largest empire in the New World before the arrival of the Spanish. The Incas heritage of domesticated plants and animals and agricultural technology from the previous cultures gave the population an advanced social organization. As a result, biodiversity conservation and appropriated technologies were the keys in a sustainable agricultural system which was quite advanced for the time.

It is now well recognized that, at that time, food production could support the Inca's empire population which was similar in number to the population today. Nevertheless at the present, the Andean rural population has one of the lowest standards of living in South America with serious problems with food supplies and environmental degradation such as soil erosion, loss of soil fertility, inadequate use of water and loss of biodiversity. This is resulting in low crop and livestock yields.

Several attempts to control the process of degradation have been initiated, but the results were often controversial with many negative effects. A general review of the principal constraints on Andean rural development projects is presented for the Peruvian "Sierras", and a case study is presented where a holistic approach is used to analyze and integrate the different components of development to provide alternatives to the current management of the Andean ecosystem with emphasis on soil and biodiversity conservation.

2. AGRICULTURAL DEVELOPMENT IN THE PERUVIAN MOUNTAINS OVER THE LAST TWO DECADES

Agricultural development in the Peruvian Andes has been the main focus of national institutions and international organizations. In many cases, the approach has been to transfer models and techniques that are based on intensive energy and investment systems such as the use of high yielding crop varieties, the use of high levels of chemical fertilization and pesticides and the introduction of new breed livestock systems with emphasis on artificial insemination rather than forage production.

One of the main problems has been the assumption that the high Andean Mountains are a uniform and stable environment. Based on findings by Troll (1950), Pulgar Vidal (1946), Tapia (1990), and Torres (1992), the high Andean mountains in Perú are highly diverse and cover a wide range of environments that greatly influence agricultural production. These range from warm conditions at lower altitudes, such as the **yunga zone** (1000-2000 m) to the template zone known as the **quechua zone** (2000-3200 m), **suni zone** (3200-3800 m) in the central and south part of the Andes in Perú, **jalca zone** (3000-3800 m) and **puna zone** (>3800 m) . Each of these zones are highly influenced by latitude as well as exposure either on the Amazonian side to the east, the Pacific side to the west or the intermountain location. Also physiographic factors such as topography can have a drastic influence on the farming systems. Therefore, an appropriate agro-ecological zonation should not only consider altitude but also temperature, volume and distribution of rainfall, evapotranspiration and more localized conditions such as soil texture, depth, water retention and nutrient content. Mountain agro-ecological zonation is recognized as a complex entity as well as a key aspect in understanding the potential and restrictions of high altitude environments.

An agro-ecological zonation for the Peruvian Andes has been proposed by Tapia (1990), based on geographical studies by Troll (1950) and Pulgar Vidal (1948) as well as botanical studies by Weberbauer (1945) and ecogeographical work by Cabrera (1967) and Brack (1991). This agro-ecological zonation classification considers three hierarchical levels. At the first level, the mountain ecosystem is divided into physiogeographic zones. At the second level, climate is used to arrive at six different sub-regions, each with different agro-ecological conditions. Crops and livestock species and varieties are different in each agro-ecological zone as well as the levels of production. The third level of zonation considers the soils and alternative technologies to be used as the main factors which influence production.

3. THE PERUVIAN ANDEAN AGRICULTURAL SYSTEM

Considering the agro-ecological zones as the main units for environmental differentiations, it is quite important to realize their influence on biodiversity evaluation as well as on the characterization of the distribution of agricultural systems (Table 1).

Crops are dispersed, and some of the chenopods, grains, roots and tubers are adapted to low temperature conditions. Maize is the best indicator of temperature but can be grown up to 3400 m in the absence of frost and up to 3800 m in special micro-climate environments such as the islands on Lake Titicaca. Other crops that have adapted to different altitudes are quinua that can be grown from sea level to close to 4,000 m and beans that can be produced from sea level to 3300 m.

Livestock production systems are mainly concentrated in the upper zones and bottom of the valleys since most of the better cultivated pasture can be adapted to more humid conditions or irrigation.

Table 1. Agricultural systems in the Peruvian highlands.

Agricultural Systems	Agro-ecological Zone and Altitude Range (m.a.s.l.)	Species Livestock	Crops
High altitude	Janka 4500-4800	llamas alpacas	camelids
	Puna 3900-4500	alpacas llamas sheep, cattle	bitter potatoes maca, kaniwa barley
	Jalca 3200-3700	sheep, cattle potatoes, oca olluco, mashua	barley, oats
Middle altitude	Suni 3500-3900 hill sides	sheep, cattle	potatoes, oats oca
	Suni 3800-3900 high plateau		barley, pasture olluco, mashua, quinua
Bottom of the valley	Quechua 2300-3500 varying from sub arid to sub humid	dairy cattle goats, sheep	maize, potatoes amaranths quinoa, beans
Temperate	Yunga 500-2,300 maritime	dairy cattle goats	fruit, maize beans, vegetables
	Yunga 1000-2800 fluvial	cattle, goats	maize, fruits

4. CAJAMARCA PROJECT

Cajamarca is one of the 24 Peruvian departments within one of the 13 political provinces. In 1991, a micro watershed location, named La Encañada, was selected as a site to start a pilot rural development project in the northern Peruvian Andes in the province of Cajamarca (ASPADERUC, 1993). The Encanada is located 45 km north east of the capital city of Cajamarca and includes 27 "caserios" composed of 30 to 60 families each. At the present 1,200 families are involved in the project. The agricultural development activities include the following components:

- participatory diagnosis
- soil and water conservation
- agriculture improvement
    - crops and biodiversity in situ conservation
    - pasture and livestock

forestry production
- agro-industry and marketing
- peasant enterprise organization

The pattern of action for the project was characterized as:

- multi-institutional participation by five different institutions, involved in activities ranging from soil and water conservation (Pronamachs) to crop and livestock improvement (INIAA) and agro-industry (ITDG), coordinated by the Agriculture Research Department at the University of Cajamarca (ASPADERUC) and the stakeholders, the local Agriculture Producers Association;

- interdisciplinary activities included social studies, soil sciences, agronomy, in situ biodiversity conservation, animal production, forestry, agro-industry, economics and interactions; and

- intensive local participation: from the beginning of the project, the local people were involved not only in the task definition, but, in the design of programs and activities, with emphasis on the "organized group work" which includes 12 to 20 families with the experience to work together and freedom to start soil and biodiversity conservation actions. By the third year of the project, 90 different groups were formed and they dedicated at least one day a week to work on terrace building, raise field borders, drain channels, work on irrigation, participate in forestry activities, help in germoplasm evaluation and seed production and improve forage conditions. The entire family participates in these processes.

4.1. Results of Biodiversity Conservation

From the diagnostic analysis, a close link was identified between soil erosion and loss in biodiversity due to inadequate hillside agricultural practices and market effects which have mainly restricted sound local agricultural development. As a result, special emphasis was placed on the establishment of different soil conservation practices that encourage crop biodiversity.

4.2. Soil Conservation

For each soil conservation practice, the number of working days needed to conduct the work were calculated (Table 2). The peasants in the area dedicated more then 450,000 days to work in soil conservation. A total of 880 hectares of hill side now show the process of terrace building. Some 24 kilometres of land were fenced, and 300 km of trenches were made for humidity collection. All of these activities have improved the crop productivity in the area, and it was estimated that, during a regular rainfall year, production increased at least 25 %. These adaptations to the environment and market were considered as essential interventions to promote biodiversity conservation.

4.3. Crop Improvement

The Andean region is well known for its large biological diversity, including a flora of rich genetic material for many different crops that have been domesticated and are still being cultivated (Fries, 1985). Many peasants grow up to 12 different crops and as many as 20-50 varieties of potatoes (Tapia, 1994). These crops are adapted to be cultivated at different altitudes, and in the case of the Encanada project, more than 14 different crops contribute to the diet of the peoples (Table 3).

Table 2. Number of work days per each soil conservation practice.

Practice	Work days
Terrace construction, earth, side slope, per ha.	720-780
Terrace construction, stones, side slope, per ha.	700-1100
Trench for infiltration, drainage, per ha.	400-480
Fence, earth made, per ha.	270-330
Fence, stone made, per ha.	405-495

Table 3. Altitudinal adaptation of the crops in the Encañada Project in Cajamarca, 1994.

Crop	Scientific name	Altitude (m)
Native species		
Potatoes	*Solanum andigenum*	2800-3500
Oca	*Oxalis tuberosa*	3200-3500
Olluco	*Ullucus tuberosus*	3200-3500
Mashua	*Tropaeolum tuberosum*	3200-3500
Maize	*Zea mays*	2700-3200
Quinua	*Chenopodium quinoa*	3000-3400
Chocho	*Lupinus mutabiles*	2800-3300
Coyo	*Amaranths caudatus*	2800-3000
Arracacha	*Arracacia xanthorrhiza*	2700-2800
Introduced species		
Barley	*Hordeum vulgare*	3000-3500
Wheat	*Triticum sativum*	3000-3300
Faba bean	*Vicia faba*	3000-3300
Arveja	*Pisum sativum*	2700-3100
Lenteja	*Lens esculenta*	2700-3100

Potatoes are cultivated on about 30 % of all agricultural land; therefore, special emphasis was placed on improving its production. One of the important factors is seed quality. In previous diagnostic surveys, the lack of seed storage facilities was identified as a factor seriously affecting seed sanitation and quality. More than 50 new tuber seed store facilities were built with a total storage capacity of more than 140 tons of seed.

The organization of the "seed fairs" was essential in the process to promote in-situ conservation of the genetic material for variety selection as well as publicize local information on the different characteristics and uses of the local land races which have been preserved by the local peasants for centuries. During the last five years, more than twenty "seed fairs" have been organized. The process involves the selection of a day that is dedicated to organization. A formal invitation is distributed to all leaders of the "caserios" so that the local authorities are informed of what was to be documented and how the seed presentation was organized. A central site was selected by the peasants each year, and the participants and their produce were selected well in advance of the fair. Each fair on average involves between 30 to 60 participants and the presentation of more than 20 crops and 1,200 ecotypes.

During the seed fairs, an individual registers the material presented and notes information about its characteristics, so evaluation and selection of the "exposition winners" price are facilitated. Not only the number of varieties are counted but also the quality of the material, knowledge of the producer and utilization of the land races are considered. One important finding was that women had the best knowledge about indigenous agriculture and were particularly knowledgeable about the uses of different crop varieties (Tapia, 1994). For example, campesina Mrs. Rosa Abanto could identify 56 different varieties of potatoes and knew the pattern of growth, insect and disease resistance, use, time of cooking and taste of each. More than 30 varieties of oca and olluco tubers have also been identified. Through the participation of peasants, six new varieties of potatoes and three varieties of oca were selected and are now being produced in larger quantities. Another peasant displayed 27 different coloured seed beans, and his wife knew the use of each one in different dishes and the altitude range where the main varieties were best cultivated.

Arriving at high seed quality production was one of the objectives in the project. About 40 to 50 varieties from six different crops were seeded each year within the peasants fields and these included selected materials presented at the seed fairs. This assured a sufficient supply of genetic material for distribution.

Native and commercial variety potato trials were carried out by interested peasants. A revolving fund was established, and at the moment, half of the total potato seed requirements in the area is obtained from these fields. Also, other tubers such as oca, olluco, grains and quinua were selected to improve the seed quality.

The second successful step in biodiversity conservation was the initiative to discuss the maintenance and proper use of germoplasm. Peasant workshops, which encouraged the participation of conservationists, "seed fairs" winners and interested peasants, were found to be most effective in promoting new efforts that addressed the cost of germoplasm maintenance, labour availability at the time of seeding and harvesting and in organizing a "yunta credit system" in order to get oxen to plough the land.

In a second workshop, issues relating to soil and weather effects on the germoplasm conservation were discussed and, as a result, the "peasant germoplasm bank" was established where each of the campesinos can deposit 1 to 2 kg of tubers and 100 g of grains to be maintained in the bank and seeded in rotation in peasants fields. The peasants can obtain the material that they lost in a specific year due to climatic events.

Finally, a third workshop will to be organized to investigate the relationship between crop diversity, conservation and the market. The goal is to organize the marketing of local native crop varieties.

5. CONCLUSION

Plant genetic germoplasm, in-situ conservation and proper use of local crop varieties should be important components of any research and development project. It should be noted that local domesticated crops have been influenced by numan activities and are now part of the natural environment. These crops have a great potential to contribute to sound ecosystem management.

Mountain conditions, such as those found in the Himalayas and Andes, are typically rich in plant genetic resources, and a methodology is required to involve local people in long term evaluations of local crop varieties, including both major and minor crops. Plant genetic resources are key in the development of cropping strategies for agricultural production in a world which is subject to dramatic changes in climate, land use and surface conditions.

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