Characteristics and practices of land use in the central Andes of Peru: a case study

David Lopez Cornelio†

Faculty of Life and Environmental Sciences, Shimane University, Japan

EMail: davlzo@hotmail.com | Fax: 4734669

ABSTRACT

Three major types of land use in Huanuco (central province in Peru) are discussed on the basis of cartographical and socioeconomical data, document reviews, and field surveys. This traditional agricultural region has critical importance for being the gateway for timber transportation from the eastern mountainous tropical forests where also extensive coca plantations forced human emigration, land abandonment, and deforestation. An optimal land use map was built by overlaying four maps of biophysical characteristics and delineated cultivated areas from a Landsat TM image using ILWIS gis software. In Peru, ancient agricultural systems still coexist with the intensification of commerce. Property types, rates of land use changes, as well as the use of and the number of farms, are discussed. The type of land use varies periodically among each district within the province. State policies not fully structured indicate a poor understanding of the real needs of the Andean society. From now on they must combine elements of tradition, central planning, and markets.

Keywords: Andes, land use change, land reform, property rights, traditional systems.

INTRODUCTION

The Andes is a mosaic of local habitats with broad tolerant crops overlapping, high elevations, mostly arid, and high eco climatic heterogeneity per area unit (Denevan, 2000). Pre-Columbian intensive cultivation supported dense and complex states, but since the conquest it became wasteful of land and labor (Kay, 1998), in contrast with the shift from quantity to quality in food production of European countries (Evans et al, 2002). Other countries intend to make compatible communal/traditional land tenure systems with structural adjustment and economic reform (Ridell, 2000).

The effects of population growth are uncertain (Scherr, 1999), with the cost of land relative to labor increasing as people change their practices to offset declines in productivity due to intensification. Land degradation and intensification occur simultaneously and incomes may increase during degradation (Birch-Thomsen, 2001). In Peru, the costs of soil erosion in Peru (in 73% of its area) are between 5-10% of the

agricultural sector production (Young, 1998), affecting the people through reduced food supplies, lower income and increased landlessness. Inadequate institutions can be a main factor for land degradation (Schweik et al, 1997) but also adjustments through them positively affect the environment (Mazzucato and Niemeijer, 2002).

The study describes main land use of a representative province in the central Andes of Peru. Even though the patterns of land use reflect the current economic model (Silberstein, and Maser, 2000) and are bound to the local development processes, the paper focuses on the actual physical condition of land use in the ten districts of the province. The hypothesis is that the prevalent conditions of land use in the province are able to support economic growth with reduced land degradation within the framework of globalization, which currently tend to widen inequality in developing countries (Van Ginkel et al, 2002). Although a successful combination of local and global know-how is a precondition for development, neo liberal policies in the Andes must be carefully monitored; the irony is that their leading proponents are from countries that heavily subsidize their own agricultural sectors.

MATERIALS AND METHODS

Location

The province of Huanuco is located in the central Andes (Fig. 1) at 08°44'55"-10°20'21"south latitude, and 74°39'00"-77°30'00"west longitude, it has 10 districts with a total area of 409171 ha. The landscape comprehends three main watersheds with semiarid mountains, except the humid tropical conditions of Huallaga valley. In this last, 7217 ha (Ives, and Messerly, 1999) are planted with coca (*Erythroxylum coca*) with revenues around 4,000$/ha/year (Tammen, 1991), double that is realizable from the cultivation of legal crops (Hunefeldt, 1997). Because of immigration, shantytowns around Huanuco city proliferated. Policies failed to treat land as natural capital that progressively increases its value (Silberstein and Maser, 2000), but property rights policies alone cannot reduce environmental impacts (Keipi, 1999).

The population is not equally distributed. Huanuco district has 74676 habitants, even though covers 4.27% of the provincial area, the same case in Amarilis (3.38% of the total area) with 60762 habitants, while Chinchao district (44.5% of the total area) has only 22011 habitants (Table 2). However, the rates of areas suitable for agriculture are relatively high in Huanuco, Amarilis, Chinchao and Santa Maria del Valle (SMValle) (Fig. 8).

Methods

Official statistical data, based on the agricultural unit (AU) from the last two provincial agricultural censuses (1986 and 1996), were analyzed. An agricultural unit is an extension that may comprehend many patches at different altitudes with a unique owner and in the same district. Field visits were carried out from October–December 2000 in 4 districts on farming methods and land management according to a questionnaire (Table 1). The results are discussed in the following subtitles. The methodology considers that the results could be put into a wider context using census and household data in which an important milestone is the land reform of the early 1970s (Cotlear, 1989).

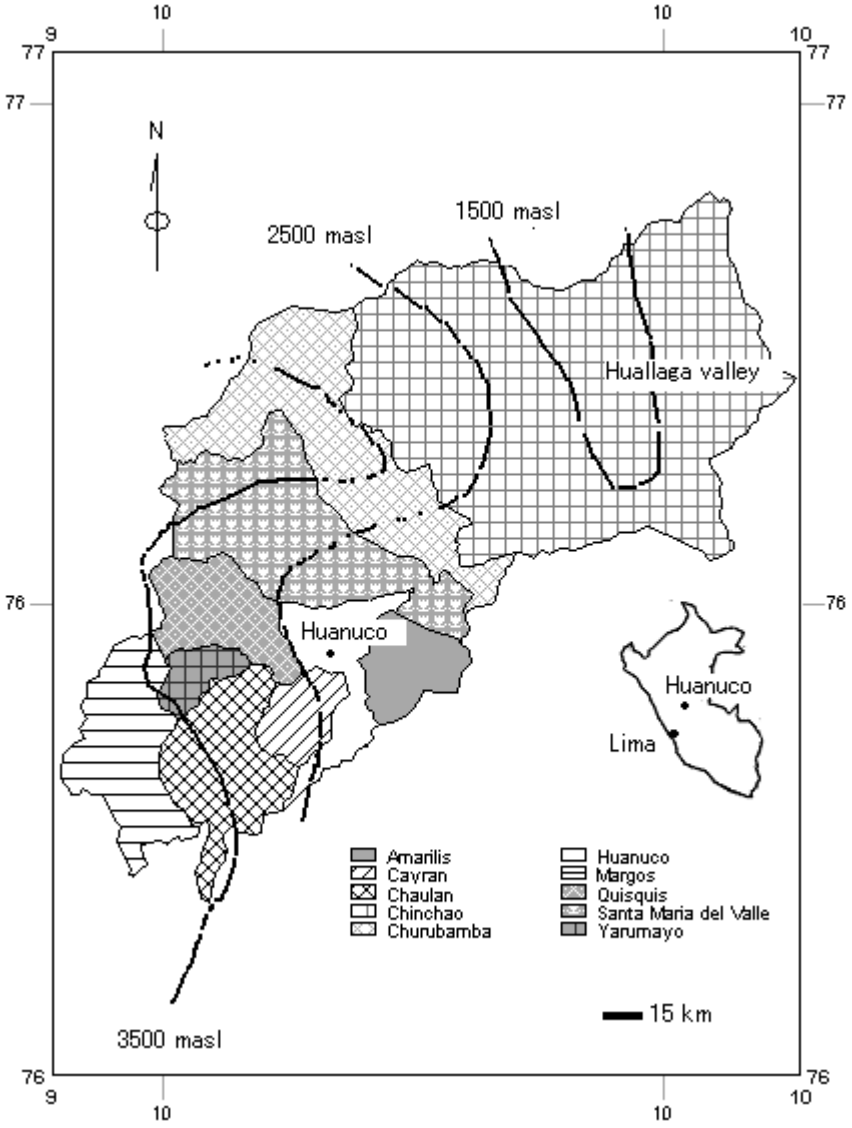

Fig. 1. Location of Huanuco province with delimitation of districts.

Table 1 Contents of questionnaire for field interviews (adapted from Mantang and Shaofang, 1995).

The crops
* Crops raised and purpose.
* Agricultural cycle organization
* Main constraints for yields improvement
The livestock
* Type of livestock and purpose
* Grazing organization
Natural vegetation and trees
* Availability of natural/planted forests. Uses.
* Rights on forest resources. Potential problems.
* Potential multiple use of trees on farms
* Constraints to establish forest plantations.

A map of land use suitability for a central Andean province was built by overlaying 4 land type maps of 1985 (forests, ecological zones, climatic and soils) at a scale of 1/250,000. In the overlaying operation, made by pairs of raster maps, pixels on the same positions in both maps are compared and the occurring combinations of identifiers or values of pixels are stored. These combinations give an output cross map and a cross table. The cross table includes the combinations of input values or IDs, the number of pixels and the area for each combination (ILWIS, 2003). The selected descriptor of each polygon in the resultant map (figure 6) is the most concurrent among the four descriptors of each land type map for that polygon (table 2). The result is a map of optimal land use (ideal map) suitable to the biophysical characteristics of each site, on which the extent of cultivated areas (from a Landsat TM image) was overlaid to get the extension of cropped areas per district. The correlation between the actual (regional census) and ideal distribution of land areas per type was measured by the Spearman's rank correlation coefficient (the population of both variables in the bivariate analysis are not normally distributed). To determine the rate of land use conversion around the city of Huanuco, polygons demarking urban sprawl drawn on aerial photographs with 33 years of time difference were compared.

RESULTS

Land reform

The central government has tried to formalize property rights 22 times since colonial times (De Soto, 2000). The land legislation laws of 1849, 1853 and 1909, established various means of access to land in the Amazonian region: land could be bought, received as a temporary or permanent concession, appropriated at no cost, or

granted under colonization contract (Santos-Granero and Barclay, 1998). The agrarian reform initiated in 1969-1980, the most striking in Latin America (Kay, 1998), changed the land structure in social terms, but not the land concentration and agricultural output. The argument was that redistributing land was better than costly investments in modern technology, which may also displace labor, and could increase land productivity more easily. At that time, 0.3% of the agricultural units (AU) owned 66% of the agricultural land, while 50% of the smaller AU owned only 2.2% of the land (Cotlear, 1989). The enforcement of a development model by the central government intended to gain popular support, destroy oligarchic domination, control conflict and rural discontent, improve income distribution, stop massive migration to the cities, and create a stable sector for an expanding internal market. The designed system of price controls and monopoly forced the country to spend 25% of its annual budget on food imports (Hunefeldt, 1997) and land rents fell from 20% to 2-3% of total household incomes (Van Ginkel et al, 2002). The reform was applied by regions and not by agricultural units to gain time and broader coberture (Matos and Mejia, 1984), moreover, it largely excluded the mass of small holders (the most vulnerable to temporal unemployment) introducing new factors of social differentiation. The probe is that after a decade of land redistribution, peasants which grouped into the National Confederation of Agriculture (CAN) and the Peasants Confederation of Peru (CCP) forcefully occupied land that was assigned to the created cooperatives and agricultural societies (Matos and Mejia, 1984).

The cooperatives seldom succeeded, few of them were able to repay their accumulated debts, and the majority was converted into communities during the 1980s. Their number reached an all-time high of 5,680 in 1994 (Hunefeldt, 1997). The conversions were authorized by changes in the basic land reform legislation, and were put into effect after majority votes of the cooperative members in each case. Preferences of the people involved were contrary to the original intention.

The main changes in the agrarian structure were: 1) Land owned by rich landlords passed to the workers, 2) the quantity and the quality of land received was variable and unequal, 3) the reform modified the worker status, from salaried to cooperative-salaried, 4) the land received in marginal areas consolidated the traditional production systems, and 5) the land reform affected only 36.7% of AU in the Andes (in contrast with 64.5% of AU affected in the coastal region). After 1980, privatization returned the structure of the AU distribution to near that of the 1960s trend. Figure 2 shows the evolution of the agricultural unit dimension (changes in percentage from 1961 to 1985) (Gonzales de Olarte, 1994). The total area of AU of 5-10 ha increased 4.1%, AU of 1-2 ha and AU of 10-20 ha increased only 1.3 and 1.4% respectively. The total area of farms within 2-5 ha and larger than 100 ha decreased 3% and 2.8% respectively. Globally, from the 30.6 million ha of agricultural and grazing farms in the country, 10 million were affected by the reform, 11 million (mostly grazing farms) came under common property and 10 million are small and medium private holdings. The total agricultural land affected by the reform (43.9%

irrigated and 23.5% rain fed) contrast with the grazing areas transferred (23.4%) (Matos and Mejia, 1984).

Table 2. Weights assignment table per types of each map. Ranks 0 and 3 indicate the lowest and highest priorities for land use respectively, chosen according to the description. Final classes after overlaying are denoted as a (agriculture), f (forestry), g (grazing) and c (conservation).

MAP	TYPES	DESCRIPTION	RANKING			
			0	1	2	3
	A(r)A'H4	Hot weather, yearlong rainy, very humid.	a	g	f	c
	A(r)B'2H3	Warm weather, yearlong rainy, humid.	c	a	g	f
	B(i)B'1H3	Weather semicalid, scarce rains on winter, humid.	c	g	a	f
Climatic	B(o,i)B'3H3	Semicold weather, scarce rains on winter and autumn, humid.	g	a	f	c
	B(0,I)C'H3	Cold weather, rainy, scarce rains on winter and autumn, humid.	a	g	f	c
	C(I)C'H3	Semidry weather, cold, scarce rains on winter, humid.				
	Bh mo	Mountainous environment, shallow soils, exhuberant vegetation.	a	g	f	c
	Cp	In Andean highlands above 3,800 masl, cold, variety of grasses, extensive grazing.	a	g	f	c
Forests	Df	Mainly located at the lower levels of mountaineous forests. Deforested areas occupied by secondary vegetation on different stages of development.	a	c	g	f
	Msh	Shrublands (perennial and decidual), average temperature: 9–18	a	g	c	f
	Pj	Andean graaslands of hard leaves. Above 3800 masl.	a	f	c	g
	A2s(r)	In andean valleys, suitable for annual crops.	c	f	g	a
	A3c–P1c	Conformed by two groups of soil use capacity: (1) with agricultural vocation and weather deficiencies and (mainly tubers on slopes lower than 15%) (2) with pastures vocation, also with weather limitants (on slopes over 20%).	c	f	g	a
	F3c–P2e–A2sc	With vocation for reforestation on areas with low soil quality (40% of the asociation total extension), with vocation for pastures on soils with medium quality (30%) and protected areas on soils with severe restrictions.	a	c	g	f
Soils	P1c–X	Located on high Andean plains, suitable for pastures on low slopes and deep soils, superficial soils on slopes over 75% are denominated *of protection.*	a	g	f	c
	P2e–X	Steepy phisiography, mainly of protection. Pastures can be produced with suitable practices.	a	f	g	c
	X–F2e	Distributed on mountaineous tropical forests, because of the topography (slopes over 75%) only 30% of its total extension can be used in forestry.	a	g	f	c
	X–F3e	Distributed on mountaineous tropical forests, because of the topography forestry use can be done on slopes less than 50% with careful harvesting systems.	a	g	f	c
	X	Because of topographical and soil limitations cannot be used for forestry, pastures or agricultural activities. Have value for minning, ecotourism and hydrologic cycle maintenance.	a	g	f	c
	bh–PT	Humid forest premountaineous tropical. Total Precipitation/year: 1000–2000mm Annual biotemperature (average): 16–24C	c	f	a	g
	bp–PT	Pluvial forest premountaineous tropical. Total Precipitation/year: 4000–8000mm Annual biotemperature (average): 16–24C	a	g	f	c
	bs–PT	Dry forest premountaineous tropical. Total Precipitation/year: 500–1000mm				
Ecological		Annual biotemperature (average): 16–24C	c	g	f	a
zones	bs–MBT	Dry forest low mountaineous tropical. Total Precipitation/year: 500–1000mm Annual biotemperature (average): 12–16C	c	g	f	a
	bmh–MT	Very humid forest mountaineous tropical. Total Precipitation/year: 1000–2000mm Annual biotemperature (average): 6–12C				
	bp–MT	Pluvial forest mountaineous tropical. Total Precipitation/year: 4000–8000mm Annual biotemperature (average): 6–12C	a	g	f	c
	pp–Sat	Pluvial param tropical subalpine	a	g	f	c

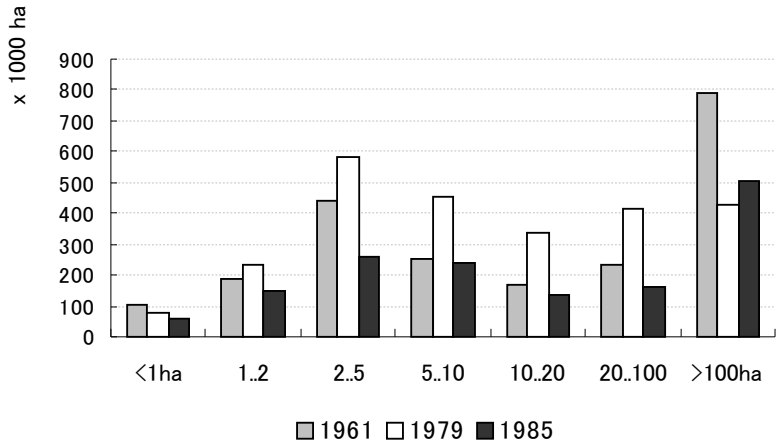

Fig. 2. Evolution of the agrarian structure in Peru (Gonzales de Olarte, 1994).

The next period of rural development (1980-85) followed a worldwide trend and included the dismantling of associative enterprises. Traditional communal rights of peasant communities were made more "flexible", land could be sold or mortgaged. This benefited the richer peasants within the peasant communities and alienated those who did not have the resources to purchase land. The divergent period inaugurated with presidents Alan Garcia (1985-90) and Alberto Fujimori (1990-2000) witnessed the intensification of the privatization process. Garcia's plan included a new land-distribution program, particularly for peasant communities, and economic policies (price controls, state subsidies, credits, and privileged exchange rates to favor the purchase of goods) designed to strengthen small-scale producers. Initially associative enterprises were promoted, but turned to privatization. Fujimori's neo liberal program, confronted with hyperinflation and terrorism, could not thoroughly plan rural development (Hunefeldt, 1997). Two important steps were the enactment of the *Agricultural Law of Promotion and Investments* in 1998 (DL 26505) ended the restrictions on private ownerships imposed by the agrarian reform. A subsequent *special project of land entitlement and cadastre* (DS 006-98-AG) regulates the land tenure, legally and physically amending the properties affected by the agrarian reform. Currently, 73% of the peasant communities and 47% of the private small holders have been registered and entitled (PETT, 2002).

Agricultural and grazing systems

Rental contracts such as sharecropping allow for mitigating the capital and risk market failures (Echevarria, 2001). Sharecropping mechanisms and reciprocal exchanges of labor, oxen, and dung between households alleviate inequalities in land

distribution. On fields not used for maize cultivation, the peasant rotates barley, wheat, and beans, followed by a period of fallow, alfalfa, and potatoes, at which point the cycle begins again. Because of modernization, the rate of land under fallow in the Andes decreased from 41% in 1964 to 33% in 1971 (Cotlear, 1989). The effects of fallow decrements are not fully perceptible, and areas that seem under fallow may actually loss its fertility since the 18% of usable land has been degraded at different degrees (Young, 1998).

Although agricultural production is much more labor intensive and specialized than herding, this last is an important non-technified economic activity that relies on natural grasses and post harvest residues. Livestock serves multiple objectives (quasi money, animal traction, provision of derivate products, purchase of human labor, provision of fertilizer).

Natural grasslands predominate in all districts, ranging from 22.09% (Chinchao) to 76.79% (SMValle) (Fig. 3). Communal pastures shrunk because of privatization and families strive to have high and low altitude grasslands to seasonally move the animals. Grazing is a main economic activity in Amarilis, Chaulan, SMValle and Margos districts, although is complemented with agriculture since do not constitute a constant flow of incomes.

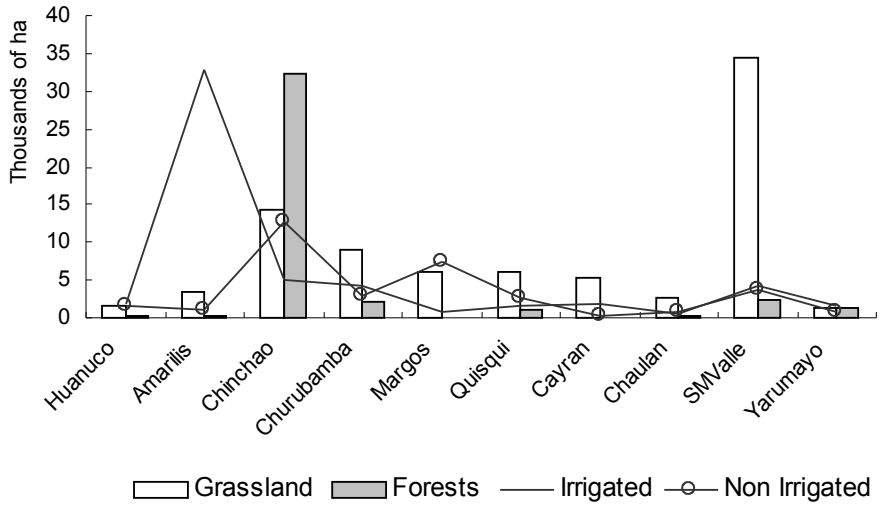

Fig. 3. Land use type (ha) per district (INEI, 1996).

Soil erosion in abandoned/fallow fields is due to the unregulated grazing (Harden, 1996). Cattle management rather than the elimination of pastoralism is essential. Table 3 shows the livestock totals per type and they range from 2133 (Yarumayo) to 7833 (Margos). The activity is especially important in Amarilis, Margos, Chaulan and SMValle districts.

Table 3 Characteristics of districts

	Alt.(masl)	Latitude	Area ha (%)	Tot. hab	Settlement type *	Livestock**
Huanuco	1858-3500	9.55'40"	17458 (4.27)	74676	32s 05c	5000s 1000c 800g
Amarilis	1900-3800	9.57'45"	13815 (3.38)	60762	17t 03c	10000s 3000c 1500g
Cayran	2060-3800	9.59'45"	9942 (2.43)	3940	01t 18s 02c	8000s 300c 500g
Margos	3260-4800	10.01'05"	28921 (7.07)	16570	22t 06s 02c	20000s 2000c 1500g
Chaulan	2800-4185	10.03'07"	28101 (6.07)	5404	10t 07s 01c	15000s 1000c 1500g
SMValle	1865-4400	9.51'45"	49565 (12.11)	17965	04t 30s 12c	15000s 1000c 2500g
Chinchao	2000-4000	9.46'15"	182307 (44.5)	22011	03t 32s 02c	1000s 4000c 1800g
Churubamba	1835-3800	9.46'20"	56267 (13.75)	16570	04t 30s 07c	8000s 2500c 1000g
Quisqui	2450-4170	9.54'06"	16294 (3.98)	5607	11t 06c	5000s 1500c 1000g
Yarumayo	2600-3910	9.55'45"	6411 (1.57)	2582	04t 05s 02c	5000s 600c 800g
	* towns (t) dispersed households (s) communities (c)					
** sheep (s) cows (c) goats (g)						

Forest condition

Forestry development is still insufficient, contrastingly with the intensive use of forests in the Himalayas (Ives and Messerly, 1999). Deforestation is consequence of the skewed distribution of arable lands, chronic landlessness and the macroeconomic stresses of the 1980s (Keipi, 1999).

According to figure 3, forested areas range from 0.315% (Margos) and 0.54% (Cayran) to 50.08% (Chinchao, mostly tropical secondary forests) and 25.89% (Yarumayo, mostly eucalyptus plantations). The *National Program for Soil and Water Conservation* (Pronamachcs) directs the reforestation projects in the highlands, and the *Reforestation Committee* in the Amazonian basin. Pronamachcs administrates eleven tree-breeding centers in the province with an annual production of 147,500-394,000 seedlings (OIA, 2000). Although 8,267 ha have been reforested until 1991, the 24.2% of the province had been deforested (INRENA, 1994), especially in Chinchao district, where for every 4 ha that are deforested, 1 is under actual cultivation and 3 are abandoned (Schweik et al, 1997). In the highlands, woods are used for firewood (90%), construction, (5%) and carpentry (5%) (Espinel, 1996). To satisfy energy requirements, a family needs two poles of eucalyptus (50 cm dbh) per year. Income from wood is complementary, confined to early stages of agricultural frontier expansion, and tends to be reinvested in agriculture and cattle ranching.

Shrub and grasslands can be converted to more productive categories of forestland. Steep regions supporting woodlands are an invested capital that farmers can use at the most convenient time or give to the inherited. Trees also protect and nurture agricultural lands. They would neutralize the inevitable environmental consequences of overgrazing and continuous cropping. Reforestation costs per ha range between $100 and $800 (McGaughey and Gregersen, 1983), unavailable for most of local farmers. Eco-tourism, as well, would add value to unutilized highlands where most of

the archeological sites are located. However, lack of funds is not always the problem but that loan conditions are inappropriate for investments in the sector (McGaughey and Gregersen, 1988). The government commonly funds reforestation (Keipi, 1999).

Measures of Stratification and Inequality

While poverty and inequality in rural areas still depend on access to land, the contribution of land concentration to the explanation of total income inequality has declined over time. Income inequalities within communities are higher than resource inequalities (Gonzales de Olarte, 1994). Average family incomes in a modern region can be four to five times higher than those in a traditional region (Cotlear, 1989) and educational achievement is the most important source of income differences (Van Ginkel et al, 2002).

Modern holdings (private ownership, artificial irrigation, mechanization, and use of chemicals) are commonly located in the lowlands; they influence and coexist with the highland traditional ones (common property, native crops, rotation, and long fallows). Their integration through flows of energy, materials and investment is asymmetric. Highland communities give more importance to landholding conflicts, whereas middle and lowland communities give more importance to difficulties in acquiring chemicals (fertilizers and pesticides).

A source of inequality in farm size is demographic differentiation. As households begin, grow, and mature over the course of their life cycles, changes in land holding reflect fluctuations in the demand for land associated with each stage (Chayanov, 1996). A young household forms and expands, acquiring land to meet its growing needs. Later, as children mature and leave the household, pressures decline and land holdings may contract. Increasing population, combined with bilateral inheritance, results in successive subdivision of land at the death of the owner. Extreme fragmentation creates difficulties for technological innovation since many of their packages are inadequate in small properties. Technological change facilitates the evolution of land use systems and at the same time, this evolution facilitates the diffusion of technical change. Since AU with less than 2 ha cannot sustain a family with 5-6 members, peasants approach the use of resources through cooperation.

Interviews with 44 family heads and 11 groups of farmers showed that a common concern is the decrease of land productivity and availability. Farmers recognize that a plot that produced around 20 bags of potatoes actually only yields four. However, that perception is not as acute as chronic cash shortages (Mayer, 2002). The cost of soil recovery ranges from US$ 777~962 /ha/year (Santos-Granero and Barclay, 1998).

Land use systems

Land, water, grazing territories, and labor were neither bought nor sold in pre-Columbian times (Mayer, 2002). Changes in field systems reflected adaptations to changing environments and socio economic demographic conditions, based either on innovation or diffusion (Denevan, 2000). Peasants still manage multiple farms at the same time to maximize human labor and get advantage from the ecological variability. In a dual decision making system, the household is the producing unit, while at a higher level the community administers a vast territory. The difficulties of supplying and scheduling labor limit the total size that a family can farm.

The land can be divided into three concentric circles around each town. The nearest one is under intensive use, privatized, and generally irrigated. The parcels located in the outer circle are of common use, mainly for grass, and are located above 4000 masl, or are areas without drainage. In "modern" communities, communal rotation has disappeared, and the privatization of land has expanded. This process is faster in communities situated at low and intermediate altitudes (Denevan, 2000). The system of cropping and the property rights are different in each circle. Within the agricultural belt, abandoned fields and non-cultivatable land are referred to as *tierra eriaza;* which are not irrigated and are communally controlled and open to residents of the village for grazing and the collection of herbs and firewood. The most common form of access to land is inheritance (Guillet, 1995), followed by purchase, sharecropping, and to a lesser extent, renting and acquisition of land as collateral for a loan (*anticresis*). Agricultural plots are the basis of a land market in which prices are regulated by supply and demand, and there are no restrictions on sales to outsiders (*forasteros*).

Factors interrelation and statistics of land use per district

The correlation between the total AU and entitled AU with district area are positive (R=0.64 and 0.61 respectively), irrigated area and population (R=0.51), total and entitled AU (R=0.78), and altitude and AU under common property (R=0.91). Variables with non significant correlation are the total of AU with the number of AU under common property (R=0.04), the area of grasslands with the number of AU under common property (R=-0.04), population and total of AU (R=-0.08), irrigated and forested areas (R=-0.02) and irrigated and grassland areas (R=-0.07) (Table 4). Santos-Granero and Barclay (1998) add that the length of occupation is correlated with greater land fragmentation and that the relation between the proportion of perennial crops and the proportion of fallow land is negative.

Table 4 Correlation matrix between main parameters (total of districts).

	A	B	C	D	E	F	G	H	I	J
A. Area (%)	1.00	-0.04	-0.13	-0.35	-0.22	-0.17	-0.24	0.64	0.61	0.00
B. Population	-0.04	1.00	-0.51	0.33	0.51	-0.39	-0.30	-0.08	0.25	-0.27
C. Altitude (masl)	-0.13	-0.51	1.00	-0.17	-0.21	0.25	-0.14	-0.16	-0.56	0.91
D. Agric. Land (ha)	-0.35	0.33	-0.17	1.00	0.92	0.07	0.31	-0.39	-0.23	-0.12
E. Irrigated area (ha)	-0.22	0.51	-0.21	0.92	1.00	-0.07	-0.02	-0.20	-0.07	-0.13
F. Grassland (ha)	-0.17	-0.39	0.25	0.07	-0.07	1.00	0.27	-0.29	-0.32	-0.04
G. Forest land (ha)	-0.24	-0.30	-0.14	0.31	-0.02	0.27	1.00	-0.30	-0.23	-0.18
H. Total AU	0.64	-0.08	-0.16	-0.39	-0.20	-0.29	-0.30	1.00	0.78	0.04
I. Entitled Properties	0.61	0.25	-0.56	-0.23	-0.07	-0.32	-0.23	0.78	1.00	-0.33
J. Common Properties	0.00	-0.27	0.91	-0.12	-0.13	-0.04	-0.18	0.04	-0.33	1.00

While in Amarilis, Cayran and Yarumayo the rates of irrigated fields are 97, 86 and 65%; in Chaulan, Quisquis, Chinchao and Margos they are 39, 38, is 29 and 10% respectively (Fig. 3), meaning that in the last four districts more than half of fields depend on rains. Accessibility is a main factor to access irrigation infrastructure; Amarilis and Cayran are next to the city of Huanuco. The 32723.3 ha of irrigated plots in Amarilis constitute 58% of the total irrigated area in the province. The distribution of irrigated areas in the province is heterogeneous. Irrigation influences the crop structure, the type of tillage, and the level of fragmentation of the agricultural unit (Gonzales de Olarte et al, 1987). The irrigation canals are built by communal labor, anyone wishing to have land allotted in the new area must participate in their construction.

Margos has two communities and 8538 AU under common use (Table 3, Fig. 5) while in Churubamba there are seven peasant communities and only 1119 AU under common use. Production zones with higher productivity (lowlands) accelerate the degree of privatization (Mayer, 2002). Effectively, in Churubamba half of the total AU has only one patch while in Margos only 17% (Fig. 4). Communities do not necessarily control common land, individual herders can share common grasslands. There are more patches per AU in highland than lowland areas (parallel use of diverse production zones). In Churubamba 122 AU comprise between 11 and 15 patches of land. In Chaulan it is 35, and in Yarumayo it is 65. In Margos, 5 patches compose 223 AU and 318 AU by 6 to 10 dispersed patches, the higher values for those ranked. The proportion of AU with only one patch ranks from 14% (Chaulan) and 16% (Margos) to 54% (Huanuco) and 67% (Chinchao). In half of the total districts, more than half of AU posses only one patch (Huanuco, Amarilis, Chinchao, Churubamba, and Yarumayo) (Fig. 4).

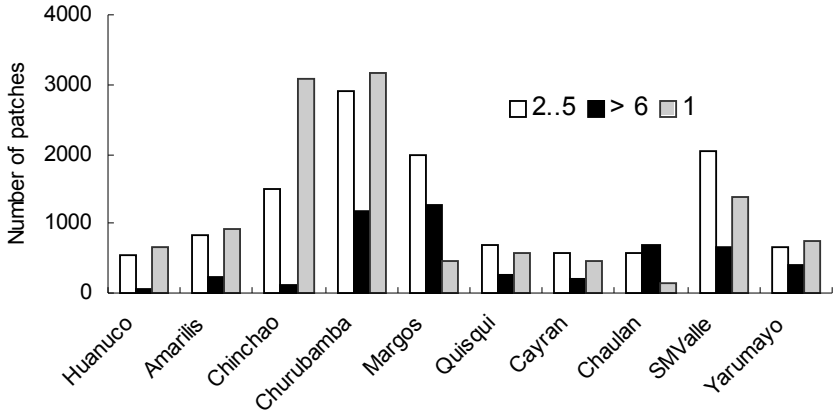

Fig. 4. Number of patches per agricultural unit. (INEI, 1996).

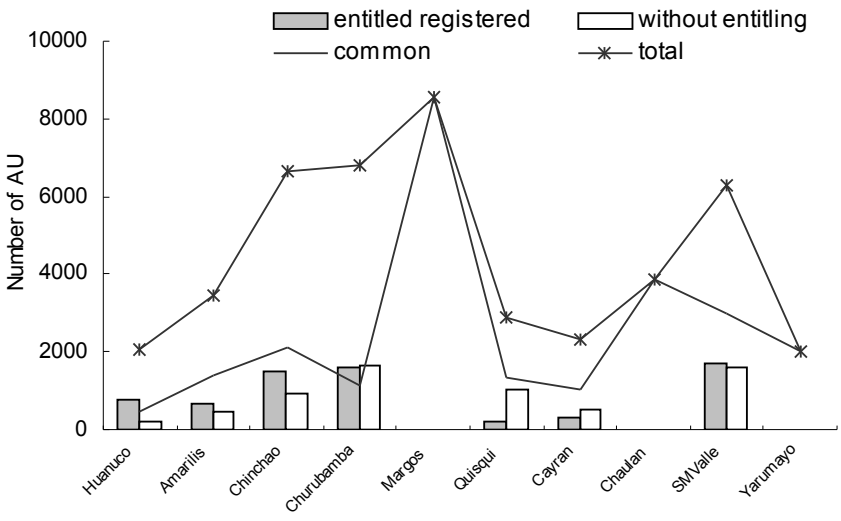

Fig. 5. Land tenure condition per district (status of agricultural units per district) (INEI, 1996).

The number of entitlements in each district depends on its accessibility and distance to the capital. In Margos and Yarumayo it is less than 1%, while in the Huanuco district it is 39%. The proportion of AU under common property in each district is 100% in Margos, 98% in Chaulan, and 100% in Yarumayo (Fig. 5); in contrast, there is 23% in Huanuco and 17% in Churubamba (their territory extends from lowlands to highlands). An owner is recognized as one who is holding a land title even though it is still not registered in the official records; an owner without a title is simply denominated “land holder”.

Change in land use

The comparison of aerial photographs from 1962 and 1995 in an area of 7.30 km^2 enclosing the 4/5 of Huanuco city, indicates that croplands converted to urban areas at a rate of 2.6% per year. As there are no easy routes to change the status of land tenure, farmers in state cooperatives and other agricultural societies illegally subdivide the common land into private plots, and few have valid titles over them (De Soto, 2000).

In 10 observations, a higher correlation exists between the forest areas of the real and ideal condition maps (R=0.6364) than in the case of agriculture (R=0.463) or grassland areas (R=0.2242), explained by the overlapping in time and space of grazing and agricultural areas. In the real situation, there is no conservation or protection class as such; it is intermingled within the forest and grassland classes. Moreover, the regional census did not consider that land category. Data for the ideal condition was obtained according to the methodology; since they are types of physiographical characteristics at small scale, it is assumed that will not change substantially over time.

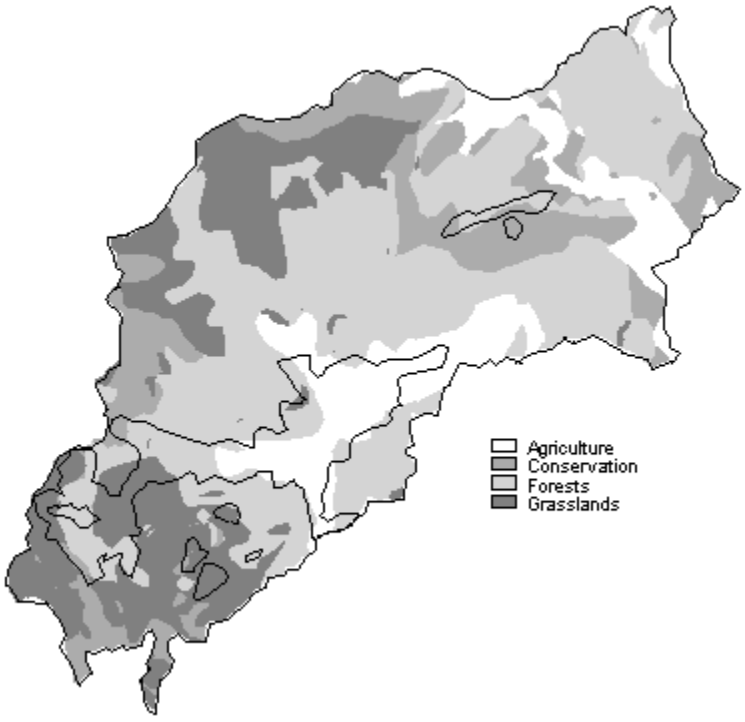

Fig. 6 Map of suitable land use with demarcation of cultivated areas.

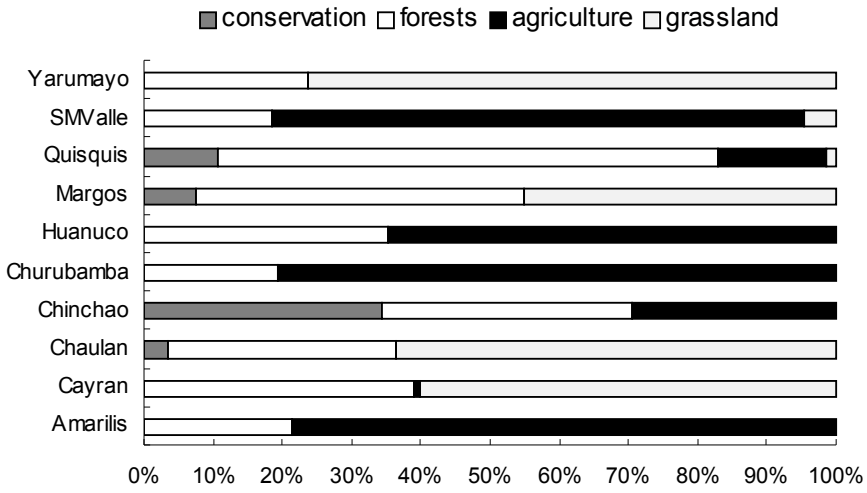

Fig. 7. Rates of crop areas established on areas with other suitability (current situation).

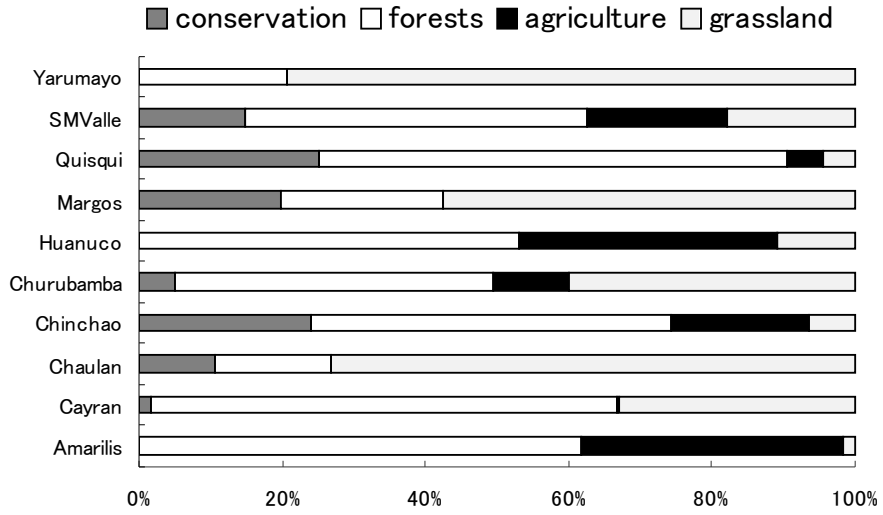

Fig. 8. Area rates per category of land use in an ideal condition.

The extent of farms established in areas with other suitability was delineated on the ideal map (Fig. 6) The total of pixels (smallest units on the map) for each case were converted to percentage of ground area considering that 1 pixel equals 0.704 km^2. In the current situation (Fig. 7) agriculture occupies over 50% of the total area in most of the districts, while in an optimal situation (Fig. 8) it is restricted to some areas and land dedicated to other uses are better distributed. The results are shown in figures 7 and 8. The cropped areas in Amarilis, Churubamba, Huanuco, and SMValle are properly located (78.6, 80.5, 64.7, and 77.1%, respectively, of the total area

cultivated in each district). However, in the same districts, the proportion of cropped areas suitable for forestry are 21.4, 19.5, 35.3, and 18.3%, respectively. In Quisqui this use reaches 72.3%. In Chinchao, primarily, and in Quisqui, Margos, and Chaulan, the proportion of cultivated plots to areas suitable for only conservation are 34.3, 10.7, 7.57, and 3.6%. The rates of cropped plots on areas suitable for grazing are high in Yarumayo (76.2%), Chaulan (63.6%), Cayran (59.74%), and Margos (45.2%). It is notable the overuse of land for agriculture in Amarilis (31291.7 ha) and Margos (8118.8 ha), for grasslands in Chinchao (8320.8 ha), Quisquis (5538.5 ha) and SMValle (29971.5 ha) and the sub use of areas suitable for forests in Chinchao (14762.52 ha), Quisquis (5670.7 ha) and SMValle (9822.5 ha).

Figure 9 is a proposed scheme to achieve a sustainable use of land in the central Andes of Peru. Common natural grasslands and agricultural holdings in marginal lands comprehend the majority of area under use; their progressive conversion to widespread recommended measures (encircled) with permanent and higher output values can be achieved through the actions described in the right box, failure in any of them will not assure success. Local institutions (diverse systems of cooperative work, sharecropping, regulated use of productive resources and control of diverse production zones at different altitudes) and incentive alternatives should be negotiated with the local communities. Technical assistance and training might enhance the managerial skills of the locals, adapt new methods of land use and reconsider good practices of traditional knowledge.

DISCUSSION AND CONCLUSIONS

Areas under agricultural, grazing, and forest use changed broadly from 1972 to 1996 in all districts, and are far from matching the most suitable land use. A farmer changes cultivation practices both from year to year and from field to field for reasons that may be spatial, environmental, economic, informational, demographic or idiosyncratic. Land use is heterogeneous among the districts. Pressure on land varies from district to district and is the main force that conduces to institutional change. Policy shifts from collectivism to market oriented solutions and back to heterodoxy created uncertainties and deepened rural divisions. Although the paradox of an ideology of egalitarian resource distribution alongside differentiation continues to provoke tensions in Andean communities (Harden, 1996). Land reforms as were traditionally conceived are no longer needed since do not solve social infrastructural problems. Even though management systems are similar, there are differences regarding intensity, areas, and type of land use. The average patch area/owner is 5 ha, with exceptions in Chinchao (less than 0.5 ha) and Churubamba (10 ha). This can hinder technological innovation since studies in other realms confirm that larger farms are more open to it (Neil and Tykkylainen, 1998); and that households with more land have higher levels of income from non agricultural employment (Echevarria,

2001). Inequality has to be confronted by reducing economic instability and through programs that improve the access by the poor to productive assets. The number of patch/owner is inversely proportional to the patch size in all cases, meaning that while large holders are prone to technological change, smallholders diversify their production in multiple cycles to divert risk. Accessibility is a main factor for the diffusion of infrastructure and property formalization. Development policies for each district will differ. In Chinchao rehabilitation measures have to focus on forest resources while in SMValle on grasslands management. In Huanuco and Churubamba the main actors are small holders while in Chaulan and Yarumayo most of the productive resources are under common use. The local social institutions have the potentiality to enable a sustainable use of land if they are duly recognized by state policies and receive an external stimulus from agencies of development. The success of this effort will depend on action within the sector (institutions, policy, technology) as well as outside the sector (economical and political stability, education, transportation, communication). Traditional land tenure in the Andes is not well described by artificial categories such as private or communal, both are complementary and intermingled. The point is not who has the right over land, but who has the right to use determined area for a specific purpose. Although the existence of production zones as a production system is not exclusive (Mayer, 2002), the inclusion of people and institutions with different objectives and interests but with the ability to cooperate in the coordination, creation and exploitation of them which is exceptional in the Andes; and forms the basis on which of land use policy must rely. Agriculture in steep areas suitable for other uses has been traditionally inherited but the customary institutions that regulated land use are diminishing because of modernization. The environmental consequences can be unexpected since peasant communities control more than 30 percent of the fragile lands (Cotlear, 1989). The evidence that privatizing cooperative property does not automatically led to sustainable investment must be pondered; it is of interest only if individual management is highly profited (Riddell, 2000). Agricultural output would rise, but the impact on employment will depend on the technologies used on the new consolidation holdings. A policy risk is that smallholders who sell their lands may move to the forested areas. Moreover, given the high ecological diversity in the Andes, it is unlikely that a land market is going to develop for second or third quality land. Andean genetic diversity is a case where common access leads to an increase in biological diversity rather than a reduction (Mayer, 2002).

People self organize in response to change (Silberstein and Maser, 2000), creating new instruments and institutional forms capable of responding to restructuring pressures (Neil and Tykkylainen, 1998). They spontaneously organize into extralegal independent groups until the government is able to create a unique system of legal property. Entitling farmers and deregulating agricultural prices can slow emigration. If the farmer has a legal right to his land, he will also invest more in its conservation. Together with a well-designed land information system it would create the needed social capital for sustainable land use. The emergence, implementation and

effectiveness of local policies depend upon the complex of economic, social and political conditions found within and beyond the locality. The changes are slow and continuous, a "green revolution" has not occurred. The growing tendency towards external linkages offers new potentialities, but also new risks for the local people. Markets tend to reinforce the extractive activities, conduces resources outside the rural realm and is indifferent to processes of environmental degradation (Neil and Tykkylainen, 1998).

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