Trends in Land Degradation in South America

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Abstract

This paper gives a brief introduction to various land degradation processes. It then gives an overview of the trends in land degradation in Chile and other South American countries. An important tendency of agriculture has been the conversion of traditional cultivations like beans and corn to new export cultivations, in particular soybeans and sorghum. Observers have noticed an obvious relationship in deforestation that has occurred in the region with the increase of pasturelands for cattle raising. Erosion that constitutes one or more serious forms, including the generalized degradation of soils in the region, can be verified, and has increased in recent decades due to uncontrolled expansion of cattle raising at unapt zones and the extension of agriculture to zones of slopes where freak erosion occurs. In particular certain countries have experienced grave characteristics, including the abandonment of extended areas. The principal problems of degradation of the soil that affect the southern region of South America are: water erosion, wind erosion, advance of dunes, extraction of soil, salinization, problems of drainage, fertility loss, acidification, soil compaction, loss of structure, biological degradation, desiccation of fertile plains, landslides, and irreversible changes in the soil use. One of the environmentally important problems of the region is associated with the expansion of the cattle economy and the resulting conversion of soils from growing traditional crops to livestock feed crops (soybean and sorghum) and the conversion of forests to pasture lands.

State of Land Degradation Trends in Chile

From the agro-forestry point of view, land degradation basically refers to processes triggered by the human activities that reduce the actual and/or future capability of land to produce foods and goods of vegetable and animal origin. More specifically, land degradation refers to unfavorable alterations, either of physical, chemical or biological nature, of one or more of the soil properties. Unfortunately, due to inappropriate practices, human activity accelerates the rates of land degradation. It is estimated than around 2,000 million hectares in the world suffer some kind of deterioration as a consequence of man's activities (Donoso, 1992).

The land degradation consists of the deterioration of soil quality and, logically, of its productive capability, which completely impedes plant functions. In general, degradation starts with the disappearance of the natural vegetation that covers the soil or with the freshly broken up ground. Both practices expose the soil to direct solar radiation and excessive oxygenation causing death to the living soil organisms. This then accelerates the biodegradation of the humus which causes aggregates to disappear and with them the porous soil that the humus generated. As a result, the water and air do not easily circulate, the soil surface gets compact and can even become impermeable, and water can run off the soil instead of becoming stored. The ultimate effect can be diminished crop performance and less profitable returns for the farmer.

The environmental deterioration that causes land degradation is inestimable and there are only general ideas of the damages that this phenomenon causes. For example, water erosion causes the loss of productivity that some authors have estimated in millions of dollars. The heavy environmental, productive, and economic costs associated with land degradation require private and public efforts to protect, preserve, and restore the soil, as well as monitoring this resource.

At the Thirteenth Session of the World Meteorological Organization's (WMO) Commission for Agricultural Meteorology held in Slovenia in October 2002, a new structure, including expert teams, was agreed to and established. Among these was the Expert Team on the Management of Natural and Environmental Resources for Sustainable Agricultural Development, which was given seven basic tasks. One of these tasks was "To survey the status of, and summarize the information on, the trend in land at the national and regional levels." It is within this mandate that this paper was written.

A request was sent to each member of the working group for Agricultural Meteorology of the WMO Regional Association IIII. Argentina, Bolivia, Ecuador, Paraguay, and Uruguay answered the request. In the case of Chile and other countries, this author provided the necessary information through contacts, literature review, and information and studies from organizations such as the United Nation's Food and Agriculture Organization (FAO).

Some Theoretic Aspects of the Processes of Degradation of Soils

In developing countries, the increasing need of food and firewood have resulted in the deforestation and the cultivation of crops on highly sloping land, which has produced severe erosion. Further complicating the problem, it is necessary to take into account the loss of highly productive farmland due to the expansion of industry, cities, and roads.
The over-exploitation of natural resources is the other main environmental problem that results from the combination of economic, social, and institutional factors. These problems have their origin in the over-exploitation of species with high commercial value, without taking the reproduction periods, size, and population into consideration and/or the unsuitable use of the soils for this production.

Water and Wind Erosion

Erosion is perhaps the one process of land degradation that causes the main impact, since it is often of great magnitude, irreversible and, in extreme cases, creates the total loss of soil. The erosive process is related to intrinsic soil properties such as texture, structure, stability of aggregates, and apparent density. Determining erodibility are the slope (grade, length, and form); rainfall (frequency, intensity, and duration); vegetation coverage; and the erosion control practices (Figure 1).

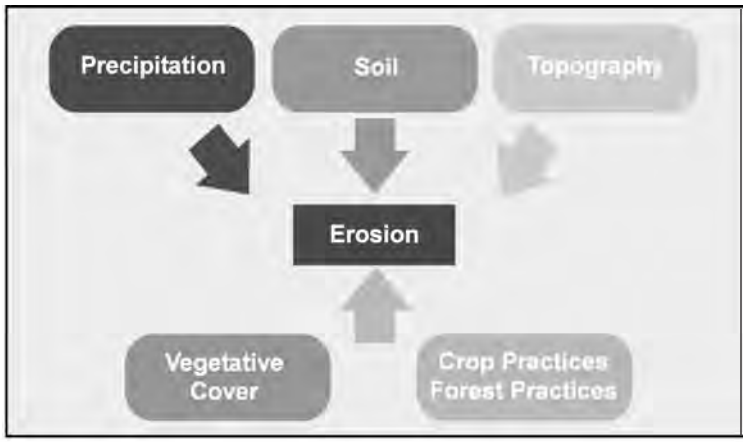

Figure 1. Factors that affect soil erosion.

Water erosion begins with the impact of the raindrop on the surface of the soil, which disperses the finest soil particles in many different ways and loosens the particles from the soil aggregates. The particles are thus separated, carried along by rainfall runoff, and once the soil capacity of infiltration is surpassed due to the intensity of the rain, this begins laminate erosion. When runoff becomes organized preferentially in little furrows, it increases its speed and kinetic energy, producing furrows (Figure 2); and is accompanied by landslides in the form of plates or displacements of a short distance without rupture of the surface, forming little perpendicular ridges to the slope. Finally, it can develop furrows and turn into trenches and ditches, with a total loss of the soil at the affected sector (Figure 3).

Where several furrows come together or integrate, ditches can form to a depth of over 30 centimeters (cm). The rate of the erosion of ditches depends on the characteristics of the basin: the size of drainage basin, characteristics of the soil, the sediments, the size and form of ditches, and the slope of the ditch.

Figure 2. Showing the formation of furrows.

Figure 3. Ditch formation in Navidad, Chile.

Salinization

Salinization is another process of land degradation that generally derives from the use of saline waters of poor quality in crop irrigation without considering the impact of this saline water leaching through the soil. The worsening quality of soil is due to the accumulation of salts in the crop-root zone. This accumulation of salts prevents the plants from absorbing ground water and, therefore, reduces its growth and diminishes the biological productivity of the affected land.

Acidification

In agricultural land that is regularly cultivated with crops, frequent leaching of nutrients beyond the reach of the plants' roots can happen. In the same way, a progressive decline of fertility can occur with an increase of acidity and toxic effects due to the alteration of the equilibrium among the soil chemical components.
The main cause that limits the productivity when a certain level of "critical acidity" is exceeded is the toxicity of the aluminum that occurs in those conditions. An excess of aluminum decreases the absorptive capacity of water and nutrients by the plants and limits the growth and activity of roots.

Urbanization

The development of housing due to the growth of cities generally occurs on fertile soil. This development can cause the best agricultural soils to be lost, impeding the subterranean recharge of soil moisture and aquifers and destroy many microflora and microfauna that live in the soil. In many countries, a good portion of soils with high agricultural potential is found within urban limits, and fast urban growth is a threat to prime agricultural land.

Pollution

Soils can also degrade when toxic substances accumulate in it over time. The FAO defines pollution as a form of chemical degradation that causes the partial or total loss of soil productivity. The accumulation of toxic substances is produced by artificial means as a consequence of human activities; but accumulation can also be caused by natural mechanisms that release substances contained in the rocks, allowing concentrates in the soil to reach toxic levels.

Soils possess a certain capability of withstanding human interventions without deteriorating. However, this capability has largely been surpassed in many places, as a consequence of the production and accumulation of industrial or urban use.

The pollution of soils also takes place due to the inappropriate removal and absence of treatment of human trash. The illegal dumping of industrials residues constitutes a serious problem of soil pollution.

State of Land Degradation Trends in Chile

In Chile, agriculture occupies a major place in the national economy, being an activity that occurs principally among the central and southern regions of the country. Among the natural resource sectors of Chile, agriculture ranked second in its contribution to the Gross National Product from 1996 to 2000.

Nearly 62 percent of the Chilean territory exhibits some form of soil erosion. Deforestation, improper irrigation, and the abuse of cultivation techniques have been an intrinsic characteristic in agriculture.

The large areas of eroded land in various forms and variable degrees of intensity that exist in Chile are related to the frailty of the ecosystems. One of the natural factors that affect the deterioration is the topography of hills and mountains that exist across most of the national territory.

The Andes Mountain Range is composed of igneous, sedimentary, and mixed rocks that were subjected to energetic physical processes and therefore caused erosive actions, which increased the transport of sediment towards a Central Depression. Theoretically, the Central Depression would have a physical character of ecological balance. Regardless of its flat topography, the unsuitable management techniques of soil and water resources tend to produce erosive processes of a certain magnitude in many sectors.

The physiographic position, the slope, and the original material of the soils are factors that have a marked influence on the erosive phenomena of the coastal mountain range. In general terms, the soils derived of igneous rocks display a greater degree of susceptibility to erosion.
These soils have a clay subsoil of low permeability and a decomposed rock substrate with low cohesion (gravel), characteristics favoring runoff of surface water and the formation of active erosion gullies and channels (Peralta and Peralta, 1990). Most of these soils are found on

hillsides subject to intense grazing and removal of shrub vegetation. Hillside soils are generally used in seasonal agricultural production and have no plant cover for part of the year. On the other hand, soils derived from sedimentary materials do not generally show obvious signs of accelerated erosion.

The adoption of unsuitable agricultural practices in large rural sectors of the country has provoked a decrease of crop yields, an increase in production costs, a decrease in the wide use of soil options, an impoverishment of affected zone, and even increased migration of the population. In many zones, a vicious circle has developed between the increased soil erosion and the deepening of local poverty.

The Natural Resources Research Institute of Chile (1999), currently called the Information Center of Natural Resources, has made the only study that covers the entire continental territory of Chile. The study, which is entitled "Fragility of Natural Ecosystems of Chile," was done to establish the situation of the soil and vegetation resources and to formulate a diagnosis of the soil erosion situation.

Land Degradation by Water and/or Wind Erosion

According to the Agricultural and Livestock Service (Spanish acronym SAG), 60 percent of the forest and agricultural area in Chile show moderate to very severe erosion. The most important problems of degradation by soil erosion in the agricultural-forestry sector is found in the altiplano sector, the foothills and mountains of the Andes in the Norte Chico coastal mountain range. Wind erosion is most pronounced in the semiarid steppes of Patagonia, where the soil remains dry for periods during intense spring and summer winds that easily remove and transport fine soil particles from the surface horizon.

Degradation of the Soils by Salinization

Salinization has been observed in many sectors of irrigated vineyards in the transverse northern valleys like Copiapó (Figure 4). In addition to these soils being degraded by machinery, they are also naturally saline or sodic due to climatic, topographic, and/or drainage reasons, therefore they tend to accumulate salts. Crops, especially fruit-bearing ones, do not tolerate high concentrations of salt or sodium, which will decrease the start of harvest, seed germination, and overall productivity.

Formation of Dunes

It is also necessary to mention the losses of agricultural soil and of biological potential produced by the action of dominant winds, which transport and produce accumulations of fine sands in the shape of dunes. According to a survey made at the beginning of the 1960s, Chile had about 74,500 hectares (ha) of coastal dunes between the central and south regions. In addition, there exist nearly 56,000 ha of continental dunes in the central-south region of Bío-Bío.

Figure 4. Soils with salinization in the Copiapó Sector.

The coastal dunes in the country form, in general, to the north of the mouths of large rivers. This situation is caused by dominant coastal currents which move sands from a south to north direction discharged by the rivers, where waves deposit them on the beach. From there, the wind transports the sands and accumulates them in the form of dunes near the coast.

Loss of Productive Soil Capacity Due to Mining-industrial Pollution

In the majority of cases of soil pollution in the country, the toxic chemical substances come from mining and industrial activities. The soils receive residual materials emitted by these activities, generating a conflict of interest between mining and agriculture, mining and public health, and mining and environmental health.

The soil areas with high accumulations of copper are due to particulate material originating from the industrial sector. At close proximity to mining complexes, the concentration of this metal in the soil exceeds 100 times the natural content, which easily surpasses the maximum tolerance limit for plants. There are also accumulations of lead, arsenic, and cadmium, which entails serious risks for people's health.

Loss of Arable Soil Due to Urbanization and Change of Destination for Industrial Materials

Due to the strong pressure to expand the urban limits of numerous cities in the center of the country, especially in regions V, VI, and Metropolitan Regions, proper attention has not been given to the urgent need to rationalize the use of soil resources that have a greater potential for agricultural activity.

State of Land and Degradation Trends at Regional Levels in South America

In South America, soil erosion is the main threat for land and this problem affects 68 percent of the land resources. Heavy rains and unsuitable agricultural practices on the slopes of hills and mountains are important causes in the loss of agricultural potential.

Deforestation has caused the degradation of about 100 million ha in South America, of which almost 70 million have been due to animal grazing. In the case of watersheds, deforestation is a key factor in the region. This process is very severe on western slopes (faldeo) of the Andes, where it principally affects tropical forests known as the "Yungas," which extend from Colombia to Argentina.

In South America, it has been determined that the high environmental costs of agriculture are related to soil erosion, the loss of soil fertility, the degradation of lands by animal grazing, and excessive use of pesticides. Agriculture on unsuitable lands and/or with inappropriate techniques is characterized by a series of effects which includes:

- Increasing erosion of slopes due to deforestation, over-grazing, and inappropriate agricultural practices linked to both subsistence economies and large-scale business developments;
- Increase in the surface runoff and evaporation, reduced infiltration, and dramatic increase of erosion;
- Silting-up of rivers, diversion and impairment of river beds, and increased flooding frequency in the middle and lower courses during the rainy season;
- Drying-up of rivers and reduction of ground water during the dry season;
- Rapid silting up of reservoirs.

Soil degradation is also produced by the fragmentation of water systems, intense urbanization, uncontrolled pollution, and construction of large engineering projects, all fueled by an exponential growth of the human population and the lack of planning in the development process (Abramovitz, 1996; Comisión de Medio Ambiente, Desarrollo de America Latina, and el Caribe).

Current Situation of Soil Degradation in the Republic of Argentina

Due to its contribution to the economy and through the exportation of agricultural products such as grain and meat, agricultural production is the most important productive activity of the country. This traditional agro-export activity was the principal source of foreign exchange that financed the development of the country, and for many years it allowed for acceptable development. The agricultural sector continues to have a widely recognized importance in the Argentine economy.

Nevertheless, soil does not receive enough consideration since it supports Argentina's agricultural activity. Almost 60 million ha are affected by water and wind erosion to either a moderate or severe level. Economic losses due to soil degradation are estimated to be nearly 700 million dollars per year.

The undulating landscape, intensity of the summer rains, low levels of water infiltration into the prevailing clay soils, and practice of conventional agriculture are the main causes of soil degradation. Many provinces are affected by this phenomenon.

The direct causes of wind erosion in the semiarid region are the lack of crop rotations, the reuse of inappropriate cultivation implements, over-grazing of natural and cultivated fields, deforestation of unsuitable lands for agriculture, and a common practice in this region, the tilling of unsuitable lands with ill-suited agricultural practices.

In the beginning of the 1990s, it was estimated that 20 percent of the national territory was affected by water and wind erosion (nearly 60 million ha). It has been estimated than each year between 200,000 and 650,000 ha of land are eroded (Casas, 2001).

Among the main causes of accelerated erosion in Argentina are the advance of the agricultural frontier on marginal lands without using the correct techniques; intensification of yearly cultivations without considering the aptitude of the land, conservation measures, and necessary management; uncontrolled elimination of vegetation, particularly deforestation; over-grazing of pasturelands; and deliberate and accidental fires.

Another important process at the national level is the physical degradation of soils as a result of excessive cultivation without crop rotation, improper handling of organic matter and agricultural waste, and inappropriate farming systems. The consequences are the creation of tillage pans, reduced infiltration, and increased risk of water erosion. These impacts are particularly severe in areas permanently under crops or under long-term rotation.

Soil salinization is also a serious problem in Argentina, affecting both irrigated and dry-farmed land. On irrigated land, the advance of salinization is widespread and accelerated primarily because of excessive irrigation in inappropriately drained areas or, in some cases, to the extraction of brackish groundwater. In several areas, over 60 percent of irrigated land has salinized soils.

Current Situation of Soil Degradation in Bolivia

Bolivia is a country with various geographic and ecological characteristics, offering a multiplicity of natural landscapes like high mountain glaciers, high plateaus, and valleys and plains with jungles and savannas. It possesses a great diversity of cultures, ways of life, and agroeconomic conditions.

The area affected by degradation covers 41 percent of the national territory and is mainly located in the Departments of Oruro, Potosí, Chuquisaca, Tarija, La Paz, Cochabamba, and Santa Cruz.

In Bolivia, the main environmental problem is land degradation, which is increasing and threatening, and is fundamentally expressed in an intense process of erosion that produces the loss of capability in agricultural and forest soils, the destruction of the productive base of the country, and the aggravation of poverty.

Bolivia is one of the more dramatic cases in the region. Between 1954 and 1996, the area of eroded soils increased from 236,833 kilometers (km^2) to 428,700 km^2, an increase of 86 percent according to official numbers (Benites, et al., 2003).

Official reports indicate that there is a systematic degradation of vegetation and forest coverage where people build urban settlements that do not meet minimal environmental sustainable requirements.

In addition to environmental implications, land degradation has serious economic consequences. Annually, 40 thousand ha of national territory lose productive capacity due to the effect of degradation. In addition to obvious environmental implications, this situation affects the economic development of the agricultural and forest sectors, which causes the loss of approximately 50 million dollars per year and represents 4 percent of the total output of the sector. According to data provided by land use and coverage maps, 82 percent is covered by pasture and forest lands susceptible to be used in more intense forms, which entails a potentially high risk of erosion and/or degradation of these ecosystems (Benites, et al., 2003).

The development of human settlements and the corresponding use of natural resources on steep slopes and semiarid climatic conditions have almost occupied all of these lands causing the disappearance of original forests in exchange for land preparation for agriculture, grazing, and firewood.

The continued use of the land has led to water erosion of the soil and to overgrazing. In some sectors of the Cochabamba valleys, irrigation and semiarid climate have generated salinization of soils. In these sectors, one encounters soil and water pollution due to mining activity.

Conclusions for Bolivia

- The different processes of soil degradation in Bolivia have taken place over large territories with advanced degrees of deterioration.
- Even though the impact of soil degradation on the Bolivian economy has not been quantified, it is evident that the there are very important socioeconomic outcomes like migration, increased costs in agriculture and infrastructure, and the systematic impoverishment of rural producers.
- Bolivia has extensive areas covered with forests and natural pasturelands in fragile environments with little management, which entails a high risk of increasing the area eroded by the advance of the present-day agricultural frontier.
- There does not exist a soil conservation service on a national scale, and what sources of information do exist are very dispersed and very local.

Current Situation of Soil Degradation in Brazil

In the country of Brazil, soil degradation began 4 centuries ago with the arrival of the Europeans and the first deforestations. This accelerated in the 19th century with the development of sugar cane and coffee plantations.

From the 1970s, the increased pace of export cultivations caused large soil degradation. In the 5 years from 1975 and 1980, Brazil moved into third place in the world among soybean producing countries by replacing subsistence or low-impact agriculture with highly mechanized agriculture. The acquisition of agricultural machinery increased 2,000 percent between 1975 and 1995 (Merten, 1996).

This trend greatly modified the biological activity of the soil, and it increased land erosion by four to five times. Today, the state of Sao Paulo loses 200 to 250 million tons of arable land per year, a number that would have to be multiplied by thirty to obtain a national estimate (Merten, 1996).

Cultivation of Soybeans and Cattle

In the case of soybean cultivation, over the last 60 years this crop has expanded from almost zero to more than 21 million cultivated ha. The cultivation of the soybean started in the more arid southern states of Brazil, but it has now extended to the center and western zones, invading mainly the Latin American savannah forest and to a lesser extent the tropical forest of the Amazon. One of the driving forces of the expansion of soybean agriculture has been the huge expansion of the cattle ranching in Brazil, mainly in the states of Mato Grosso, Pará, and Rondônia. The amount of cattle heads increased from 26 million in 1990 to 164 million in 2004. The International Finance Corporation (IFC), which is part of the World Bank, directly participated, for a short time, in the expansion of soybeans as well as in the cattle operation in Brazil.

Traditionally, the increase in cattle ranching has been identified as the leading cause of deforestation in the Amazon, but now soybean cultivation occupies a close second place. Currently, both factors together have caused the clearing of 80 million ha in Brazil (approximately equivalent to 10 percent of the country's total surface area), and since Brazil possesses a larger area of tropical forest, it also undergoes larger deforestation. Until the end of the 1970s, deforestation in Brazil was considered a minor problem that had a limited local impact. However, the situation has changed in a radical way. During the following 20 years, 50 million ha of forests were destroyed in the states of Pará, Amazon, Mato Grosso, and Acre, which constituted 14 percent of the Brazilian Amazon (CEPAL, 2000).

Many people have reiterated the danger that soybean expansion has on the ecosystem of the humid tropical forest. It has been estimated that in 2020, soybean production could destroy nearly 22 million ha of forests and savannahs in Latin America.

Consequences of Deforestation

They are numerous factors that contribute to the uncontrolled deforestation of Brazil. The most notorious agents are the cattle farmers, who make good use of the subsidies granted by the government destined to stimulate the expansion of the livestock industry. The exploitations of gold mines, the flooding due to hydroelectric dams, and commercial tree harvesting are other important factors.

The long-term impact of deforestation on soil resources can be serious. The clearing of native vegetation cover for agriculture and subsequent burning exposes the land to the intensity of the tropical sun and to torrential rains. This can negatively affect the soil by increasing soil compaction, reducing organic material, leaching the few soil nutrients that exist, increasing aluminum toxicity, and thereby marginalizing agriculture. Subsequent cultivations, frequent tilling, and excessive use for cattle grazing pasture accelerates soil degradation.

Current Situation of Soil Degradation in Colombia

On the basis of a study (IDEAM, 2000) on soil degradation and land erosion for the decade of the 1990s, large soil removal and sedimentation in Colombia can be estimated as follows: 48 percent of the Colombian territory displayed some grade of degradation, of which 14.2 percent was very high degradation; 10.8 percent was high degradation; 8.9 percent was moderate degradation, 9.5 percent was low degradation, and 4.6 percent was very low degradation (Figure 5).

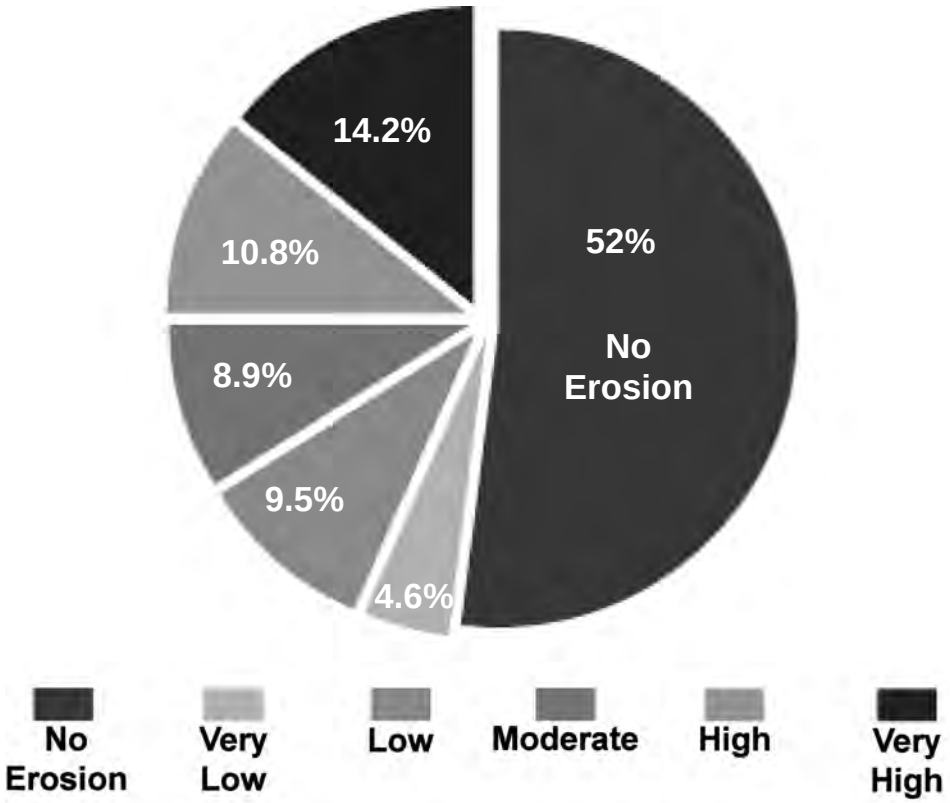

Figure 5. Represents the percentage distribution of the intensity of degradation of soils and lands in Colombia for erosion, removal in mass, and/ or sedimentation.

According to the report, soil degradation processes present in Colombia include erosion, compaction, leaching of nutrients, pollution, salinization, and sodification (sodium-affected soils). This soil degradation results from activities such as deforestation, mining, intensive and extensive cattle raising, unsustainable agricultural systems, inappropriate use of water resources, indiscriminate burnings, and illicit coca cultivations.

Deforestation and Land-use in Colombia

In the watershed of the Q. Yepes River in the Sierra Nevada of Santa Marta, Colombia, the deforestation of the tropical humid forest from pre-Columbian times, the frequent use of fire and intensive grazing have caused severe erosion and reduction in fertility, which has led to the conversion of humid forest to savannas. Soil profiles indicate that erosion has moved approximately 50 cm of the soil in areas that are currently covered by pasturelands.

Due to increasing food demand, Colombia has chosen to incorporate new lands to increase production. The humid tropical regions have suffered the impact of an agricultural exploitation, which use inherited practices such as cutting and burning trees (Olmos and Montenegro, 1987).

Current Status of Soil Degradation in Ecuador

The system of resource utilization in Ecuador is a classical example of developing countries that are forced to intensively exploit natural resources, which can result in the creation of serious problems. The principal cause of loss of biodiversity in Ecuador is the destruction of natural forests. The rate of deforestation in the country is 2.3 percent per year and by extrapolating, this implies that the country would be totally deforested in the year 2025.

More than 60 percent of the paramo zone in Ecuador is classified as a zone of human intervention, and the large majority of it is being used for agricultural intentions. Because of this, several sectors of Ecuadorian society are concerned about the degradation of the natural resources in this zone caused by agricultural uses. The agricultural production systems have their foundations in the biophysical, technological, economic, political, and cultural surroundings.

Changes in these systems can be explained by the combination of causes such as integration to the market, access to new lands, access to technologies that increase land productivity, population pressure, and degradation of natural resources used by agriculture.

Current Status of Soil Degradation in Ecuador

Soil degradation is considered among the more serious environmental problems of Ecuador (Byers 1990; White and Maldonado, 1991). A study done by De Noni and Trujillo (1986), demonstrated that 12 percent of the soils in the country (31,500 km^2) were exposed to active erosion.

Multiple forces have contributed to soil degradation of the region, including agricultural activity, monoculture crop production, high use of agrochemicals, and the cultivation and mechanical movement of the soil. Although the intense rains that fall on exposed soils commonly cause erosion, the high organic-matter content of black Andean soils facilitates a large degree of infiltration. As a result, runoff only occurs during the more severe rain events, that is to say, one or two times per year (De Noni and Trujillo, 1986; Harden, 2001).

The use of tractors on relatively moderate slopes (25-35 degrees) has resulted in the transport of large quantities of soil downward (Kooistra and Meyles, 1997). In the Ecuadorian Andes, mechanized cultivation of slopes has increased dramatically in the last decades, even to the point that the use of tractors is the primary cause of physical erosion and soil degradation.

Over-grazing on lands where cattle did not exist and the clearing of the forested parts of the slopes favor the acceleration of erosion and soil degradation in arid, semiarid, and sub-humid zones. These are caused by diverse factors at the intersection of climate and human activities. The problem of the deforestation, which allows water to run too quickly over uncovered slopes and wash away a large part of the humus, is the serious upsetting of the water balance.

Current Status of Soil Degradation in Paraguay

The economic base of the country is agriculture, especially the production of cotton and soybean for export. The agricultural sector generates 26.7 percent of the gross national product (PIB), employs 35.8 percent of the working population, and produces 90 percent of the registered exports (Kohler, 1992). Of these exports, about one half is exported without any processing.

Factors that Lead to Soil Deterioration

According to Kohler (1992), there are three key factors that lead to the deterioration of soils in Paraguay:

a) Establishment of unsuitable regions for agriculture and/or cattle ranching;
b) Application of technologies unsuitable for managing natural resources; and
c) Rapid changes in macroeconomics.

The pressure for land strongly emerged after 1989 due to many occupations of forested territories on the part of the farmers. The first stage in the procedure for settling land was the request to the National Parliament for the expropriation of the land, which was and still is a useful means of enabling small farmers to have access to the land. The expropriation was facilitated by the land being regarded as “uncultivated” and “unused” by the owners. To counter this trend, from 1989 the landowners began a process of massive deforestation and delimitation of all estates regarded as unproductive, so that they would be classed as being “rationally managed” and therefore not subject to expropriation. This situation doubled average annual deforestation in less than a year, reaching a record level where less than 10 percent of the country’s total land is still wooded, and the remaining subtropical woodland is forecast to disappear in 2010 (Kohler, 1992).

The various aspects that affect the erosion process in agricultural areas include:

- The system of dividing properties to be distributed to the people is done without suitable planning of existent natural resources;
- Lack of adequate technical support to the producers in their re-adaptation in the new qualified areas;
- Most of the agricultural production is oriented to the demand of international markets, such as annual crops (soybean, cotton) that leave soils exposed to degradation;
- Intensification of agricultural mechanization in certain regions of the country that causes changes in physical soil characteristics such as compaction, less infiltration of rainwater and less retention of available water for plants;
- Insufficient local scientific information on the handling, conservation, and recuperation of soils;
- Lack of political will and budget allocation directed to the treatment of the problem of soil degradation; and
- To incorporate soil conservation into technical measures and credit assistance, and to minimize the time of assimilation of the technical conservationists.

Current Status of Soil Degradation in Peru

Soil Degradation

Soil degradation is also linked to human intervention owing to demographic pressure and improper land use. Erosion is most obvious in the mountain region. At a national level, erosion covers an area of some 60 million ha, or 55 percent of the area of the territory. Also, there is a fragile equilibrium in regards to erosion in the lowland jungle areas. Therefore, destroying the plant cover accelerates the erosion process in the hilly formations, which is typical of 70 percent of the physiographic scenario of the lower Amazon jungle. Erosion occurs on hillside soils without plant cover and is subject to heavy rainfall. However, this process is partly rooted in social and economic aspects.

The Cultivation of the Coca Leaf in Peru

The cultivators of coca in the Andean Region prefer to locate their cultivations in remote forest zones, almost always in mountainous and steep terrain. The sparse ground-level vegetal layer and difficult access to these zones generally stimulates the production of illicit cultivations. In order to prepare the land for illicit cultivations, forests are devastated and burned before sowing the coca. Due to the low fertility and the need to evade the authorities, the fields are abandoned after two or three plantings and the new fields are opened inside the jungle. This practice accelerates the deforestation of large extensions of forests and destroys lumber resources that would be available from a more sustainable use of the forested land. Additionally, the recurrent practice to sow in such a fragile soil can rapidly lead to environmental deterioration and the depletion of natural resources, especially in the loss of the topsoil layer and sedimentation downstream.

In 2000, the deforestation affected 9.6 million ha (12.6 percent of the Amazonian forest of the country), and can be calculated on an average of 261 thousand ha deforested per year (0.35 percent/year). About 73 percent of these areas are in different stages of forest formation, known as secondary forests, and the product of various degradation actions (slash and burn agriculture, erosion, etc. [ENDF, 2001].

Current Status of Soil Degradation in Uruguay

The Eastern Republic of Uruguay is located in the temperate region of southeastern South America. Uruguay is an essentially agricultural country with cattle-ranching and agriculture constituting over 85 percent of the country's exports. The industry continues to transform primary raw materials into the agricultural sector.

Soil Degradation

In Uruguay, it is considered that soil degradation constitutes a complex process whose advance is manifest reduction of soil productivity and the associated ecosystems. These successive reductions in productivity correspond to different processes in the country, mainly water erosion, as well as to the socioeconomic, institutional, legal, political, and cultural factors.

In the same way, erosion represents a problem that also generates direct costs for the country, like the need to continuously replace lost nutrients, or the depreciation of land in the more affected zones.

A study by Beloqui and Kaplán (1998) concluded that although 30 percent of the land displays some degree of degradation, the deterioration of the soil properties is relatively low in relation to its prolonged use; nevertheless, the degradation of the structure of the surface horizons is closely related to the loss of organic matter.

Current Status of Soil Degradation in Venezuela

Soil Degradation

In Venezuela, like the other tropical countries, the more common problems of degradation are water erosion, sealing, compaction, salinization, and sodification Pla (1988). According to the same author, also present are processes of physical and chemical degradation accompanied by biological degradation. Most of the degradation problems not only depend on the intrinsic soil characteristics, but also on the very aggressive climate in the majority of areas and of the adoption of agricultural production systems and practices taken directly from other parts of the world with different climatic and socioeconomic conditions (Pla, 1988).

According to FAO, deforestation in Venezuela is principally due to the demand for lands for agricultural purposes, but it is also related to the limitations of the political system for the establishment and consolidation of effective agrarian reform (FAO, 2000).

During the period from 1990 to 2000, Venezuelan forests were cut at a rate of 500,000 ha per year to be converted into agricultural land and pastureland for cattle. It is precisely in the Guarico and Apure plains where over-grazing is common, because the natural pastureland is not able to maintain the existing number of animals. If the present-day rate of deforestation in these two states is constantly maintained, it is anticipated that an almost total disappearance of the forest will occur by 2020.

In spite of the significant advances in national legislation in environmental matters and a considerable increase of the areas protected in recent years, the budgetary and personnel limitations in public agencies and the application of legal requirements are still very weak. Also the clearing of land continues at a high rate (according to estimates, the highest in the region), which results in increasing social pressure and the unjust system of tenancy of effective land-use in the country (Ministerio del Ambiente y de los Recursos Naturales, 2000).

Agriculture and livestock are the main causes of this large-scale deforestation. The process of felling trees and the burning of the remaining vegetation for pasturelands, which later will be converted into corn and soybeans fields, along with the gradual deterioration of soils and water reserves, have caused the destruction of the majority of humid forests, dry forests, and the fertile soils suitable for the agricultural production. It is estimated that south of Lake Maracaibo, 95 percent of the forested areas have disappeared to establish low efficiency cattle-ranching. However, this activity produces 70 percent of the milk and half of the meat consumed in the country.

The problems of land degradation in Venezuela worsens every day, due principally to the rapid expansion of crops that utilize a great diversity of production methods and technologies that are unsuitable for the various soil types, climate, and socioeconomic conditions. These factors are aggravated by the increasing demand for highly fertile agricultural land for urban and industrial uses. This situation has reduced agricultural production because it has become necessary to introduce agricultural raw materials and practices that guarantee yield, but that cause soil degradation.

Conclusions and Recommendations

Although there are differences in the available statistics on the various land uses in South America, the following general trends are in agreement:

1) Lands dedicated to arable crop land and pastureland with the associated strong decrease of the forest area have increased. A more detailed analysis reveals that an important trend has been the conversion of traditional cultivations like dry bean and corn to new export crops, in particular soybean and sorghum, and a clear relationship exists between deforestation and the increase of pasturelands for livestock.

2) It has been verified that erosion constitutes one of the most serious and generalized forms of land degradation in the region. This has increased during past decades by the uncontrolled expansion of cattle ranching in non-suitable zones and the extension of agriculture on slopes

susceptible to erosion, which in certain countries has forced extensive areas of land to be abandoned.

3) The principal problems of soil degradation that affect the region of southern America include: water erosion, wind erosion, advancement of dunes, extraction of soil, salinization, drainage problems, loss of fertility, acidification, soil compaction, loss of soil structure, biological degradation, desiccation of fertile plains and valleys, landslides, and irreversible changes in soil use and pollution.

4) Since the time of the Spanish conquest, Chile has been a country with serious problems of soil erosion, which has been particularly studied in the coastal Mountain Range. Chile has undergone erosion problems caused by the conversion of areas to cattle ranching, extraction of firewood for fuels, indiscriminate use of fires, and the conversion of land to cereal and horticultural use.

5) The impacts that cause soil modifications by anthropogenic intervention have been magnified with increasing mechanization, agrochemicals application, in particular by synthetic fertilizers, pesticides, herbicides and fungicides, as well as the use of improved high-yielding crop varieties, increased irrigation, etc.

6) One of the most important environmental problems of the region is associated with the expansion of the cattle economy and the resulting conversion of soils from traditional cultivations to the production of cattle feed (soybean and sorghum) and the conversion of forest areas to pasturelands.

The following are several erosion control strategies that can be considered:

- Increased vegetation cover to reduce the impact of energy from raindrops on the soil surface;
- Increased water infiltration in the soil profile by reducing surface runoff and to increase soil water availability for crops;
- Control surface runoff to reduce the erosive potential of flowing water;
- In addition to the local community, national governments must cooperate in remedying soil damages caused by human activity (erosion, chemical pollution, and others);
- Landowners must carry out productive activities based on the capabilities and ecological potentialities of the soil, preserving soil quality, and in maintaining the use of fertile soil for agricultural activities;
- To apply the following agroecological techniques: direct sowing, minimum tillage, crop rotation, cover crops, controlling cattle grazing, fertilization, composting, earthworm humus, organic fertilizers, and other appropriate technologies;
- To eradicate burning and fires and to practice regulated cutting;
- To manage areas based on agroecological capacity and soil potential;
- To regulate crops and soil techniques on high sloping land; and
- To define planning policies for rural areas, to regulate and manage appropriate land use policies, and to determine the minimum area for changing land use.

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