Sustainable Land Use Management in the Andean Region of Ecuador

S. Proano Galindo
Department of Parks and Gardens, City of Quito, Ecuador

Introduction

The Andean Region of Ecuador is inhabited mainly by poor, subsistence-level farmers who barely manage to survive by farming marginal lands that have long been depleted of most plant nutrients. The entire region has been extensively degraded by improper and exploitive farming practices, deforestation, and overgrazing which has caused widespread destruction of this mountainous environment and the upper Amazon Basin. Such a dramatic decline in soil productivity and their ability to produce food has led to a mass migration of these small farmers to Ecuadorian cities in search of employment. Moreover, large numbers of these people have abandoned their lands and left the Andean region altogether, migrating to the upper Amazon Basin where a new cycle of land degradation from exploitive agricultural practices has begun.

Recently, the Ecuador government initiated the Sustainable Land Use Management Project to instruct Andean farmers in the use of soil and water conservation measures to control erosion, and improve crop management and production practices that will, hopefully, enhance the productivity, stability and sustainability of agriculture in this region. The main focus of the project is to help these farmers to help themselves. This paper will discuss the outreach activities of the Project and some preliminary results.

The Physical Setting

Ecuador has three distinct biophysical regions: the Western Coastal Plain, the Central Andean Region (called the Sierra), and the Eastern Amazon Basin. The proposed land use management project will focus on the Sierra where communities are located on steep mountainous slopes at elevations of 2000 to 4500 meters. Eight provinces will be involved, i.e., Azuaw, Bolivar, Cafiar, Cotopaxi, Chimborazo, Imbabura, Loja and Tungurahua.

The Andean Region has two different seasons, the dry season (verano) and the wet or rainy season (invierno). The rainy season has a bimodal distribution and occurs from October to May. Maximum precipitation occurs in October north of the equator, and in March south of the equator. Annual precipitation ranges from 300 to 3000 mm and droughts are common. At higher elevations, sleet and frosts can occur. The mean temperature in the Sierra Region ranges from 10 to 18C.

Soils in the Sierra Region are of volcanic origin. They are classified as young soils and have not been subject to extensive physical or chemical weathering. Soil texture ranges from loams to clays, and pH from 4.5 to 7.5. Soils at higher elevations contain an abundance of organic matter because of the slow rate of decomposition under cool conditions. Soils at the lower elevations have a much lower content of organic matter and are usually low in their cation exchange capacity. Andean soils are generally fertile and can be made highly productive with proper management

Severe soil erosion has occurred throughout the cultivated areas of the Sierra Region of the Ecuadorian Andes. This is the result of intensive rainfall on clean cultivated, steeply sloping, and poorly structured soils. Soil erosion is also exacerbated by burning of vegetation, overgrazing, and deforestation. Cultivated lands are often abandoned because of severe sheet and gully erosion.

Natural vegetation in the Sierra at elevations of 2500 to 4000 meters, which is seldom found, consists of scattered forested areas and grasses. Some natural forests still exist on steep slopes in areas that are protected from wood gathering. Nevertheless, most of the forested areas have been cleared for cultivation and pastures.

Andean Agriculture

A wide variety of crops are grown in the Sierra including com, potatoes, wheat, garlic, beans, barley, melons, beets, cabbage, carrots, tomatoes, and a variety of fruits. Increased demand for fruits and vegetables by urban consumers has greatly diminished the production of traditional crops such as amaranth, melloco and quinoa. The crops grown on any particular farm depend primarily on the elevation and availability of water for irrigation. At higher elevations and with relatively fertile soils, farmers usually grow cold-tolerant root and tuber crops such as potatoes, onion and garlic.

Traditional agriculture in the Andes has depended very little on mechanization, although in recent years there has been an increase in the use of tractors for primary tillage. This, however, has greatly accelerated soil erosion and land degradation because it has increased the extent of clean cultivation on steep slopes. Moreover, planting densities for cereal crops have always been traditionally low (e.g.. 1 m x 1 m for corn) which leaves the soil exposed to rainfall and erosion.

The use of chemical fertilizers and pesticides in the Sierra has also increased along with mechanization, especially among farmers producing high cash value crops for the urban market. Fertilizer application is normally based on standard recommendations with little, or no consideration for the soil fertility status. Farmers often apply the wrong pesticide (for a particular situation) at improper (excessively high) dosages with little regard for their personal safety, their families, or the consumer. The availability and use of restricted-use pesticides is commonplace, particularly for potato production. Integrated pest management and biological control measures in lieu of pesticides are rarely practiced.

The Sustainable Land Use Management Project

It is apparent that there is an urgent need for small marginal farmers in the Andean region to adopt conservation farming practices to improve their productivity, protect the natural resource base, and preserve the environment. The Sustainable Land Use Management Project was planned and implemented with support from the Ecuador government to provide poor Andean farmers with the most effective, affordable, and appropriate technologies on soil conservation, ecological agriculture, agroforestry, and water conservation and management so that they could achieve a more sustainable agriculture and a better quality of life. Features of these four technologies are briefly discussed.

Soil Conservation

Soil conservation is perhaps the most important component of the Sustainable Land Use Management Project because it is absolutely essential for the successful implementation of all other technologies. Soil conservation practices will most likely include those traditional methods used by farmers for many generations, and some modern techniques as well. Some soil erosion control measures will involve rather simple agronomic practices, while others may involve labor-intensive, physical structures.

The A-Level. This simple wood-frame tool can be used effectively by farmers to plot contour lines for tillage, planting, and layout of physical structures for control of soil erosion. Project participants will learn how to use and construct the A-level with locally available materials.

Contour Tillage and Planting. Traditionally, Andean farmers have cultivated fields up and down the slope which sets the stage for excessive soil erosion and nutrient runoff. The use of tractors exacerbates the problem because they must till and plant up and down the slopes to avoid overturning. Contour farming is one of the most effective means of controlling soil erosion and needs to be widely adopted by small farmers, especially on steep slopes and using animal traction rather than tractors.

Vegetative Barriers. This particular feature involves the contour planting of narrow strips of shrubs, trees, or grasses which can effectively control soil erosion. These barriers reduce the velocity of surface runoff and retain sediment which gradually forms a natural terrace behind the barrier.

Strip Cropping and Reduced Tillage. Strip cropping consists of forage legumes and grasses planted in alternate contour strips with annual crops; it greatly reduces soil erosion on sloping lands, and increases the soil organic matter content and fertility. The use of reduced tillage in the strips where annual crops are grown (i.e., planting directly into stubble of the previous crop without plowing) can greatly minimize soil erosion and nutrient runoff.

Drainage and Infiltration Ditches. These mechanical soil erosion-control features are constructed on the contour with the aid of an A-level at various intervals to maximize infiltration of rainwater, or to convey excess water off the fields and into grass waterways or storage reservoirs before erosion can occur. The area between the ditches is usually planted to annual crops. The ditch interval is decreased as the slope increases. Maintenance consists of planting forage grasses on the ditch banks to protect them from mechanical disturbance, and periodically removing sediment and debris.

Runoff Channels and Graded Waterways. Run off channels are used to convey excess rain-water from contour ditches and field terraces to reduce the potential for soil erosion. Channels should be stabilized by planting them to forage grasses and should be protected from livestock grazing. On steeper slopes, simple rock check-dams and drop structures can be combined with perennial vegetative cover crops to form graded waterways. This reduces runoff velocity and provides a relatively stable water course.

Ecological Agriculture

The goal of ecological agriculture is to develop more productive, stable and sustainable farming systems by maximizing the use of local resources, traditional crops, established cultural practices, and indigenous knowledge, while minimizing the use of costly, external inputs of fertilizers, pesticides, machinery and credit. The ultimate production system should be self-sufficient, economically-viable, and environmentally-sound. In pursuit of this goal, the traditional methods and practices are sometimes combined with more modern technologies involving tillage, crop rotations, cover crops, non-chemical pest control, and composting. Project activities in regard to ecological agriculture are as follows:

Composting and Green Manuring. The major problems responsible for the low level of agricultural productivity in the Sierra (and throughout the Andean Region) are excessive soil erosion and the low level of soil fertility from the continual "mining" of nutrients by subsistence farmers, with little or no provision for replacement. Thus, the Sustainable Land Use Management Project will emphasize the importance of composting and green manuring (including the use of nitrogen-fixing legumes such as vetch and clover, and also some indigenous legumes) to provide biofertilizers and soil conditioners for restoring the fertility and productivity of these soils. This will also offer a viable alternative to the use of costly chemical fertilizers. The Project will offer training to farmers on simple but effective methods for composting various on-farm and off-farm organic wastes and residues into useful soil amendments.

Crop Rotations. The regular rotation of cereal, root/tuber, and legume crops have contributed significantly to reducing the populations of harmful soil-borne pests and the incidence of plant diseases. Crop rotations also help to restore soil fertility and productivity. Thus, the Project will emphasize the importance of rotating combinations of traditional and non-traditional crops.

Traditional Crops. In addition to high yielding hybrids, the Project will also promote the use of open-pollinated traditional crops. The reason for this is that many farmers in the Sierra have had little experience with hybrid crops which are often more susceptible to diseases and insect pests. Moreover, it allows farmers to collect and replant their seeds which is not practical with hybrid crops. Traditional crops include beans, potatoes, pumpkins, wheat, melloco, amaranth, corn, chocho, Peruvian white carrot, naranjilla and quinoa.

Animal Traction. The use of tractors for primary and secondary tillage operations in the Sierra is almost totally incompatible with proper soil management and conservation practices on steep slopes. Tractor plowing usually is performed up and down the slope because of the high probability of turning over when working across the slope. Thus, it is not surprising that tractors can cause serious soil erosion problems, far worse than with animal traction which is well adapted to contour farming operations. Also, tractors can cause extensive damage to conservation features such as ditches, terraces and waterways, while animal traction causes very little damage. The project will promote the use of oxen-drawn plows such as the "Arado Ecuandino" that is developed and marketed by a Swiss company.

Integrated Pest Management. IPM is an approach to the control of harmful insects and diseases which uses natural biological control measures and which largely excludes chemical pesticides. The

Project will train the extension staff in the principles and application of IPM who, in turn, can train farmers to use IPM effectively. Natural pest control extracts from plants will be used along with the release of beneficial predator insects.

Pesticide Education and Training. Most farmers who do use pesticides do not use them properly according to dosage, timing, and protection from exposure. Project staff will receive extensive training on pesticide technology, safety, and alternative approaches (such as IPM). In turn, they will provide pesticide education and training to farmers.

The Farm Management Plan. All farmers participating in the project will be required to write a farm management plan which they will prepare with the assistance of an extension agent. The plan will include soil conservation measures, crop rotations, tillage methods, crop varieties, compost making, fertilizer use and pest control approaches. The plan should maximize soil conservation throughout, while enhancing soil productivity and sustainability. The plan will serve as a model for soil conservation, agricultural production, and credit justification, and will be scaled to the individual farmer's economic and technical capabilities.

Agroforestry

The Sustainable Land Use Management Project for the Sierra will provide expertise in alternative agricultural systems such as agroforestry for soil erosion control and complementary production. Agroforesty systems can provide wood, fuel, forage, fiber, fruit, windbreaks, and mulch. All of this makes tree planting an attractive long-term investment. Specific applications of agroforestry on farms in the Sierra are as follows:

Perimeter Planting. This practice involves the planting of trees/shrubs around the perimeter (i.e., border) of fields to protect crops from erosion, sedimentation and runoff; exclude roaming animals; reduce evaporation of soil moisture; minimize mechanical injury to crops from wind; and delineate ownership. At a planting interval of 1 to 2 meters, a field of one hectare would require about 400 trees.

Most perimeter plantings use indigenous tree species such as alder (*Alnus* spp.) which are highly suited to soil and environmental conditions in the Sierra. Perimeter trees can be alternately inter-planted with brush species to form windbreaks. Thorny shrubs and stinging vines can also be interplanted with the trees in lieu of barbed wire or fencing to make the barrier animal proof.

Vegetative Barriers. Indigenous trees and shrubs planted along contour ditches, terraces and grass waterways can provide effective protection for these soil conservation structures. Nitrogen-fixing trees and shrubs are also highly beneficial because they enhance soil fertility.

Home Gardens. An important project activity will be to assist the farmers in obtaining and planting trees in home gardens that produce a variety of useful products for the household. Fruit trees will be particularly important for food and income generation. Both traditional and improved stock (i.e., grafted varieties and multi-purpose ornamentals) will be planted.

Silvi-Pastoral Planting. Trees planted in combination with pastures can enhance pasture production, provide shelter for animals, and supply forage during the dry season. Above 3000 meters elevation, pine/páramo combinations offer considerable potential; at lower elevations, alder/orchardgrass, alder/kikuyu grass, and alder/perennial ryegrass systems are recommended.

Fruit Culture. Fruit trees and shrubs will be planted in various systems on land that meets the essential criteria, i.e., fertile soil, protected from erosion, availability of irrigation, and favorable climate. Fruits that are popular in local markets will be emphasized, i.e., blackberry, apple, and peach.

Irrigation and On-Farm Water Management

The land use conservation management practices discussed earlier will definitely help the farmer to increase and sustain agricultural production without irrigation. However, if a farmer in the Sierra wishes to achieve the highest production level, he will need to develop the means of "harvesting" rainwater and storing it for supplementary irrigation.

A project goal is to attain a 45 percent increase in agricultural income from improved land management and soil conservation. However, when this is combined with efficient and timely

irrigation, net returns could increase by more than 200 percent. Irrigation will allow the production of certain crops during the dry season when demand far exceeds the supply, and prices are high.
A typical irrigation system in the Sierra consists of a crude rock inlet that conducts water into an earthen primary canal with an average flow of 40 liters/second. Such canals are from 2 to 7 kilometers in length and flow into a series of unlined secondary canals about 4 kilometers long. This type of system irrigates about 70 hectares. Other important features of these irrigation systems are briefly described.
Reservoirs and Earthen Dams. During the dry season, the collection and storage of water is problematic. Nevertheless, excess water is often available during the wet season and could be stored if facilities were available. This project will encourage provincial councils and other authorities to construct earthen dams at strategic locations above the agricultural lands to facili-tate gravity flow and distribution of water. Loans will be available for construction of small earthen and concrete-lined reservoirs which would be filled through rehabilitated canals.
Sprinkler Irrigation by Gravity. The project will promote gravity-fed sprinkler systems where lined canals are in place and where farmers have constructed small reservoirs. The purchase of plastic hose and sprinklers by farmers will be financed by credit arranged through the Project. Depending on the distance from the reservoir to the field and the number of sprinklers needed, costs should range from US $75 to $750 per hectare.
Improved Water Management. It is absolutely essential that farmers learn the basic principles of irrigation and water management, including the proper time, rate and frequency of application, so that the two biggest problems of irrigated agriculture can be avoided, i.e., over-irrigation and inadequate drainage. The Project will provide training in irrigation scheduling, water requirements of crops, soil-water relationships, water conservation, and water harvesting.

Summary and Conclusions

The Sustainable Land Use Management Project has been successful in convincing farmers to adopt improved methods of soil and water conservation and management, ecological agriculture, and agroforestry that has increased the production and sustainability of farming systems in the Sierra Region of Ecuador. For example, the average yields for seven principal crops increased 60 percent for conservation farmers compared with traditional (conventional) farmers.
The Project has shown that if small farmers are provided with proper training and support they can readily adopt and successfully implement improved conservation and production methods.
Strengthening community participation and cooperation has been emphasized at all levels of project decision-making and implementation. The ultimate goal is to increase the income of 9000 marginal farm families in 160 communities in eight Ecuadorian provinces by 1996 through the adoption of improved farming practices. Intermediate goals include complementary production activities, direct marketing from farmers to consumers, increased availability of credit from lending institutions, and increased support from the Ministry of Agriculture and Livestock.