This paper was peer-reviewed for scientific content.
Pages 046-048 In: D.E. Stott, R.H. Mohtar and G.C. Steinhardt (eds). 2001. Sustaining the Global Farm. Selected papers from the 10th International Soil Conservation Organization Meeting held May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory.

Factors that Cause Deterioration of the Land in Province "Los Andes" (North Bolivian High Plateau)

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ABSTRACT

Province Los Andes is a representative area of the north Bolivian high plateau. It is located in the Department of La Paz, between the city of La Paz and the Titicaca Lake.

The economic activities that generate income for the peasants are basically annual crops: potatoes (*Solanum tuberosum, S. andigenum*), Quenoa (*Chenopodium quinoa*), and products of cattle raising: milk, cheese, beef.

Farming is severely affected by rigorous climatic conditions, but the main problem is overgrazing. Overgrazing of the range and reduction of the length of the recuperative fallow between periods of cultivation has greatly increased the deterioration of the soil. Agriculture activities are carried under primitive technological conditions with erratic yields.

Local knowledge of the types of soil determines its possible uses. Lack of implementation of appropriate technologies causes agriculture to become less attractive to the small farmers, so they migrate to the cities in search of better opportunities. The deterioration of soils is one cause for the spiral of poverty to manifest in the region.

INTRODUCTION

Pre-Columbian civilizations of the Andes had interesting techniques of conservation of soil and water, knowledge that lamentably has been lost. These techniques included the construction of terraces, rock faced bench terraces, direct manual planting, and systems of community work. In this region they inhabited towns before the arrival of the Spaniards, and even before the establishment of the Inca empire, as they demonstrate the ruins of Tiwanaku, Lukurmata and others in the surroundings of the Titicaca Lake (Bermann, 1994). Terraces in Bolivia were built hundreds, or perhaps thousands of years ago and are still protecting the soil from erosion (Troeh et al, 1991).

One of the greater contributions from this region to the humanity is that it constituted the center of origin of the potato, a staple food crop (Ochoa, 1991).

Province Los Andes

Province Los Andes is the name of the political division of a part of the La Paz Department, located in the central part of it, region that in Bolivia is known as North Altiplano in the Cordillera de Los Andes. It has a surface of 1,658 km2, its capital is the location of Pucarani, at 32 km of the city of La Paz, 16°23' of Latitude South and 68°29' Longitude West, at an altitude of 3,849 meters. Province Los Andes owes its name to the Cordillera del Los Andes, since it is located to the feet of the eastern mountain range; the whole province is part of the Titicaca Lake basin. The Census of Population of year 1992 has registered 62,185 people; the population is mainly of aymara race, with some presence of quechua and mestizo races (INE, 1993). The Province is divided in four Sections or Municipalities: Pucarani, Batallas, Laja and Puerto Perez.

Due to the proximity to the city of La Paz, Los Andes is slowly becoming an industrial and residential area, the Titicaca Lake and its surroundings are a major attraction for tourism.

Soils

Peasants of the zone distinguish the following types of soil:

- Sandy soils, called locally "Ch'alla" in aymara language, are used to cultivate in them quinoa (*Chenopodium quinoa*), barley (*Hordeum vulgare*), oats (*Avena sativa*) and wheat (*Triticum aestivum*) for forage, generating regular yields.

  The effect of the erosion in them is low, being wind erosion more likely to take place.
- Black earth, denominated in the zone "Ch'iar laka", characterized so that in these soils peasants cultivate potato (*Solanum tuberosum*), alfalfa *(Medicago sativa*), barley (*Hordeum vulgare*) and oats (*Avena sativa*), with good yields. The most frequent kind of erosion is the hydric one as effect of rains.
- Saline soils called "Qollpa", is infertile ground, nonusable due to the high content of sodic salts. If salinity is not extreme, tolerant crops such as quinoa (*Chenopodium quinoa*) and tarwi *(Lupinus mirabilis*) can be cultivated.
- Argillaceous soils, denominated "K'inku" where local people cultivate alfalfa and quinoa, with regular yields, being heavy soils with little water infiltration.
- Peat, called "Pacu" whose basic characteristics is its high content of humidity and organic matter, where one cultivates potato, barley and oats. Yields vary from regular to good.
- A soil with a lot of gravel is called K'ala.
- Wetlands are known as Bofedales, they are a source of forages especially in the dry season.

The deepest soils (60 to 100 cm) are in the flat areas of the North zone, possibly as a result of the accumulation of eroded fine materials of the mountainous areas. The soils with better state of conservation in the province are those

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Table1. Characteristics of five study sites (0 – 15 cm).

Site	Crop/Cover	Total N %	Organic C %	K meq 100 g^{-1}	Texture
Avicaya	Pasture	0.06	0.35	0.44	CL
Igachi	Potato	0.33	3.75	1.05	SL
Ancocagua	Potato	0.20	1.61	0.92	SL
Iquiaca	Alfalfa	0.21	2.27	0.73	SL
Pucarani	Bofedal	0.45	4.98	0.40	SL

whose use is destined to prairie and perennial crop of alfalfa (*Medicago sativa*), where the erosion process is slight in spite of the ruling conditions.

Soil analysis of five superficial samples shows that soils are predominantly sandy loam, pH is almost neutral, and total nitrogen show low values (Table 1).

Climatic characteristics

The climate of the zone is dry and cold. The region presents a typical climate of the high plateau, where the cloudiness is seasonal, consequently the atmosphere is clear most of the year, generating an increase in the terrestrial irradiation, especially during the nights, with manifest loss of nocturnal heat. As a consequence, a very marked thermal variation between day and night exists (Lorini, 1994).

The presence of the Titicaca Lake is determining as far as the climate, since in proximity of the lake there is a warmer temperature, precipitation, and relative humidity, values that decrease as one moves away of the lake.

Reducing risks is more important to peasants than obtaining high yields.

Peasants rely heavily on annual crops, not in terms of great money investments but in terms of their food supply and subsistence.

The agriculture practiced in the province is very precarious as far as technology. Due to the rigorous climate, the crops that adapt to the zone are few, such as potato, barley, quinoa, oats, wheat, fava bean and alfalfa.

The intensive use of the land due to population growth caused that the length of the recuperative fallow between periods of cultivation have been greatly reduced.

Produce has as destiny self-consumption and the sale or interchange in local fairs; a smaller amount is commercialized in the cities. Little use of external inputs, such as seed, fertilizers, and pesticides, characterizes the operations. As a consequence yields are low because they depend to a large extent on the climatic conditions (rain distribution, frosts, etc.).

Soil loses gradually its productive quality

Incorporation of fertilizer is implemented only previous to the potato seeding in amounts that not meet the nutritional requirements of crops. The maximum amount of applied animal fertilizer is of 2,5 tons per hectare in the form of decomposed manure. According to the phosphorus content of the manure, it is considered that it should be applied at least 10 tons per hectare. The absence of replacement of nutrients and organic matter impoverishes the soil and diminishes the humidity retention. Insufficient nutrient reposition is not good for the agroecosystem, just as application of unnecessary amounts of nitrogen is not environmentally sensitive in developed countries (Supalla et al., 1995).

The length of the fallow period has been reduced from seven years to three, as a result of a high pressure on the earth.

Cattle is a resource badly managed

Cattle activity in the region is the main source of subsistence of most farmers but is obviously ecologically questionable under those conditions.

The considerable altitude of the plateau causes that Holstein and Brown Swiss pure races do not adapt to the region, syndrome known as "mountain sickness", so they have to cross with Creole races brought by the Spaniards centuries ago.

The pasturing in the zone is the main food supply for cattle: bovine, ovine and swine, all of them share the prairie in search of pastures, causing compaction of soils and depleting the already scarce vegetation.

In zones of high mountain range there are flocks of llamas and alpacas both Andean native species, this ones are gaining bigger acceptance in market for their high protein meat.

Impoverishment of the land

There comes a point where soils no longer qualify for agriculture as a consequence of its erosion and the degradation, and that increases the pressure over the terrains that still are apt for farming.

The farming of pasture fields has increased in the last couple of years, in the mean time the areas of native prairies have decreased.

Overgrazing has caused the reduction of the vegetal cover over the ground, generating erosion. One can observe in many sites the presence of laminar erosion, incipient rills and gullies of great depth.

Cookery causes soil deterioration

One of the main causes of the degradation of the natural resources in the rural areas is the fuel used to cook. Due to fuel shortage farmers use manure and excavated tree or shrub roots for cooking fire and even peat. Gas stoves are used only in the populated centers that are connected to the main routes and mainly in the rainy season. A family uses around 10 kg of dry manure per day to cook.

Cookery activities has become into a slaving work for

women, because it implies the fact to collect firewood or some other fuel and the work of cooking. In addition, the traditional furnace found in most homes, is inefficient in fuel use and in the time that it takes to prepare foods.

Recommendations to diminish the deterioration of soils

In order to protect the soil cover it is advisable to:

- Keep in field the fallow meadow after the harvest of oats and barley crops and avoid its pasturing.
- Increase the area of alfalfa cultivated, since the alfalfa crop offers a good cover, and it is also a good protein source for cattle.
- Use of native species in the borders of parcels such as:
  - *Cortadeira* sp.*, Stipa ichu* and tola *(Baccharis* sp. *and Lepidophyllum* sp.*)* as protective measurement against hydric and wind erosion.
- Incentive a greater application of organic fertilizers to lands.
- Diffuse the construction of improved stoves in order to save more fuel.
- For prairies in serious state of deterioration, it is recommended to isolate these lots completely, with the purpose of promoting the recovery of natural vegetation of the grass and vegetal associations.
- A good practice for the recovery of the prairies is to construct drainage ditches in order to reduce run-off and to increase to the harvest of water.
- Any effort would be made to try to recover the pre-Columbian techniques of production, because those were adapted to the local conditions, which could include the removal of bovine cattle from some areas.
- Promotion of the use of technologies and agricultural production systems that are less dependent on the climatic conditions, such as greenhouses, hydroponics, forage conservation, confined smaller animal raising (pigs, guinea pigs, poultry).

Institutional deficiencies that must be considered

Rural development of this zone was pursued by the government of Bolivia and by NGOs and development agencies since a long time without success, in the mean time there is a strong migration of peasants to the cities in search of better opportunities.

Bolivian government is delegating the environmental management and the productive issues to local governments or Municipalities, as part of the policy of administrative decentralization. Nevertheless, the Municipalities are still very weak institutions respect to human and economic resources, under these conditions it will be very difficult that they succeed in the short and medium term.

In spite of all the limitations found for agriculture, it constitutes a challenge for agronomists and decision makers to promote and implement innovative and sustainable ways of production in this zone.

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