Lund University International Master's Programme in Environmental Science

Could locoto be an alternative product to substitute coca growing? A Case Study of Chapare-Cochabamba-Bolivia

Master's Thesis
By

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Summary

This paper focuses on the possibility of introducing an alternative product in Chapare (Cochabamba, Bolivia) in order to substitute the coca growing. Coca growing has been bringing several problems such as damage of the environment and social instability; coca, however, is a very good source of income for many families, but the US government has been putting a lot of pressure on this region for the total eradication of coca. The crop that is proposed in this paper for replacing the coca is called locoto (*Capsicum pubescens*), which has been chosen because of its numerous applications in food technology and medicine. Chapare complies with its requirements in terms of topography, climate and soil. An analysis has been carried out from a sustainable development perspective. According to the results and particular conditions, locoto could be considered a competitor for the coca, whose benefits include: promoting social stability, less damage in the environment and relatively good incomes if the market is ensured. However, for the success of this project, correct tools of training and education must be applied with the Bolivian government support and US government assistance.

Keywords: Sustainable development, Chapare, coca, locoto.

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(Sustainable Development) recognizes that the problems of poverty and underdevelopment cannot be solved unless we have a new era of growth in which developing countries play a large role and reap large benefits. (WCED 1987:40)

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1. INTRODUCTION

Due to the expansion of drugs market in the whole world, many plants, which are the raw material for these drugs, have been causing problems related to the environment and to society from different angles. For example, coca growing in South America, especially in the Andean region[1], has been negatively affecting the environment through pesticide use, chemical dumping, deforestation, soil erosion, water pollution, a shift to mono-agriculture, biodiversity loss, and a potential loss of cultural eco-knowledge (TED 1997). In an attempt to assist the Andean region, and to lessen the international drug trade, the United States has attempted to set up economic alternatives with hopes of shifting the economies of Colombia, Peru and Bolivia away from this highly profitable market (TED 1997).

In the case of Bolivia, the coca plant has become the cash crop of the country, bringing million of dollars to the economy because coca is a source of the drug cocaine. It has also been the only provider of work for thousands of poor people who feel the government of the country is unable to provide their basic necessities. The production of coca in the countryside has become almost unstoppable, where hundreds of hectares of forest are being cut yearly for the cultivation of the plant (TED 1997). Also, toxic chemicals are being dumped into rivers and soils as a result of the manufacturing of cocaine (an illegal industry). The government, with assistance from the United States, is trying to restrict the expansion of coca, but this has had little success. One of the major challenges or problems that the Bolivian government faces is the fact that many people in Bolivia consider the coca growing a part of their culture and a necessity for their economic survival. Therefore, this study focuses on the possibilities of increasing sustainability by proposing an alternative crop that could substitute coca plantations in Chapare (Cochabamba, Bolivia).

1.1. Objectives

The general objective of this study is to investigate if by introducing a crop called "locoto"(*Capsicum pubescens*) as an alternative product to coca, the sustainability in Chapare (Cochabamba-Bolivia) could be increased. That is done for the purpose of; first, decreasing the damage of the environment and second, increase the social welfare in that region. Thus, the problem is analyzed from a sustainable development perspective. To comply with the general objective, this study embraces the following specific objectives:

- To assess the current coca impacts (social, economic and environmental).
- To investigate locoto market and analyze its problems.
- To assess the possible impacts of locoto (social, economic and environmental) after introduction in the Chapare region by simulating the transition process.
- To compare the effects coca vs. locoto from a sustainable development perspective.

1.2. Methodology

The methodology basically consists of collection of information about coca (*Erythroxylum coca lamark*) and locoto (*Capsicum pubescens*). This allows conclusions to be drawn regarding the suitability of locoto as a crop replacing coca plantations The analysis is carried out from a sustainable development perspective by taking into consideration some concepts from both land use-planning and environmental economics. To assess the social, economical and environmental impacts, three primary methods are here applied SIA (social impact assessment), ecological economics and EIA (environmental impact assessment) respectively. To compare different scenarios, system analysis is employed and a program is also developed to perform the simulation. A market study is also carried out to estimate the national and international demand of locoto. The data are introduced as part of the modeling and a multiple regression analysis is employed to find the relationship between price with respect to supply-demand, and biodiversity loss, which is estimated by using the species-area relationship (SAR). As a summary of the methodology, a flow chart is presented below:

[1] In this case the Andean Region is referring to Colombia, Peru and Bolivia

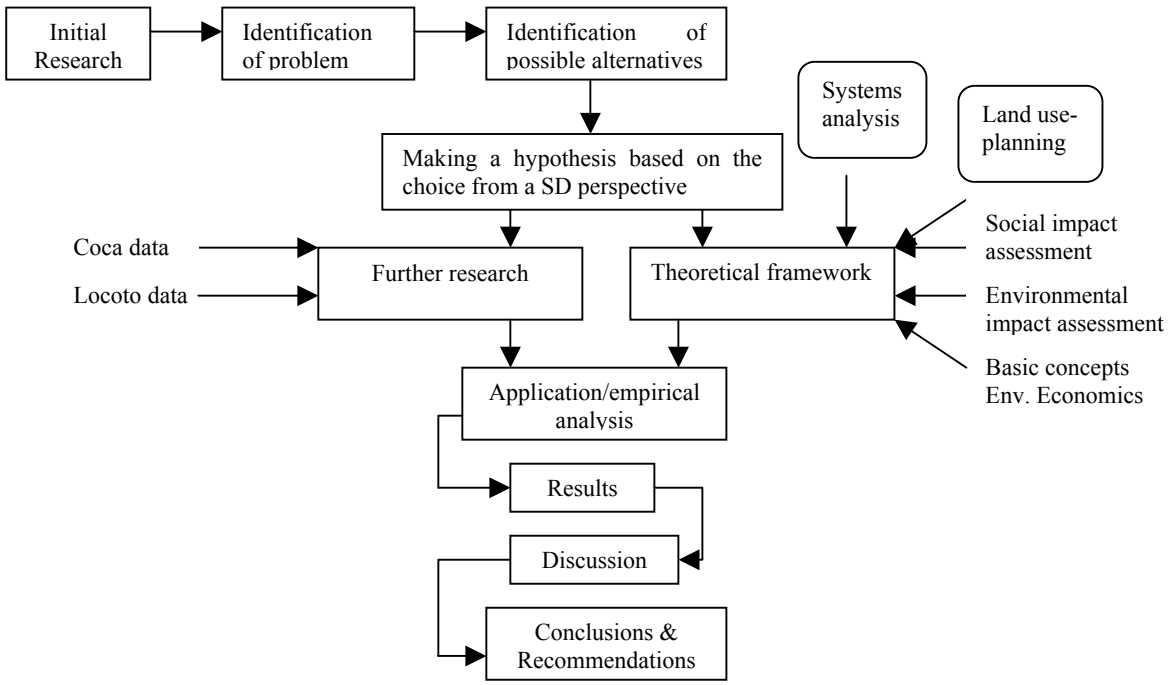

Figure 1: Methodology of study

It is important to make clear that the study is carried out using secondary data as visiting the area was not possible. So still, we believe that the herein presented information is reliable and does not have any particular bias.

1.3. Scope and limitations

1. This study only propose locoto as an alternative to substitute coca, it does not include other possible crops.
2. This study is not a complete life-cycle analysis (LCA) neither for coca for locoto.
3. Employment, income and GPD per capita are used as socio-economic indicators, which are in direct relation to social stability.
4. Biodiversity loss and deforestation are the main environmental indicators.
5. The study does not specify the areas where locoto could be grown inside Chapare, but includes a general review about the land's capability of that region.
6. This study does not include all the steps in land-use planning but it identifies the problems, the opportunities for change, it evaluates the land capability and analyzes environmental, economic and social aspects.
7. The impacts on the environment due to the transportation are not analyzed.

1.4. Description of the problem

Coca is grown in two places of Bolivia, in Yungas-La Paz and Chapare[2]-Cochabamba. As currently, the major problems are observed in Chapare, this study focuses upon this region.

The problem of coca is illustrated by a causal loop diagram as seen in figure 2. It started in the 1980's when many people began to migrate to Chapare as a consequence of higher rates of poverty in the

[2] Chapare is a province of Cochabamba and it has been characterized as the best place in Bolivia to grow coca.

rural area, which has provoked a change in demographic densities. For example, the rural upland population[3] has been moving to Chapare in response to the crisis of underdevelopment, primarily because of the importance of the area in producing coca leaf. Chapare provides employment and incomes to many people. Large numbers of poor rural people migrate to Chapare for varying lengths of time to work in the care of coca plants, and the harvesting of coca leaf and many more work carrying coca leaf from isolated farms to bulking and processing centers and in the initial stages of extracting the cocaine alkaloid from coca leaf (Painter 1998).

Nevertheless, those activities have been causing environmental problems such as pesticide use, chemical dumping, deforestation, soil erosion, water pollution, a shift to mono-agriculture, bio-diversity loss, and in some cases a loss of cultural eco-knowledge (TED 1997) and some other indirect global impacts (CO_2 emissions). As coca is source of employment and incomes, it contributes to keeping good levels of social stability. On the other hand, the US and Bolivian governments have been trying to stop those activities by implementing policies of eradication (TED 1997) for the reason that the cocaine is perceived as a threat to global society, by stimulating traffics, consumption and crime. This pressure has created social instability because the farmers have realized that coca is a secure business, so they don't accept the policies adopted by the Bolivian government (N.N 2001). For example, Armenta, Jelsma et al. (2002) argue, the coca eradication programs promoted by the U.S. and Andean governments, may serve to limit the production of coca, which will deprive poor people of their most profitable income. Also, the availability of cocaine is hurting the society with the growing number of addicts in countries, where cocaine gets good markets. Americans identify coca as the raw material of a deadly drug, which feeds crime and kills young people (Americas 1998).

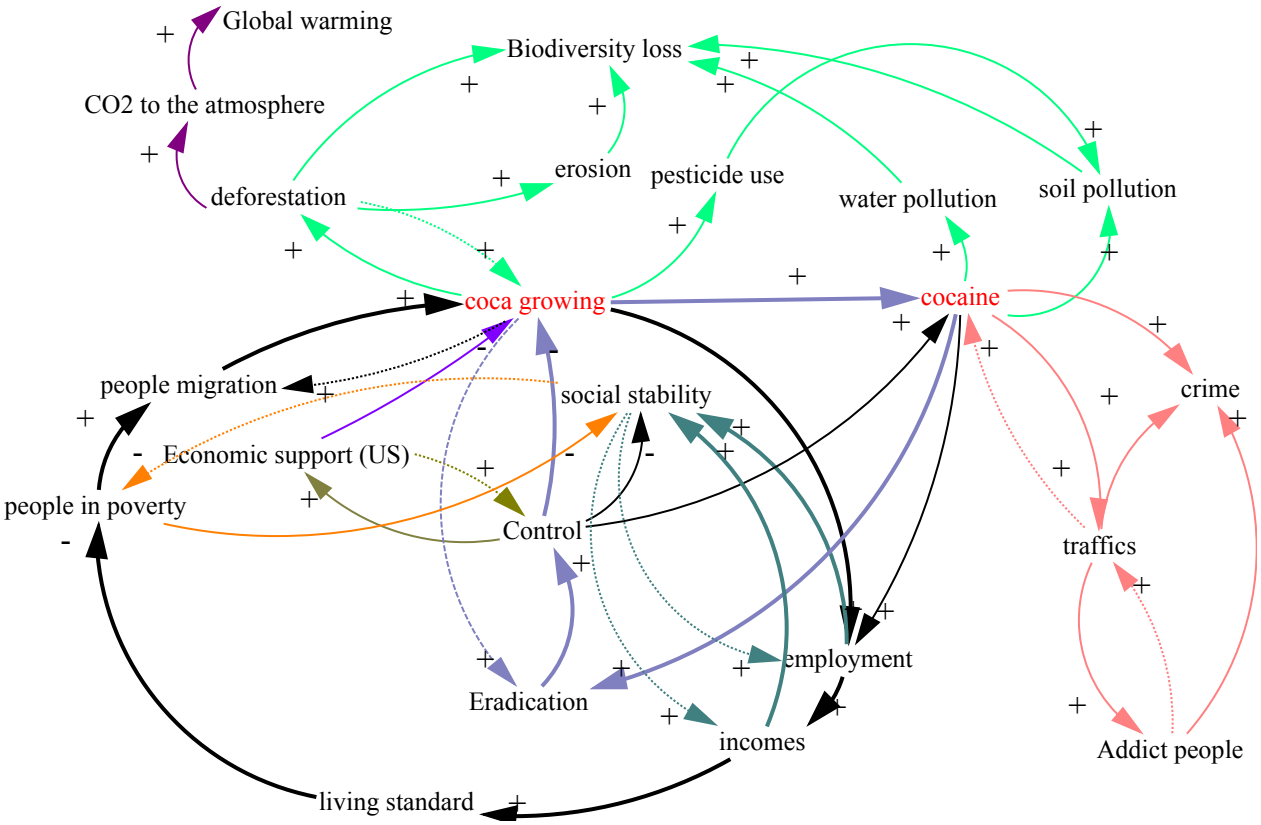

Figure 2: The Problem (current situation)

[3] People that live in provinces where the altitude is 2000-2500 meters above the sea level.

1.5. Deduction of the main causes of the problem

In summary, it can be affirmed that the main driving force for the coca growing in Chapare is poverty, which provokes more social instability because of the control that comes from the US and Bolivian governments when people want to plant coca. As mentioned, coca growing and the industry of cocaine bring several environmental problems but is a good source of income and employment for the people by increasing their living standard. In addition, coca is also grown because is also part of the indigenous culture.

Finally, the Bolivian government with the US assistance has been trying to substitute the coca with other alternative products, but at present they have not been successful with their objectives, because coca growing has had more advantages.

1.6. Discussion of remedies and hypothesis

As mentioned before, coca has negative effects on the environment including pesticide use, chemical dumping, deforestation, soil erosion, water pollution, a shift to mono-agriculture, bio-diversity loss, and in some cases a loss of cultural eco-knowledge and other problems related to the society.

As coca is illegal in Chapare, it is not possible to apply any land use planning or sustainable agriculture plan to improve the sustainability, neither to make improvements related to processing of coca in new products. It is unacceptable for the Bolivian and the US governments.

Therefore, the possible solution for this problem might be: "To substitute coca by other crop, which would bring more benefits to the society from social, environmental and economic perspectives. The hypothesis of this study is that 'locoto' (*Capsicum pubescens*) could be an alternative even though; there could appear more options. In this case, we believed that due to its potential benefits in terms of food and medicinal applications, locoto could be traded in a big market. The causal loop diagram (See figure 3) shows the interactions, once locoto could successfully be introduced in Chapare.

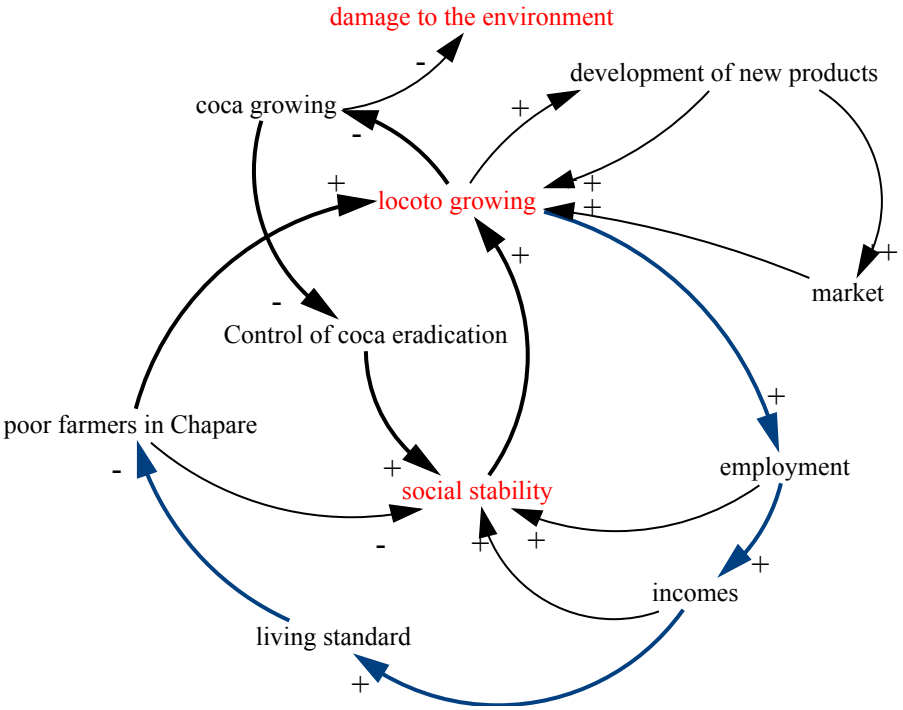

Figure 3: Future situation, once locoto has been introduced

To test if the hypothesis is logically viable; this study will answer the following questions:

- Why has locoto been chosen?

- Does locoto have a potential market to compete with coca?
- Could locoto be grown and introduced in Chapare?
  If so: What would be the benefits for the environment?
  What would be the benefits for the society?
- Pesticide use: is it possible to reduce the pesticide use by growing locoto instead of coca?
- Chemical dumping: will the locoto processing effects on the environment be less harmful than cocaine making?
- Deforestation: could deforestation be better controlled if people would grow locoto instead of coca? If so, erosion would also be avoided.
- Water and soil pollution: What would be the effects of locoto growing-processing on the water and soil? Could they be negatively affected?
- Monoculture: Could locoto growing promote monoculture?
- Could locoto growing have negative effects on the bio-diversity?
- Could locoto growing avoid the loss of cultural eco-knowledge?
- Could locoto growing generate incomes and employment to the people?
- Is locoto a good alternative to coca?

2. THEORETICAL FRAMEWORK

2.1. Sustainable development and sustainability

There are several definitions about sustainable development, and the concept normally depends on the type of approach. In general, the concept of sustainable development involves three major points of view: economic, social and ecological (See Figure 1).

The economic approach is referred to as the maximum flow of income that could be generated while at least maintaining the stock of assets or capital, which yield these benefits. The social concept of sustainability is people-oriented, and looks for maintaining the stability of social and cultural systems, including the reduction of destructive conflicts. The ecological view of sustainable development focuses on the stability of biological and physical systems; protection and biological diversity is a key aspect. (Munasinghe 1992)

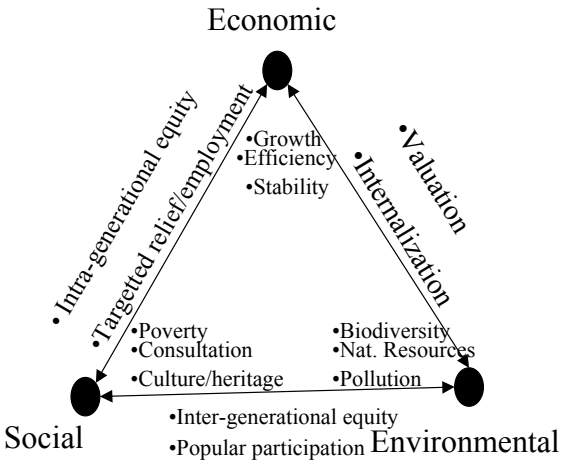

Figure 4: Factors of sustainable development
(Munasinghe 1992)

Other concept of sustainable development can be defined as maintenance and sustainable utilization of the functions (goods and services) provided by natural ecosystems and biospheric processes; conversely, in a situation of unsustainability, where the limits of the biosphere's carrying capacity are exceeded, not all of the environmental functions can be fully fulfilled anymore (Vellinga and et al 1995); however, the most

understandable concept is given by WCED (1987), which establishes that development must meet the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987).

2.1.1. Symptoms of Unsustainability and Sustainability

Some of the important symptoms of unsustainability include these not usually mutually exclusive or independent symptoms (Rao 1999): Climate change; Ozone depletion; Atmospheric acidification; Toxic pollution; Biological species extinction; Deforestation; Land degradation and desertification; Depletion of non-renewable resources like fossil fuels and minerals; and Urban air pollution and soil wastes.

Economic sustainability needs social sustainability for helping organizations to empower self-control and self-policing in peoples management of natural resources. Social sustainability will be achieved only by strong and systematic community participation or civil society. Social cohesion, cultural identify, institutions, love, commonly accepted standards of honesty, laws, discipline, etc., constitute the part of social capital that is least subject to measurement, but probably most important for social sustainability. Although environmental sustainability is needed by humans and originated because of social concerns, environmental sustainability itself seeks to improve human welfare by protecting the sources of raw materials used for human needs and ensuring that the sinks for human wastes are not exceeded, in order to prevent harm to humans. (Van Dieren 1995)

2.1.2. Sustainability Indicators

According to Bossel (1996) the indicators have three main functions: 1) Simplification: They supply information on the functioning of systems which are too complex to be assessed or measured directly; 2) Quantification; and 3) Communication. Indicators show information in quantitative form and allow the description of complex social, political, public or natural processes (Habert and Schandl 1999).

2.2. Environmental and Social impact assessment

It is difficult to provide a clear definition of impact assessment; however, it can be defined as the process of identifying the future consequences of a current or proposed actions (Becker 2001). In terms of *environmental impact assessment (EIA)*, it can be described as a process for identifying the likely consequences for the bio-geophysical environment and for man's health and welfare of implementing particular activities, EIA is a process having the ultimate objective of providing decision makers with and indication of the likely consequences of their actions (Wathern 1995). EIA procedure should begin early in the planning and evaluation of projects and programs and continue throughout the life of the activity as a management operation (James 1994). On the other hand, *social impact assessment (SIA)* is defined as "the process of identifying the future consequences of a current or proposed action which are related to individuals, organizations and social macro-systems. After analyzing the past, we have to explore the future. In the preliminary phase of a social impact assessment project, future analysis is restricted to a critical inventory of trends. (Becker 2001)

2.3. Systems analysis

System thinking is known as principles of organization, theory of self-organization. Holistic perspective is also known as "systemic" and the way of thinking it involves "system thinking". By shifting the attention towards an interdisciplinary approach, system thinking inevitably becomes a part of analyzing problems. It enables one to understand causes and effects of problem and how different aspects of society and the natural environment interrelate through feedback loops. (Haraldsson 2001)

2.4. Land-Use Planning

The driving force in planning is the necessity for change, the need for improved management or the need for a quite different pattern of land use dictated by changing circumstances (FAO 1993c).

As Chapare needs an urgent change of land use due to its high instability, the objectives of the land-use-planning seem to support even more what sustainable development looks for; therefore, it is crucial that the land-use-planning be taken into account for the analysis as a complementary part of this study.

2.5. Cost-Benefit Analysis

Cost-benefit analysis (CBA) is a widely practiced technique of project appraisal. It is used in circumstances where it is felt that important components of either the real costs or the real benefits of a project would not be adequately represented by market prices. (Perman, Yue Ma et al. 1996a)

2.6. Market failures

1) *Externalities,* an economic activity may bring benefits or losses to others, 2) *Public goods*, some goods cannot be charged for in the market place. For example, everyone receives protection from national defense. If defense is provided for one person it automatically becomes available to everyone. People cannot be excluded from benefits if they do not pay, 3) *Imperfect information*, the market requires that consumers and producers have all the information they need to arrive at rational decisions, 4) *Rent seeking*, the market economy makes possible many unproductive activities which yield 'rents', that is earnings over and above those which are justified by competition. (Ingham 1995), 5) *Government intervention*, firstly many resources are not traded through competitive market structures, in which property rights[4] are clearly established. Efficiency gains may be obtained if government can create and maintain appropriate institutional arrangements for market and property rights (Perman, Yue Ma et al. 1996b).

3. THE COCA PLANT, ANALYSIS OF ITS IMPACTS

3.1. Characteristics of the coca plant and its uses

Erythroxylum coca Lamark is a tropical shrub of the order **Geraniales** and the family ***Erythroxylaceae***. Coca has a nearly 4,000 years tradition in South America, and it is an important element of Andean culture (Musto 1998). Traditionally, community and political solidarity were maintained through production and exchange between the highland and lowland areas of the Andean region. Coca has been used to relieve fatigue and hunger and also for medicinal and health purposes. However, due to the relatively recent high-profit motive, a new tradition of coca production as a cash crop has emerged (Musto 1998). Andean peasants and miners traditionally have consumed coca by sucking wads of leaves, keeping them in their cheeks for hours at a time. Often the coca is combined with chalk or ash, which helps dissolve the alkaloids into saliva (Krol 1998). Coca chewing reduces hunger pain, and workers say the leaves give them strength and endurance to work for many hours at high altitudes, often in extreme cold. Perhaps the most ancient use of coca in South America is its employment in various spiritualist practices and religious rituals (Krol 1998; Musto 1998). Another use is the ingestion of herbal teas, which is common in many countries. In South America, herbal teas frequently consist of pure coca leaf or coca leaf mixed with herbs. The plant material may be loose or bagged for individual servings (Jenkins, LLosa et al. 1996). The coca leaf has also been industrialized into more than 30 products, including shampoo, toothpaste and medicines, but exports are largely prohibited (Culture 1999). Ironically, the only legal importer from the US is a company called Stephan, which imports about 175 000 Kg/year to make a kind of anesthesia and prepare an ingredient to be part in the end flavor of Coca Cola (Rojas 2002). In general, coca leaves could have very good and interesting applications; however, the most efficient way to get good incomes, is from making cocaine.

[4] According to Hanley and Jason (1999), property rights are vital to a successful market system. The system, in which property rights are involved, represents a set of entitlements, which define the owner's privileges and obligations for using resources.Hanley, N., J. Shogren, et al. (1999). Introduction to Environmental Economics.

3.2. Environmental impacts

A study carried out by CEEDI-LIDEMA[5] argue that coca in itself is not generally regarded as harmful to the land or to the environment. Coca effects on the environment seem average or even benign, especially in comparison with other crops that are grown in the region. For example in Sud Yungas[6], the depletion of soil nutrients because of the cocas was quantified by being demonstrated that coca annually removes less nitrogen, phosphorus and potassium than maize, an annual crop. However it is seen that, producers expand coca fields through deforestation and clearing out other plant species, which leads to biodiversity loss as, due to these actions, plants and trees, which are essential for preventing soil erosion, are lost (TED 1997). In accordance with Salm and Liberman (1997), and based on an analysis of satellite images, the rate of deforestation of the tropics of the Department of Cochabamba between 1985 and 1995 totaled 2600 square kilometers, corresponding to 23% because of coca plantations. It should be pointed out that the high migration by many people from other regions of the country to Chapare, has led to a quicker settlement and additional deforestation as a result. In regards to the use of chemicals for the control of plagues and pests, it is normally required biocides. The application of biocides (in this case herbicides or pesticides) is always harmful to the environment, whether to a greater or lesser degree. This task is frequently performed by the farmers who have more economical stability and access to the technology. (Salm and Liberman 1997)

Due to the high demand of coca, the agricultural sector is shifting to single crop production, or monoculture; thus, the potential for eco-knowledge is being lost in the region (TED 1997). The emphasis on coca production may cause the loss of specialized, sustainable agricultural techniques (Americas 1998).

3.2.1. Cocaine and the environment

The cocaine production is a process carried out in three steps: first, obtaining of coca paste from coca leaves; second, obtaining of cocaine basic paste and finally, the obtaining of cocaine hydrochloride. The conversion process of coca into cocaine causes dumping of precursor chemicals in streams and rivers. This contaminates waters and soils, and subsequently invokes human health risks and loss of biodiversity as well. Processing coca leaves into the paste that is sold to drug traffickers requires outdoor laboratories where the leaves are mixed with different solvents. After the coca paste is made, the waste is dumped into the nearest river. (TED 1997)

3.2.2. Toxic chemicals used in manufacturing

In the process of purifying the raw coca into cocaine, the following chemicals are mainly required: a) *Acids:* Sulfuric acid, hydrochloric acid or nitric acid. b) *Solvent:* Ethyl and sulfuric ether, acetone, toluene, methyl- ethyl-ketone or/and kerosene. c) *Bases:* Sodium and calcium carbonate, sodium and potassium hydroxide or/and ammonia. d) *Oxidizer.* Potassium permanganate. Many of these chemicals are toxic, and some can also cause explosions and fire (ether and acetone). They thus represent an additional threat to health. When these toxics are discarded, they are absorbed and ingested. They have toxic effects on men and animals, destroying fertile land, poisoning food crops and fish, and polluting water used for irrigation and drinking. Although it is difficult to approximate the quantities of chemicals used in cocaine industry; a study carried out by Dourojeanni (1992) estimated that the process requires 0.15 L of kerosene, 0.083 L of sulfuric acid (H_2SO_4), 0.0417 Kg of calcium carbonate ($CaCO_3$), 0.167 g of potassium permanganate ($KMnO_4$) and 0.0417 Kg of toilet paper for each Kg of coca leaf. Regarding to the refining, it is approximately required 0.0917 L of acetone and 0.0917 L of toluene or other benzenic compound for each kilogram of basic paste produced. On the basis of an average production of 2 700 kilograms per hectare per year of dried coca leaf, table 1 has been obtained.

[5] CEEDI-LIDEMA (Liga De Defensa De Medio Ambiente), "Evaluación Ecologica de los Cultivos De Coca"
[6] Sud Yungas is other region where coca is also grown. It is located in La Paz.

Table 1: Amount of chemicals needed to process a hectare of coca

Coca (Kg)	H_2SO_4 (L)	$CaCO_3$ (Kg)	Kerosene (L)	$KMnO_4$ (G)	Paper (Kg)
2 700	225	112.5	405	450	112.5

It is also known that the yield of cocaine/coca is about 0.25% (PDAR 2002); hence, the 2700 Kg of coca leaf are equal to 6.75 Kg of cocaine/hectare, which also implies that 74.25 L of acetone and a benzenic compound are needed to process that amount.

Table 2: Toxicity and effects of the most employed compounds in the cocaine processing

Compound	Acute Toxicity	Chronic Toxicity	Action on Animals	Action on Plants
Calcium Carbonate	A severe eye and moderate skin irritant, considered being of low toxicity. It can be irritating to the respiratory tract. Symptoms include sneezing and slight nose irritation. Ingestion of very large quantities may result in intestinal obstruction and constipation	There are no reported chronic health effects for pure calcium carbonate. If there is more than 1% crystalline silica (quartz) present in the calcium carbonate, exposure to air bone concentrations may increase the risk of developing silicosis, a disabling lung disease	It was applied to the surface of rabbit eyes and no negative effects were noted. Rats were exposed to high airborne concentrations for 90 min. With no pathologic changes noted	No data
Potassium Permanganate	Eyes and Skin: May cause irritation. Ingestion: May cause gastrointestinal discomfort. Inhalatation: May cause irritation to respiratory tract. Others: Contact with combustible material may cause fire.	There is no data for chronic toxicity , but in conditions of overexposure may cause perforated septum, severe irritation or burns on eyes and skin. The target organs are respiratory system, central nervous system, blood, and kidneys.	Oral rat LD50[7]: 1090 mg/Kg; subcutaneous mouse LD50: 500 mg/Kg	Very strong oxidizing agent
Kerosene	Eyes and Skin: May cause irritation. Ingestion: May cause gastrointestinal discomfort. Inhalatation: May cause irritation to respiratory tract.	There is no data for chronic toxicity .The target organs are respiratory system, eyes skin.	Oral man TDLo[8]: 3570 mg/Kg;	No data
Sulfuric acid	Eyes and Skin: May cause irritation. Ingestion: May cause gastrointestinal discomfort. Inhalatation: May cause irritation to respiratory tract.		Major environmental impacts include fish kills, fish disease, destruction of habitats and loss of aquatic biodiversity. Severe acidification on the soil and rivers. Disturbance of soil as a natural accumulator of carbon. Strong oxidizing agent. Contamination of flora and fauna on the site because of the reaction of sulfuric acid with other minerals that are present in the soil.	
Benzenic compounds	They primarily affect the central nervous system & the hematopoietic system, at high concentrations it rapidly causes CNS depression, which can lead to death, all three blood cell lines may be adversely affected.	They can cause hematologic toxicity such as anemia, leukemia, thrombocytopenia or pancytopenia after chronic exposure.	Benzenic compounds are hazardous air and water pollutants. Its occurrence in the rivers can deplete the biodiversity and also contaminated the groundwater by infiltration.	

Source: (Immig 1998); (CBSC 1998); (USDA 2001); (CBSC 1998); (Hicks, Bowman et al. 1999); (Lovley 2000); (Phelps and Young 1999)

[7] LD50 is the amount of a material, given all at once, which causes the death of 50% of a group of test animals. (Lethal dose)
[8] It means Toxic Dose Low and gives the lowest dose causing a toxic effect.

It is seen that the most harmful compounds for the environment and the human health are sulfuric acid, the benzenic compounds and manganese permanganate; on the other hand, the less dangerous is mainly calcium carbonate.

With the purpose of identifying and assessing the impacts of coca in the environment, table 3 illustrates the impacts related to the two main activities in which coca is involved. To make this, as recommended by Gupta and Asher (1998), the environment is analyzed at various levels: local, national and global, which have to be hierarchically linked.

Table 3: Impacts of coca in the environment

	LOCAL	NATIONAL	GLOBAL	IMPACT
COCA GROWING	III	II	I	Deforestation
	III	III	II	Loss of biodiversity
	III	II	-	Erosion
	III	II	I	CO_2 Emissions
	I	I	I	Global Warming
	II	I	-	Soil pollution
COCAINE MAKING	I	-	-	Deforestation
	III	II	-	Soil pollution
	III	II	-	Water pollution
	III	II	I	Loss of biodiversity
	II	I	-	Human health risks

The scale for assessing the impacts is represented by the Romanic numbers I, II, III. The highest impact is designated by III and the lowest by I. So, the more important local impacts in terms of coca growing are deforestation, loss of biodiversity and erosion but for national and global levels is essentially loss of biodiversity. Regarding to the impacts associated to the cocaine making the most harmful ones are soil pollution, water pollution and loss of biodiversity. On the other hand, in national and global levels, loss of biodiversity again appears to be of major importance. As coca cultivation has been leading to increased deforestation, it brings about national and global impacts such as increased CO_2 emissions and contribution to the global warming; however, these are considered as not too high in comparison to the global rates. As seen, there are also some human health risks related to the cocaine making; first, the process results dangerous because the needed solvents are toxic and some of them are cancerigenic agents, so to be in direct contact with them is risky and second other indirect ways of exposure are via water and soil contamination.

3.3. Economic impacts

An economic analysis carried out by Rojas (2002) regarding to the coca production in relation to GDP for the period 1980 to 1999 shows that this activity starts to be stronger since 1983. The economic percentage increment per year in average up to 1990 was 13%; in that year, the coca represented 1.3% of the Bolivian GDP. However, as a consequence of implementation of Law 1008[9], the crescent economy tendency due to the coca activity started to change. Even more, this change was accentuated since 1997, the year in which Dignity Plan[10] was put into action. The economic percentage decrement per year up to 1999 was 30% and it represented 0.37% of the GDP. As seen in figure 5, coca has relatively been an important element in the country's economy. However, during the last years, the tendency has been shifting towards decreased contribution to the GDP.

[9] In 1988, Law 1008 was promulgated to restrict regions for reducing coca growing. It regulates the production, distribution and commercialization of the coca. It also includes the control on the importation, distribution and sales of chemical substances that can be used in the chemical process to obtain cocaine. It establishes penalties and procedures for any illegal activity that might be linked with the narco-traffics when those substances are involved.

[10] Dignity plan was known as the program to eradicate coca, including Chapare and Yungas (in Yungas is just allowed to produce 11 000 hectares of coca)

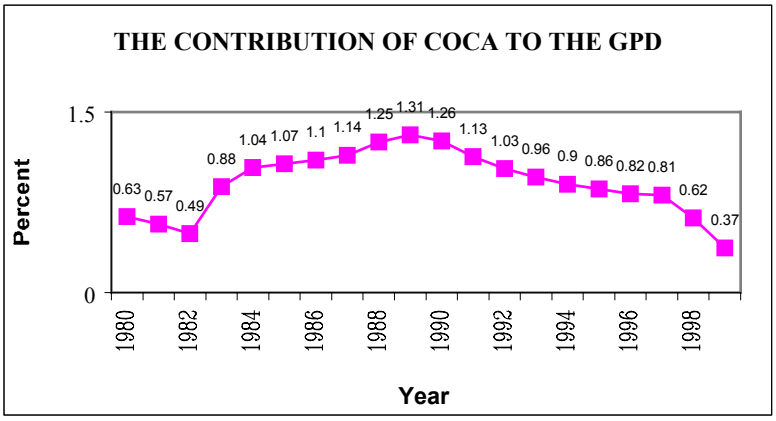

Figure 5: Importance of the coca economy in relation to the GPD 1980-1999
Source: (Rojas 2002: 17)

This reflects that the coca trade has also had a big importance for the peasants and for the people in general. It is not a coincidence that many people have been complaining about the hard situation for not having dollars[11]. Although the dollar is not the official currency in Bolivia, most of the transactions are carried out by using this international currency.

3.3.1. Evolution of the coca price

The normal coca price in the 1980's was relatively high and stable (Rojas 2002). In 1988, the price started to drop because of the excessive coca production, even though the policy of eradication began in the same year. This was some sort of reaction performed by the peasants in response to the Law 1008. For example, in 1990, the average price was established at 23.6 US$ per 100 pounds of coca by being the lowest price in the coca history. Since 1991, the coca price tended to increase with small fluctuations. In 1998, however, as result of implementation of Dignity Plan, a substantial increment was seen. In this sense, in 2000, the highest coca price was observed, due to there was more demand than production. The next figure clarifies the trend about coca price:

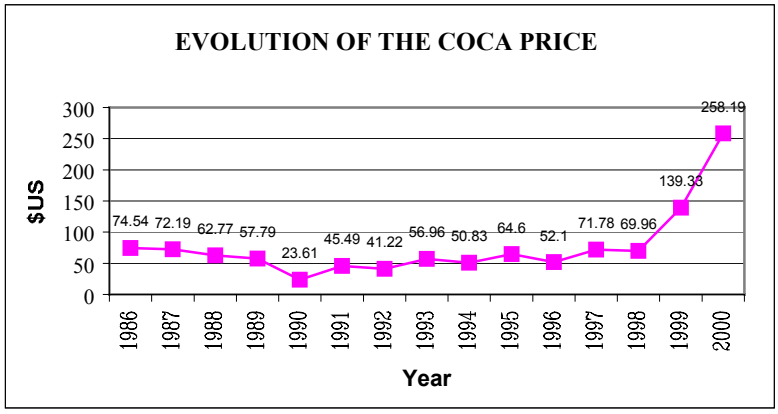

Figure 6: Evolution of the annual average coca price (given in $US/100 pounds).
Source: (Rojas 2002: 25)

In conclusion, figure 6 shows how the price is dependent on the demand, as there must be the same demand than before or there is probably much more, the coca production is not enough to supply the entire market.

[11] Most of people prefer to save money in dollars instead of Bolivianos (Bolivian currency) because the inflation is much less. The same often occurs when people want to make business.

3.3.2. Alternative development

There have been several crops that were encouraged to be grown in Chapare, such as banana, cassava, orange, rice, mandarin, palm, black pepper, maracuyá and others (Morales 1999). Among them, the more important ones are orange and banana, which can be seen in the figure 7:

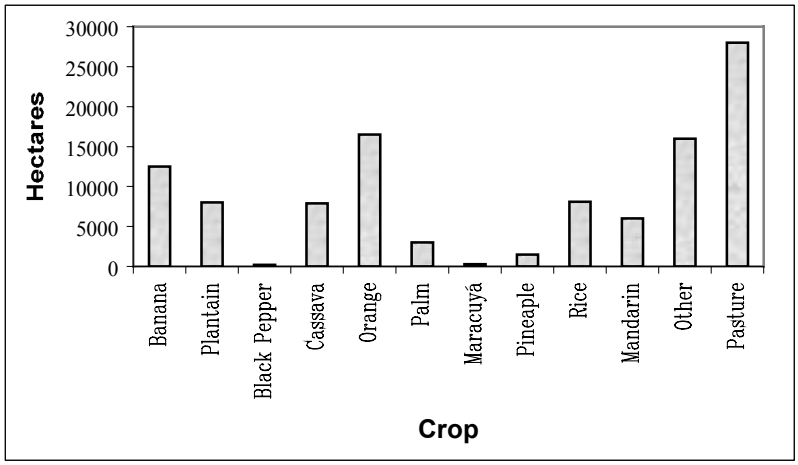

Figure 7: Cultivated Area in the Chapare Region – 1999
Source: (Rojas 2002: 35)

It was established that several of these crops exhibit higher levels of profitability in comparison with coca, under certain circumstances[12]. For example, the conditions of the highways should be good; but they are normally in bad conditions. Besides, due to the different obstructions in the highways organized by the coca growers[13] a lot of difficulties and conflicts are provoked, increasing the difficulties associated with the trade of these products. That is a crucial point, because most of the crops are perishable in a short period of time (Rojas 2002). In addition, and related to the previous point, it is a fact that the coca can be conserved longer, for this reason many farmers prefer to cultivate it. On the other hand, and probably more importantly, is that the alternative crops have not had important markets outside of the country, which avoids an increase in the growing of alternative crops. Anyway, until now, there has not been found other crop able to compete with coca from an economical perspective (TNI 2002). In 1998, it has been estimated that 1% of the total agricultural area was occupied by coca plantations (Rojas 2002).

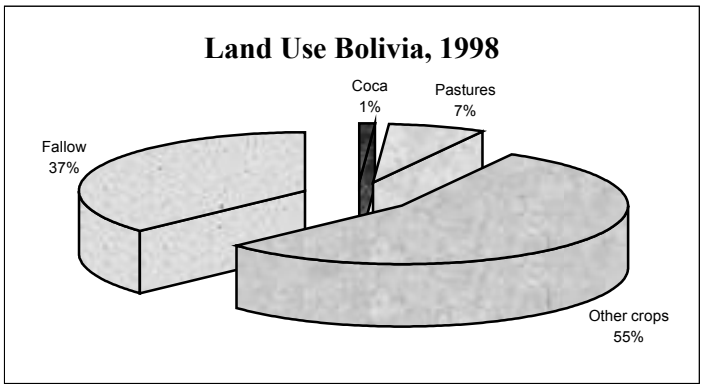

Figure 8: Agricultural land use, 1998
Source: (Rojas 2002:21)

[12] The author argues that coca gets lower return to the investment than other crops and there are other driving forces for growing it, that is cocaine making, which increases the incomes even more. In the meantime, he supports that affirmation by mentioning a newspaper reference "65 factories of cocaine and 85 wells of processing were destroyed" (El Diario, December 30th, 2001).
[13] Coca growers have been carrying out marches and obstructions on the highways as sign of claiming against to the coca eradication since 2000.

Figure 9 shows the importance that coca has, even though the eradication program has been implemented with some achievements, it is currently seen that the coca plantations are being increased again. To confirm this trend, figure 9 illustrates the current situation where the cultivated area reached 7510 hectares in 2000; however, by 2001 it was increased to almost 9000 hectares by showing that the dignity plan was deferred due to the social instability.

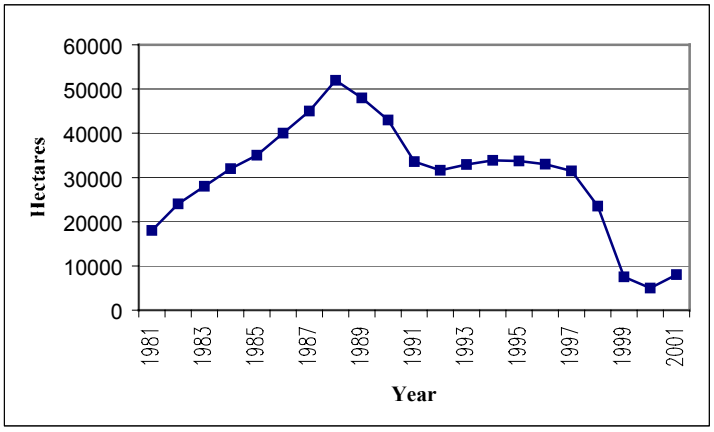

Figure 9: Cultivated area of coca-Chapare
Data from: (Rojas 2002); (PDAR 2002)

In conclusion, the coca impact on Bolivia's economy appears to be important and especially for the farmers' economy, which relies on it much more than any other choice.

3.4. Social impacts

3.4.1 Migration

Migration is a response to the impoverishment and land degradation afflicting such upland areas as Campero and Mizque provinces[14]. Labor scarcity provoked by migration perpetuates the mutually reinforcing relationship between the two processes. The most frequent rural destination for migrants from much of central Bolivia during the 1980's and 1990's has been Chapare (Blanes 1994).

A private Bolivian social science research institution interviewed 194 Chapare farmers regarding their settlement experiences and the agricultural production systems. Of the 194 farmers interviewed, 176 responded to questions about why they had moved to the Chapare. Of these, 143 (83%), said they had migrated because of a lack of economic opportunity, in the form of inadequate land or income, at home. Of the 194 farmers interviewed, 187 provided information on their landholdings in their communities of origin. Of these 187, 111 (59%) reported that they did not own land in their home communities, meaning that they had been landless before they migrated, or that they had given up their claims to land in their home communities after settling in Chapare. Of the remaining 76 farmers who continued to own land in their home communities, 48 (64%), of them owned one hectare or less, while 92% owned three hectares of land or less. (Bedoya and Painter 1991)

By the end of 1981, there were 247 immigrant settlements in Chapare, whose settler population was approximately 83 525 (Flores and Blanes 1984). By 1987, this population had more than doubled again, to between 196 000 and 234 000 (Durana, Anderson et al. 1987).

Chapare farms are small compared to those in lowland settlement areas elsewhere in Bolivia, with the mean size between 9 and 12 hectares (Painter 1994). The mean area of settlers' landholdings in Chapare is about 10 hectares, with between 1.25 and 4 hectares under cultivation. Coca leaf generally accounts for between 0.5 and 1.6 hectares of the area under cultivation. Even more important than the mean figures, however, is the unequal land distribution (Painter 1998). Figure 10 shows the distribution of land among the

[14] Cochabamba is divided into 16 provinces and Campero and Mizque are located in the South of Chapare.

farmers, information that is based on a database from DIRECO[15], divides the farmer population according to residence in one of the Chapare's seven micro-regions[16].

In fact, this migration process results in a kind of 'tragedy of the commons'[17], because many people migrate to Chapare to exploit the soil and its resources indiscriminately.

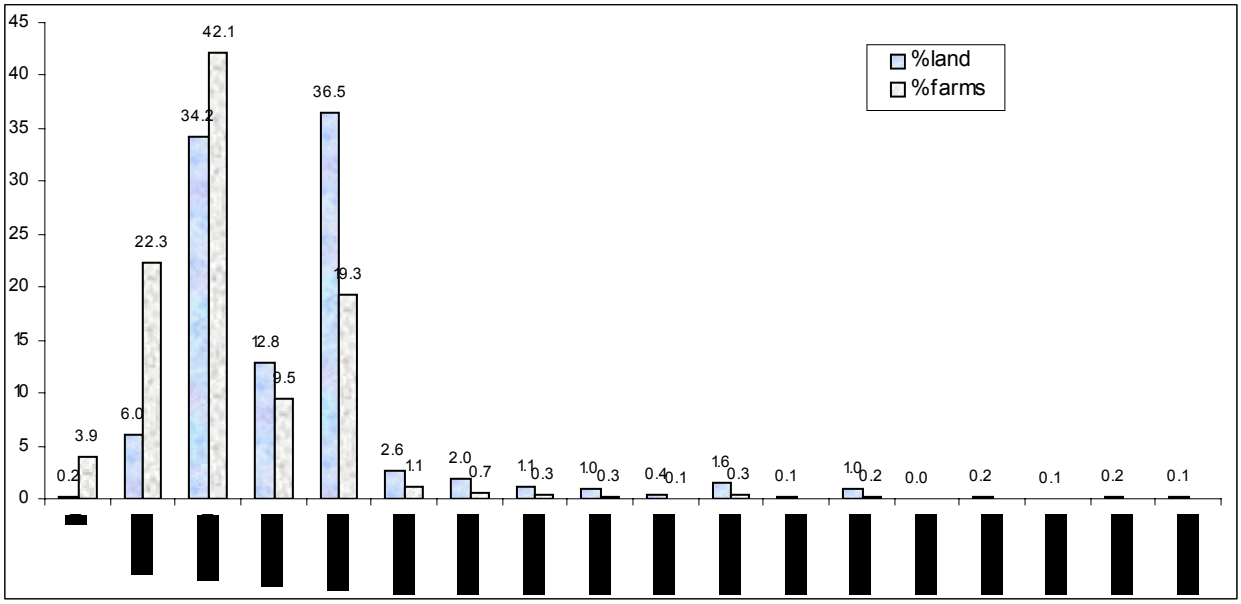

Figure 10: Distribution of % land and % the farms per range of area

As observed, only 19.3 % percent of the farmers own 36.5% of the total land, which makes difference respect to 42.1% of the people who own just 34.1% of the total land; other relevant data from this figure is that 6.0% of the people own lots with land area smaller than 5 hectares, which implies that the most of the farmers own large areas to grow different crops.

One result of the large number of small landholdings, coupled with the variation in agricultural potential of Chapare land, is that the upland pattern of families relying heavily on off-farm income is reproduced in the Chapare. Various accounts of how families organize migration between upland and lowland areas exist. Carafa, Arellano et al. (1987) report that it is common for husbands and older sons to work family land in the Chapare while wives and daughters remain in upland areas, caring for small children, farming—if the family maintains land in the upland area, or attending to some commercial activity. Various data suggest that off-farm income, most of which is generated by women, is very important for Chapare settlers (Carafa, Arellano et al. 1987).

3.4.2. Wage labor

Coca is the single most important crop, as one would expect, since it is crop for which there has been the most reliable market over the last decade, but coca is by no means the only crop cultivated by Chapare farmers. Hired labor is used more in coca production than it is for crops in general, reflecting coca leaf's importance as farmers most reliable source of cash. Table 4 shows that the smaller coca producers with one hectare or less, hire workers to supplement family labor resources more frequently than do farmers with larger areas of coca. Coca leaf is the most difficult crop to accommodate within a production system based

[15] This information is found at Painter (1998: 153)

[16] Chapare has been divided into seven microregions by the Instituto Boliviano de Tecnologia Agropecuaria (IBTA), the microregions vary considerably with respect to their potential for supporting agriculture, with Microregions I and III generally regarded as having the greatest agricultural potential.

[17] The case of a communal pastures area where all individuals are free to graze their livestock. The 'tragedy' arises because these 'commons' were typically heavily over grazed.

on family labor, because its labor requirements are very high in comparison to other crops. It is also clear that coca leaf is relatively more important for smaller farmers than for larger ones, because of the relatively larger investment that small farmers make to establish a coca plantation. The most important labor requirements are associated with the heavy amount of weeding required to protect young coca plants until they are big enough to shade the ground. One hectare of coca requires about 120 person/days in weeding. (Painter 1998)

Table 4: Type of Labor Force Utilized According to Land Area in Coca Leaf Cultivation

	Only family labor force		Family labor plus Hired labor	
Number of Coca Hectares	No. Farms	%	No. Farms	%
0.1 to 0.5	17	47.2	19	52.8
0.51 to 1.0	10	38.5	16	61.5
1.01 to 2.0	19	55.9	15	44.1
2.01+	1	5.9	16	94.1
Total	47	41.6	66	58.4

Source: Data from CERES interviews. (Painter 1998:156)

3.4.3. Coca eradication

There have been several attempts to stop coca growing and cocaine production based on an eradication program, for example, implementation of military control in the Chapare region and destruction of many coca plantations by using different ways. In Bolivia, data demonstrating the amount of cocaine captured by anti-drug forces shows a considerable increase since the passage of Law 1008, but reflects the increase in drug production as much as the increase in police efforts (Laserna, Vargas et al. 1995). In the structure established under Law 1008, the courts are no longer given the right of balancing civil liberties against police needs to conduct investigations. All rights are given to prosecutors and the police and none to the accused (Farthing 1997).

According to AIN (1993) there have been several human rights violations; the Bolivian anti-drug forces have beat up, extorted, stolen and occasionally tortured people. The use of lethal violence by UMOPAR[18], on the other hand, has been very rare. Their cars and trucks have no license plates, their uniforms bear no names and during operations their faces are often painted to avoid identification. AIN research discovered cases where victims have been shot, submerged under water, beaten while suspended in the air, burned with cigarettes, etc. Many of these violations have occurred during interrogation, but they have also been committed against people neither accused of any crime nor arrested. The actions of the UMOPAR in the Chapare region rarely affect the large drug traffickers who are for the most part not based there nor have any need to directly enter the region. UMOPAR's activities therefore fall on coca growers and those who work in the lower levels of the trade (Farthing 1997). In 1997 after General Hugo Banzer Suarez was elected, the dignity plan was adopted which directly affected the coca production, because he determined to stop illegal coca growing by the year 2002 (Americas 1998). In 1998, coca growers marched on the capital for many days and hundreds of kilometers in defense, as they see it, of their right to make a living. In 2001, coca growers blocked the main highways that connect the most important cities in Bolivia (La Paz, Cochabamba and Santa Cruz) by avoiding the trade exchange among these cities and provoking unrecoverable economic damages to different groups of people (small entrepreneurs and other enterprises). (N.N 2001)

Based on Becker (2001), table 4 illustrates the coca impacts from a social perspective which are analyzed at different levels: micro, meso and macro.

[18] UMOPAR is a military group, which has been responsible to control the Chapare region for avoiding activities related with the narcotraffics.

Table 5. Socio-economic impacts of coca

	Micro	Meso	Macro	Impacts	Positive	Negative
COCA GROWING	III	II	-	Employment	X	
	I	I	I	Cultural	X	
	III	II	I	Incomes	X	
	III	II	-	Migration	X	X
	III	II	I	Social confrontations		X
COCAINE MAKING	II	I	-	Employment	X	
	I	II	III	Incomes	X	
	III	II	II	Social insecurity		X
	I	II	III	Crime		X
	-	II	III	Drugged people		X

By using the same criteria than before, III signifies the highest impact and I is the lowest. Coca growing thus possesses positive impacts for the society because it provides employment, incomes and some cultural issues regarding to other uses of coca in a kind of indigenous ceremonies. The migration process might result in benefits for the individuals but for the Chapare region this might be negative because of the intrusion of new people to occupy new land without any right. Due to the eradication process a lot of social confrontations are provoked, so this impact is therefore considered as being negative on the three levels. Likewise, cocaine processing provides employment and incomes to the individuals, so from a meso and macro levels perspective, both of them play an important role by resulting positive impacts. However, coca making creates social insecurity, crime and drugged people, and it is these negative aspects which are the main focus at international levels.

3.5. Discussion

By making a quick visualization about the current situation in the Chapare region, under the criteria of Rao (1999), we identify symptoms of unsustainability, which are basically the biodiversity loss and deforestation. In terms of biophysical sustainability, then, the maintenance of nature is not being supported by the current human actions what implies that this is not the way to maximize options for current and future generations.

As said by Habert and Schandl (1999), one essential point is that sustainable development aims to shape socio-economic behavior towards nature in ways that guarantee the preservation of the life-supporting natural systems for future generations. In the coca case, in accordance with the data presented in this chapter, the problem of coca requires a quite complex analysis. The Bolivian government has been focusing more on coca eradication programs than any other factor. It is simultaneously the truth that it has been making some recognized efforts to increase the social stability by proposing alternative development, but those efforts did not get the expected outcome. Regarding the environment, apparently, it has never been taken into consideration even though significant impacts have been identified as shown by the impact assessment. If we look at the concept of sustainable development, we will realize that there were recognized efforts to help the preservation of the natural systems but with little success. This is mainly because people are looking for their own possibilities to survive without caring the consequences. Obviously, the international justification for a rapid response in the eradication process is an apparent urgency of the international drug problem.

The discovery of cocaine has been a consequence of applying science and technology to make possible its isolation from the coca leaves. As with every addictive drug, cocaine itself gets large markets in the whole world with some externalities from different angles. Firstly, externalities from an environmental perspective are mainly identified by the pollution of the soil and rivers and secondly, externalities from a social perspective are human addiction and perhaps the different types of crimes that are made during the traffics. The isolation of cocaine was not developed in Bolivia but in other places in the world with more scientific knowledge. Unfortunately that knowledge has been transferred to some Bolivian people who comprehended the economic benefits associated with cocaine production. So, to start the challenge of

change, we have to understand what sustainable development means. As said by Redclift and Sage (1995), sustainable development answers problems initiated in the North, with our "global" development model. We have to understand sustainable development within a cultural context of our own-*our* view of nature, *our* problems with science and technology, *our* confidence in the benefits of economic growth; but, sustainable development has become a "global" project, and our capacity to find solutions is seriously reduced by our inability to recognize that we are the prisoners of our history (Redclift and Sage 1995).

4. LOCOTO, LOCOTO PROCESSING AND MARKET

Locoto *(C. pubescens)* is a relatively unknown chili. It is found from Mexico to Bolivia. Common names include rocoto or locoto in South America. Other common names are manzano and peron because the fruits can be apple- or pear-shaped. It is a perennial small shrub in suitable climatic conditions, living for a decade or more in tropical South and Central America. Capsicum probably evolved from an ancestral form in the Bolivia/Peru area (Heiser 1976).

The most typical attribute of chilies is pungency and must be considered one of its most important features. Some have argued that pungency should be one of the five main taste sensories, along with bitter, sweet, sour, and salty (Bosland 1994). Chili pungency is a desirable attribute in many foods. In most parts of the world, pungency increases the acceptance of the insipid basic nutrient foods. Many innovative uses of pungency are being studied (FAO 1993a).

Due to its different applications in the medicinal and the food fields; it could probably become interesting. The main reasons why locoto was chosen as study case are the following:

- Locoto can be transformed in other products in order to avoid the perishability.
- There is a market for these products outside of Bolivia, especially in the US.

As many authors argue, the causes for the failure of other alternative products have mainly been: (1) To promote products in an over saturated market (i.e. inside of Bolivia), (2) Perishability of the product, (3) Lack of good highways for transportation and lack of international markets. The features of locoto seem to comply with the requirements, at least in terms of perishability and market factors.

4.1. Capsicum uses and applications

Capsaicin[19] is found only in chili peppers and in no other plant, animal, or mineral. Detectable to the human taste buds to one part in one million, this powerful compound is extracted from hot chilies as an oleoresin (thick oil) used in hot sauces and pepper sprays. Many experts believe that capsaicin use as a medicine has a great future that scientists are just beginning to discover. (Collins, et al. 1995)

Medicinal use of capsicums has a long history, dating back to the Mayas and Incas who used them to treat asthma, coughs, and sore throats (Bosland 1994). The Aztecs used chili pungency to relieve toothaches (Bosland 1994). The pharmaceutical industry uses capsaicin as a counter-irritant balm for external application (Carmichael 1991). It is the active ingredient in rubdown liniments used for sore muscles. The capsaicin is used to alleviate pain. Creams containing capsaicin have reduced pain associated with post-operative pain for mastectomy patients and for amputees suffering from phantom limb pain (Carmichael 1991). Further research has indicated that capsaicin cream reduces pain associated with arthritis (Collins, et al. 1995). Chili powder is added to birdseed to prevent squirrels from eating it; there is no effect on birds and the vitamin A in the powder brightens the birds' plumage. One interesting use of capsaicin as an animal repellent involves insects (Collins, et al. 1995).

From a nutritional perspective, the content of Vitamin C is relevant and it is about 340 mg/100g of capsicum and the dried samples have about 40-60 mg/100 g (Abram, Ferreira et al. 2001). It has also been demonstrated that the capsicums contain Vitamin A, E, and B_{12} in significant amounts (Maga 1975) and finally (Kehayoglou and Manoussopoulous 1977) confirmed the presence of 14 essential aminoacids in green

[19] Capsaicin is a chemical compound that is present in Capsicums and gives this spicy or hot flavor (pungency).

capsicum and 16 in paprika. The carotenoids that are present in the capsicums constitute one of the most important groups of natural pigments; the appearance of some types of cancer has been linked with the lack of certain oxygenated carotenoids (xanthophylls) in the diet, which are thus considered to be anticancer compounds (Minguez-Mosquera and Horneno-Mendez 1993). Most of the capsicum sp. are red, orange, green or rarely white, the concentration of colorants vary from 0.69 mg/Kg (white variety) to 10 mg/Kg of fresh capsicum (green variety) and between 127 to 1600 mg/Kg of fresh capsicum for the red varieties (Govindarajan 1986). Capsicum oleoresin is currently used in a wide assortment of foods, drugs, and cosmetics, as well as for improving the feather color of flamingoes in zoos or koi in aquariums (Reeves 1987). An Oleoresin capsicum spray (OC) has been developed as well and is employed by the police in the US. Here, when employed in the facial area, this ingredient causes the eyes to tear and swell shut, and mucus to drain profusely from the nasal passages (Morabito and Doerner 1997). Also, coating fiber-optic cables with the chemical could prevent rodents from gnawing on them (Collins, et al. 1995) and to conclude, it has been found to be useful in the tobacco industry because it contributes a pleasant flavor when combined with tobacco (Barragan 2001).

4.2. Locoto processing

There are different products obtained from locoto as shown in figure 11.

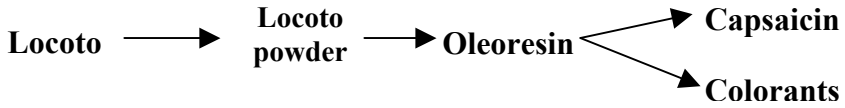

Figure 11: Obtained products from locoto

The major problems in locoto processing are basically the handling of solvents, for example the solvents that are employed in the extraction must carefully be selected; because if they are difficult to separate completely from the oleoresin, the product could be rejected due to the food norms that do not allow high concentrations of the organic solvents in this kind of products. The solvents that are more commonly used are alcohols, ketone and hexane (Bautista and Mato 2001). From an environmental and human health perspectives; inflammability, toxicity and no-use of cancerigenic agents must be taken into account during the process of selection of the suitable compound.

4.2.1. Specifications of the end product

To accomplish with the market conditions in terms of specifications of the end product, it must be considered that fruit shape and the size are no important; however, they need at least 120 ASTA[20] color units (Derera 2000). The content of capsaicin is also other important parameter and it can vary depending on the type of the market, however, it is recommended to keep the concentration lower than 0.5%. For the case of locoto, the color concentration varies from 195-255 ASTA and the content of capsaicin goes from 0.12 to 0.45% depending on the color and ripening of the fruit (Rojas 1998).

4.3. Locoto: National market

In Bolivia, locoto is commonly consumed as a fresh product; it is used for preparing llajwa[21] and can also be consumed in slices as part of some salads. The current national production is about 20000 ton of fresh-locoto/year (Diez 2001) and it has been increasing progressively as observed in the following table:

[20] To test according to the ASTA (American Spice Trade Association) analytical method a special glass filter must be used. The extractable pigment content is eventually expressed in ASTA units.
[21] It is a kind of hot-sauce, which is made by smashing locoto and tomato together. It is widely used as a condiment for many Bolivian dishes.

Table 6: Bolivia: Production of locoto

Period	Average (tons/year)
1986-1982	6000
1991-1987	10000
1996-1992	13000

Source: Censo Nacional Agropecuario (Diez 2001)

Another product, which has become of relative importance in the national market, is called *locoto en polvo*[22]. Diez (2001) considers that around 250 ton of fresh-locoto/year are employed for this purpose; so, most of the material is sold as a fresh product, it is estimated that less than 4% is trade as *locoto en polvo*. To have an idea about the demand it is vital to consider the locoto price, as noticed in figure 12, there is an increment from May to September, that is because in winter the locoto's production decreases; therefore, the market it is not completely supplied. According to Diez (2001), the average price[23] was equal to Bs. 98, the highest price was equal to Bs. 190 and in summer the lowest was registered as Bs. 25 per quintal[24]. It is believed that the demand that is not covered during one year is approximately equal to 4 500 tons of fresh-locoto. The Municipality of Colomi[25] is the major producer of locoto, able to supply about 7 000 tons and the cultivation area is approximately equal to 700 Hectares generating Bs. 15 million per year. Diez (2001) also indicates that PROTAL[26] ensures good prices for the farmers who deliver their product for being dehydrated and then the product can be trade either inside or outside of Bolivia. Although the final product is mainly for the national market, there is a small amount that operates in international markets.

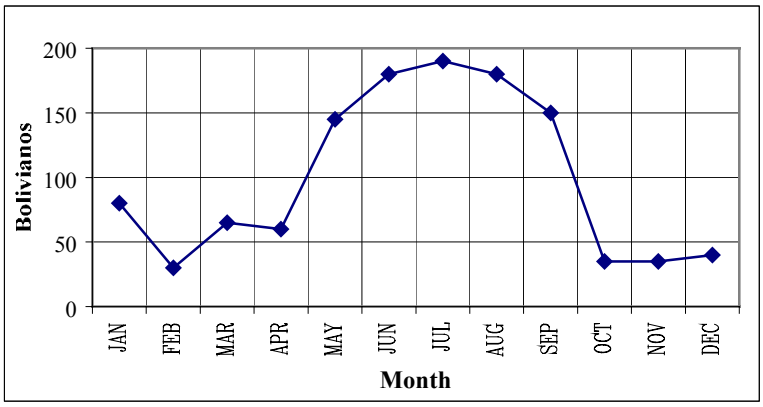

Figure 12: Average price of locoto.
(Diez 2001)

4.4. Locoto: International market

The study of international market potential is carried out for dehydrated locoto and oleoresin, mainly because of the relative simplicity that the process involves from a technical perspective (high technology is not needed) and also the requirements of investment are not so high. The exports as a fresh product have not been considered because it is risky due to the locoto perishability, a factor that is removed when locoto is processed. A particular characteristic of the dehydrated capsicum market is that consumers and producers are concentrated in countries located in Europe, Asia and North America. The exports are dominated by

[22] Locoto en polvo means locoto powder, and it is obtained after being dried and milled.
[23] The average price is in Bolivianos (Bs), which is the Bolivian currency. 1 $US = 5.6 Bs (July, 2000).
[24] It equals to 48 Kg.
[25] Tablas Monte and San José are villages where locoto is currently grown; those villages belong to the Municipality of Colomi.
[26] PROTAL is a Peasantry Rural Association with 80 active members who are in direct connection with more than 200 locoto growers.

countries such as China, Spain, Malaysia, Singapore, Mexico; and the imports are mainly performed by USA, Malaysia and Singapore.

4.4.1. Imports: Dehydrated Capsicum

In 1996, the international dehydrated capsicum imports reached 202 399 tons, yielding an income approximately equal to $US 418 million in the whole world (Schwartz and Mato 2001). In regard with imports by country, the United States has been the largest importer in the world. In 1996, the US imported 40 618 Ton of dehydrated capsicum (Schwartz and Mato 2001), which made 20.1 % of the total imports (see Figure 13a). That amount represented about $US 77 million. Thus, the US market has become very significant within this business.

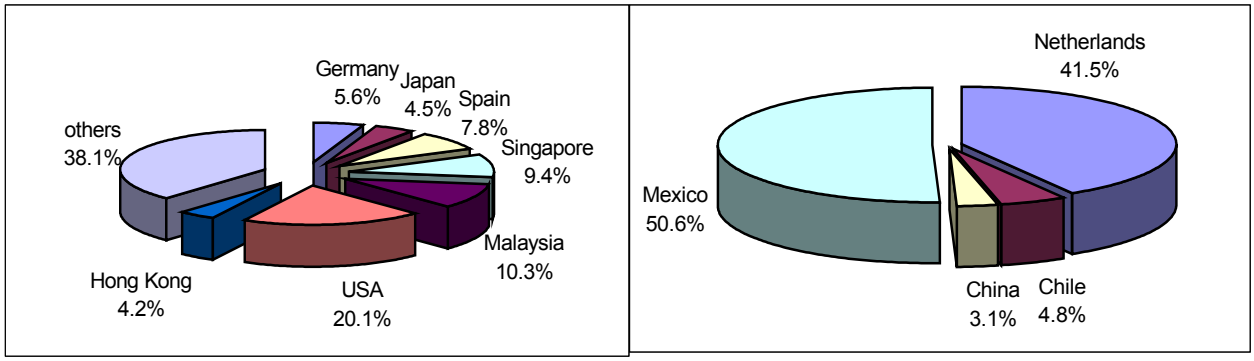

Figure 13 a-b: a) Imports by country b) Imports to USA by country (1996) (Schwartz and Mato 2001)

It is also relevant that the US has been importing dehydrated capsicum from different countries and the major supplier is Mexico with 50.6% of the total imports as seen in figure 13b. Chile is also another supplier with relative importance, reaching almost 5% of the total imports by the US.

4.4.2. Exports: Dehydrated Capsicum

Exports total 137 532 tons, representing a value of more than $US 296 million, and again the principal exporter is Asia with more than 50% of the total exports (Schwartz and Mato 2001). China has for a long time been one of the main supplier to the international market, even though its exports have been decreasing (Schwartz and Mato 2001). As seen in Figure 14a, in 1996, China was the recipient of 31.1% of the total exports. In regards to American countries, we have to point out that the most important ones are Mexico and Chile with 5.1 and 3.6% respectively.

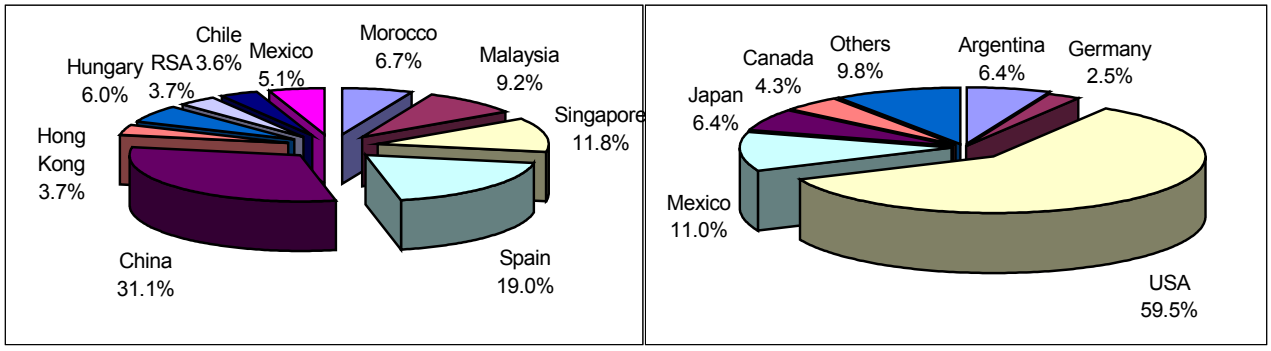

Figure 14 a-b: a) Exports by countries (1996) b) Exports by Chile 1998 (Schwartz and Mato 2001)

As Chile is a country with certain potential in this kind of industry and it is geographically situated close to Bolivia, it is important to look at the countries, which it exports to. So, the possibility of becoming a competitor can be widely considered. Figure 14b shows the exports by Chile in 1998.

In 1997, Chile exported 4 440 ton, an amount that increased 30% in 1998, a year in which the exports reached 5 780 tons (equal to $US 19 million).

4.4.3. Market for capsicum oleoresin

The main importers of this kind of product are the US and UK, even though other consumers such as Japan, Canada, Australia and Mexico are also important. As the US constitutes the major importer of oleoresin, it will first focus attention on that country. The US suppliers are illustrated in the next figure:

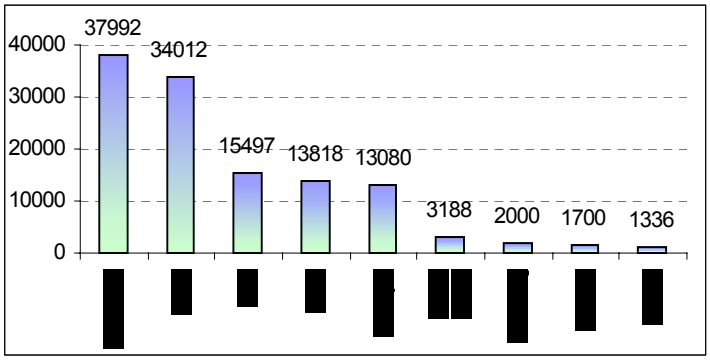

Figure 15: US oleoresin imports in Kg (1995).
Source: US Department of Commerce (Rojas 1998)

The total amount of oleoresin imported by the US was 122 623 Kg, which made almost $US 4 million (Rojas 1998). Historically India and Spain have been the most important exporters but India has been having problems because of the excessive proliferation of new industries, provoking a lot of oscillations in the oleoresin price; between January and September 1996, approximately 50 ton of oleoresin were exported to the US for a total amount of $US 2 million (Schwartz and Mato 2001). On the other hand, Spain has been producing between 300 to 430 ton/year and has been operating with a more stable price (85 $US/Kg). In 1995, the Spanish exports were about 450 ton and generated more than $US 38 million (Schwartz and Mato 2001).

4.4.4. Prices in the international market

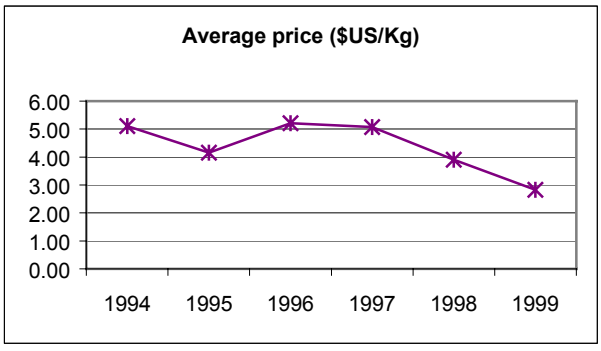

Figure 16: Dehydrated capsicum prices per year (USA)[27]

In general, the price for products made from capsicum varies widely and depends on the supply-demand, the country where the product comes from and the end characteristics of quality. As the target in

[27] It was obtained by dividing the total amount of money by the total of exports in Kg of Capsicum.

this case is the US market, calculations[28] were made in order to get the average price for dehydrated capsicum per year; this is revealed in the figure 16.

Since 1994 to 1997, the price of dehydrated capsicum has been getting slight fluctuations; but during 1998-1999, it showed an abrupt falling until to get a price equal to 2.97 $US/Kg; the minimum price registered during the last decade. However, Derera (2000), reports an average price equal to 4.02 $US/Kg of dehydrated capsicum.

As explained before, the price for the oleoresin from capsicum varies between 40-85 $US/Kg and again the factors in which the end price depends on, are basically supply and demand.

4.5. Discussion

Since large amounts of locoto could be traded internationally either as powder or oleoresin this section intends to identify the benefits and problems from an environmental economics point of view.

International trade poses a particular problem for poor countries trying to manage their environments, since the export of natural resources remains a large factor in their economies, especially those of the least developed nations. The instability and adverse price trends faced by most of these countries make it impossible for them to manage their natural resource bases for sustained production. The rising burden of debt servicing and the decline in new capital flows intensify those forces that lead to environmental deterioration and resource depletion occurring at the expense of long-term development (WCED 1987). That instability in developing countries referred to the price trends is clearly seen at section 4.4.3. where, for example the price difference for oleoresin between India and Spain is more than the double, being the Spanish price much more stable. In case of Bolivia, we could probably expect to have an international average price about $US 50/Kg which implies slightly higher than the Indian one.

However, in terms of environment, it exists a certain kind of risk to lead to environmental deterioration for the reasons explained before, this problem would be considered an important constraint for locoto trade and also comparing locoto and coca; locoto must compete with other similar products from different countries what makes difference because coca itself gets markets easily.

Another constraint to consider is that international trade tends to result in unequal emergy[29] exchange in favor of developed countries. However, equity in trade can be achieved by treaty, adjusting imports and exports to balance emergy. If the emergy trade balance is uneven, the difference can be made up in education, or technology transfers duly evaluated for their emergy contributions. In this way, balances between nations can be equated while still allowing countries to be in different levels in the urban-rural hierarchy and national specialization.

5. CHARACTERISTICS OF LOCOTO AND LAND CAPABILITY

5.1. Characteristics of locoto *(Capsicum pubescens)*

The genus *Capsicum* is a member of the Solanaceae family that embraces near to 2000 species among herbs, bushes and trees. Most of them grow in the tropics (Lozoya, Di Fabio et al. 2001). The genus *Capsicum* consists of approximately 22 wild species and five domesticated species (Bosland 1994): *C. annuum*, *C. baccatum*, *C. chinense*, *C. frutescens*, and *C. pubescens*. *Capsicum* is endemic to the western hemisphere and the pre-Columbian distribution extended from Mexico to South America (Jolliffe and Gaye 1995). It is a perennial small shrub in suitable climatic conditions, living for a decade or more in tropical South and Central America. Capsicum probably evolved from an ancestral form in the Bolivia/Peru area (Heiser 1976). Chili fruits are considered vegetables, but are berries botanically. Chili types usually are

[28] Based on the available data at Schwartz, M. and R. Mato (2001:279-309)

[29] Emergy is the amount of energy that is required to make something. It is “the memory of energy” that was degraded in transformation process. The concept of "emergy" (with an m), which originally was meant to stand for "embodied energy. It denotes the amount of energy that has been invested in a product Odum, H. (1996). Evaluating International Exchange. Environmental Accounting Emergy and Environmental Decision Making. C. o. E. Policy, John Willey & Sons.

classified by fruit characteristics, i.e. pungency, color, shape, flavor, size, and their use (Smith, Villalon et al. 1987; Bosland 1994). The *Capsicum pubescens* normally has purple flowers; even though, there are other cultivated species with variations in the color. The seeds and fruits can also vary in terms of shape, size and pungency and the color of the ripe fruit can be red, orange or brown. (Lozoya, Di Fabio et al. 2001)

5.2. Land-use planning and land capability and its components

Land-use planning is the systematic assessment of land and water potential, alternatives for land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options. Its purpose is to select and put into practice those land uses that will best meet the needs of the people while safeguarding resources for the future. (FAO 1993c)

According to FAO (1993c), the objectives of a land use planning from environmental, economic and social perspectives are:

a) *Environmental:* Conservation of soil and water resources, pasture and forest resources, quality of wildlife habitat, scenic and recreational value for tourism and leisure industries.

b) Economical: To carry out a Cost-Benefit analysis, financial analysis.

c) Social: To make a social impact analysis studying the effects of proposed changes on different groups of people. Particular attention should be given to effects on women, ethnic minorities and the poorest sections of the community. There are no fixed procedures for assessing the social impact of a proposed change of land use. Some examples of social factors are: basic needs, employment and income opportunities, land tenure and customary rights, community stability. To start with a methodology based on a land use planning the first think to look at is by assessing the land capability.

The concept of *land capability* is defined as the factors that are primarily concerned with the potential biological productivity of land and this is determined by four main components of the environment. In descending order of importance they are: climate, local topography (ruggedness, steepness, exposure) which cause local variation in climate and disposition of soil type; soil; and existing vegetation including the effects of destroying it and replacing with another crop. Climate is the dominant influence on land-use in the tropics, this factor include the seasonality of rainfall, the maximum and minimum temperatures, relative humidity occurrence of frost, etc. The influence of topography on land capability is best seen in the increasing restrictions of possible alternative uses as terrain becomes more broken and rugged. Soil requirements are supply moisture, nutrients and mechanical support (for planting); however, there is no one optimum soil since different species grow best under different conditions of nutrient supply, moisture regime, acidity, etc. Finally, the constraint on land capability is the need to clear vegetation before introducing another land-use. Although, in theory, clearance is always possible, it must not be done. (Evans 1992)

Anyway, as one of the objectives of the present study is to substitute coca plantations by locoto growing, last point is not considered. In consequence, the research on the land capability for growing locoto in Chapare will only focus on the three first components mentioned by Evans.

5.3. Soil and climate requirements for growing locoto

The *Capsicum pubescens* is a culture of warm-humid climate. To reach a well development; it needs day temperatures between 20-30°C and 16-20°C during the night. When the nocturne temperature is lower than 15°C, the plant grows very slowly. The high temperatures combined with low moisture can make dried the flowers and fruits and can exterminate the plant; however, there is tolerance up to 40 °C when the moisture is high. Especially, during the first periods of growth, it is very necessary that the moisture be higher than 50%. This capsicum also requires luminosity during the whole vegetative cycle; in the absence of sunlight, its development can be threatened and also can affect the synthesis of vitamins and other essential compounds. (Lozoya, Di Fabio et al. 2001)

The requirements of capsicum in terms of soil are: middle texture, deep, good drainage, with significant amounts of phosphorus and nitrogen and pH between 5 and 7 (Vilarnau Moncusi 1996). The pungency is increased when the soil is saline, poor in nitrogen or compact and also when the climate is dry

and warm (Milla 1996). The suitable altitude for growing it is between 800-2500 meters above the sea level. The presence of conspicuous leaf pubescence and black seeds readily distinguish this chili from any of the other species. It has also seen that this chili could be adapted to cooler temperatures, 4.4° to 21.1°C (40° to 70°F), but does not tolerate frost (Cichewicz and Thorpe 1996).

5.4. Chapare and its characteristics

Chapare is located in a transition region between the very tropics of the Bolivian Amazon and the valleys of Cochabamba. For this reason, it is considered to be a sub-tropic.

The tropics receive large amounts of solar radiation throughout to the year and as a result seasonal fluctuations in temperature are minimal and there is no distinct winter season, which are also characteristics of the Chapare region. Some classification systems conceptualize tropicality in hydro-meteorological terms and differentiate the tropics bases upon the relationship between water inputs (precipitation) and water outputs (evaporation). Numerous other schemes for defining and subdividing the tropics have been proposed by climatologists, geomorphologists and biologists. Difficulties of delimiting the outer boundary of the tropics and defining different types of tropics are particularly pronounced, especially across of continental areas. (Reading, Thompson et al. 1995)

A study carried out by OEA (1979), mention that Chapare can be divided into three major portions. The upper portion composed of piedmont and low hills, dense subtropical forests on steep slopes rise above numerous small valleys and streams. The middle portion, a stabilized alluvial plain of approximately the same size as the upper portion, contains high terraces with good drainage and is near of the piedmont. Finally, on the lower portion, the major rivers broaden here, and the soils are quite fertile, but annual floods could undercut agricultural potential. The whole area is humid and subtropical, even though the climate varies slightly with the elevation. Table 7 summarizes the facts of this region.

Table 7: Summary of Chapare Physical Characteristics

Area:	5000 km2
Population (2000):	150000 hab.
Physical characteristics:	
- Hold-ridge life zones:	
- Predominant Humid Tropical Forests with variations to Very Humid in piedmont areas and Sub-humid in northern plains	
- Subtropical Rain Forest in low mountain area	
- Dry Tropical and Dry Subtropical Forests	
Elevation range:	600 m to 2000 m
Annual average temperature:	25 C
Minimum & maximum:	12 to 35 C
Relative humidity:	70 ± 10 %
Soil pH:	4.0 to 7.5
Soil texture and structure:	
It varies depending on the elevation and the topography. *In middle plain terrain*, the soils are deep, which are conformed by a variety of layers of different texture, color and thickness. The natural fertility varies from moderate to low, but the constant contribution of sediments makes stable the content of nutrients. *Soils in lower plain terrain,* are located near to the rivers. They are deep and have relatively good drainage; the superficial layer and the sub-soil generally presents middle texture with moderate permeability. These soils are lightly acids, with high content of calcium and magnesium; sodium and moderate potassium; a high content also exists of nitrogen, in contrast with the prior soil. On the other hand, the organic matter varies widely and the fertility remains moderate. *Soil in the low hills* is sandy calcareous, it presents slopes from 2 to 60%, it is deep with relatively good drainage and without any danger because of the floods. It mostly presents structure in blocks and oozy texture. The permeability is from moderate to slow; however, it presents a quick superficial glide. pH is basically neutral to lightly alkaline, high content of calcium and middle of magnesium. Sodium and potassium content is low and finally the nitrogen and organic matter is middle.	
Pluvial precipitation:	1200-5000 mm

Source: (ALADI 2001) & (OEA 1979)

To make a comparison between locoto requirements and the natural conditions of the Chapare region, table 8 summarizes the features for both cases:

Table 8: Summary of requirements of locoto compared to Chapare characteristics

	D.T. (C)	N.T. (C)	H (M)	R.H.	Lum	S.Fert.	pH	N	P	Prec.
Ideal conditions for growing locoto	20-30	16-20	800-2500	>=50%	good	good	5.0-7.0	Needed	Needed	no tolerance to flooding
Natural conditions of Chapare	22-35	12-25	600-2000	>60%	good	can vary	4.0-7.5	Present	Present	High in some months

D.T. = Day Temperature. N.T.= Night Temperature H=Altitude R.H.= Relative Humidity
Lum = Luminosity S. Fert. = Soil fertility pH N = Nitrogen
P = Phosphorus Prec. = Fluvial Precipitation

5.5. Discussion

According to table 8, Chapare appears to comply with the requirements to grow locoto, even though the characteristics of this region vary with the elevation. To be more precise, perhaps, it would be very necessary to make tests or measure the variables in the places where coca currently is produced in order to ensure the land is suitable. Anyway, in accordance with the found data, the land suitability seems to be good enough for growing locoto. Thus, to cultivate locoto in Chapare region would be possible and the land that is employed and used to be for coca plantations could be utilized. The Bolivian government would strongly support this choice. In terms of equity and acceptability, land use must also be socially acceptable. Goals include food security, employment and security of income in rural areas. Land improvements and redistribution of land may be undertaken to reduce inequality or, alternative to attack absolute poverty (FAO 1993). In this point, to increase equality is an important task for governmental levels to revise current laws or implement others in order to achieve a better distribution of the land among of the peasants and the people who lives from the crops cultivation; Besides, an important procedure to carry out by the government is to make clear to the farmers what property rights means by trying to make agreements and compromises in order to ensure that there will be no longer illegal settlements. Anyway, the unsuitable distribution of land generates inequality among the people and it is one the most common problems that can be seen in rural area of Bolivia. However, perhaps, the coca plantations, which have been abandoned because of the extreme control carried out by the Bolivian and US governments through the eradication process could be allocated to the people who would wish to cultivate locoto as a new crop by increasing the equality in this way. This would also be a kind of incentive to shift coca by locoto.

By making a quick visualization based on the goals of sustainable land, the next outcome has been found: a) Environmental perspective, the risk of provoking erosion could be decreased if locoto is started to be grown, in terms of water supply, the required amount would be ensured because Chapare is a region with good pluvial precipitation.

Pasture and forest resources: locoto could involve risks of deforestation if the available land is not enough to grow locoto for supplying the entire market. *Quality of wildlife habitat*: If locoto promoted deforestation, it would provoke loss of habitats; so, loss of habitats also depends on the land that is available. *Scenic and recreational value for tourism and leisure industries:* In Chapare, there are several tourist places for recreational activities because this region of the country is paradisiacal and normally many tourists are attracted by the wonderful landscapes that remain there. Thus, if Chapare lost its magical nature due to over exploitation of the natural resources, its recreational value for tourism could be threatened. b) Economic analysis: As found in the previous chapter, the market of locoto is relatively large; because of its different applications in the food and medicinal fields. A study carried out by Diez (2001), demonstrates that the benefit/cost ratio is equal to 1.52/1, which implies that locoto gets positive return to the investment. From a financial perspective, it appears to be feasible to get economic support from USAID; because, that institution normally finances projects performed inside of Chapare, when the projects show positive return to the investment, the project shows positive impacts on the Chapare's society and most important, the coca leaf substitution is involved. c) Social perspective: if we implement the project by knowing that the return to the investment is positive, incomes and employment from a licit activity could be gotten. Besides, the social instability due to coca issues would also disappear.

To complete the analysis, the following chapter will focus on a more detailed study using indicators of sustainability and showing the main outcomes.

6. THE LOCOTO GROWING: AN ANALYSIS OF ITS POSSIBLE IMPACTS

To analyze and predict the possible impacts that locoto could have in the future, firstly, we have to look at the current situation to see how locoto growing affects the environment and the society. In this sense, the environmental, economic and social aspects are assessed as follows:

6.1. Environmental aspects

Although, some traditional ecological methods[30] for growing locoto are employed by farmers who have certain ecological knowledge related to the land use, it is know that this crop has been leading to the deforestation in some regions within Tablas Monte and San Jose[31]. Regarding to the use of pesticides or herbicides, according to Lopez (2002), they are rarely used to grow locoto, even though; some pests and depredators can attack it. Diez (2001) reports that the weeding is made by hand and it is considered a normal activity performed by the farmers, however, it has been observed that a small number of growers employ insecticides and fungicides when realized that some pests are attacking it. The use of fertilizers is also an uncommon practice.

In general, Bolivia possesses a great potential ecological agriculture in hands of the indigenous farmers that has been conserved since the colonial times. These systems of traditional production have been adapted in harmony with the ecosystem and appropriate to tolerate, attack of plagues and illnesses, ensuring the conservation of the soil and the biodiversity that permits to obtain healthy and nutritious foods, besides this guarantees the Sustainable Rural Development can be achieved. The traditional growers have developed their own ancestral technology that is not less efficient than the modern technology or conventional agriculture, which is degrading the agro-systems causing the contamination of the environment and the foods (AOPEB 2002). AOPEB[32] has been trying to implement projects in order to increase the benefits for the growers in the cultivation of different crops (including locoto), this task is performed avoiding any perturbation in the environment, it also provides assistance and currently, in Santa Cruz, it is promoting the organic agriculture[33].

6.1.2. Locoto processing, the environment and human health

The major problems that have been identified during the locoto processing are basically the following:

- Discharge of locoto powder into the atmosphere, which could basically affect to the people who work in the milling process.
- Release of hexane into the atmosphere, the amount depends on how much locoto will be processed, and the percent of recovery that the condensation process reaches, according to Rojas (1998), it is possible to reach 94% of solvent's recovery.
- Due to the nature of capsaicin (EPA 1992) concluded that products containing capsaicin would not have adverse effects on human health and environment. Since capsaicin is used as a biochemical pesticide, all ecological effects studies have shown, that there is no certainty about its environmental fate. At the same time EPA concluded that the ten registered pesticide products that contain the active ingredient capsaicin can be used without causing unreasonable adverse effects in people or the environment.

[30] Locoto is cultivated and harvested during 2-3 years as the first crop in a new land, once locoto has completed the production; the soil is used for cultivating other crops. This process from the beginning (including the time of locoto growing) takes about 4-5 years. After that, the land is covered for a secondary forest during 8-10 years, time that is considered enough to cut the threes and start a new cycle of crops production.

[31] Tablas Monte and San Jose belong to the Municipality of Colomi.

[32] AOPEB is an NGO that promotes sustainable rural development; it interacts with small groups of farmers.

[33] The organic agriculture is based on the continuous ecological management, it should have a high probability of maintaining soils and environment for a long time and the grower should guarantee an appropriate administration and continuous measures for its sustainability. This technique does not use any kind of pesticides nor synthetic fertilizers

6.2. Economic aspects

The production cost reaches Bs. 7000 per hectare which results equal to Bs 28 per quintal of fresh locoto, the manpower (is needed for preparation of the terrain, weeding, harvesting and other agronomical activities) represents 50%, the inputs such as weeds, bags for the harvesting and the financial costs represents the remaining 50% (Diez 2001). In regards to the locoto price, it was shown at the section 4.3 that varies depending on the season. In 2000, it fluctuated between 0.35 and 0.70 $US dollars that meant revenues by more than 2,6 million of dollars.

6.3. Social aspects

The production of locoto is performed by small farmers, the cultivated area per family varies from 0.2 to 2 hectares by being the average equal to 1 hectare (Diez 2001). In Colomi, at least 850 families (50% of the community) are devoted to the locoto growing as seen in table 9.

Table 9: Number of families devoted to the locoto growing

Village	Population	Number of Families	Families who cultivate locoto
Tablas Monte	5800	1000	700
San Jose	2600	500	150
Total	8400	1500	850

Source: Diez (2001)

In summary, we can say that the locoto effects on the environment are not too harmful, even though, there are also different sources with different appreciations about the use of fertilizers or pesticides; however, all of them coincide that locoto could be grown in the absence of those chemicals. AOPEB supports the organic agriculture, which could be applied successfully, however this technique includes a major investment because it is more costly than the modern technologies. The locoto processing does not show great problems; perhaps, it would be necessary to make aware and train to the people who would work with it and also it is very important to provide them safety stuff.

Apparently, the locoto business might generate good incomes, even though the production cost does not include the transportation to Cochabamba where locoto is traded, this amount represents at least 50% extra of the cost of production. If we compare the production cost in situ to the revenues per hectare (taking into consideration the lower price of locoto), we will find out that the difference cost-revenues is almost 300%, it is assumed that these net incomes are divided among the commercialization's chain actors. The actors who represents the chain are the growers, wholesalers and retailers who deliver finally the product to the consumers; something that is also important to mention is that during the commercialization process the retailers have more losses due to the locoto perishability.

From a social perspective locoto appears to be a relatively secure source of incomes by providing work to 800 families who rely on it very much. In consequence, locoto seems to have positive impacts on the society; but in relation to the environment locoto growing shows certain potentiality for leading to the deforestation if appropriate controls are not implemented.

6.4. Modelling in Stella.

To verify the impacts of locoto, it is needed; first, to model the situation starting in the beginning of 1980's up to date and second, from the current situation to the future, in this period of time two possibilities are likely to be happened: a) Coca growing will still be going on under two situations, without too much control in terms of eradication as the tendency is today and with strict control to eradicate coca cultivations. b) Locoto could be introduced as an alternative product. The simulation is performed using Stella 5.1. and is based on the causal loop diagrams, which are shown in the first chapter.

6.4.1. Scenario 1

a) Coca growing will be going on in the future with low level of control.

The scenario starts in 1980 and it is run until 2050, it shows the problems and benefits from a sustainable development perspective, the main used indicators are deforestation, loss of biodiversity, incomes, employment, which are at the same time dependent on coca growing. To understand the dynamics of the process, a summary of assumptions and the used data are listed below:

Assumptions:

1. Migration is a function of poverty, employment and incomes. The more poverty the more migration where employment and incomes are found.
2. Chapare's population is a function of the birth rate, death rate and migration.
3. Coca price is a function of the supply and demand.
4. Number of hectares of coca is function of the Chapare population and policy of eradication, which includes Law 1008 implemented in 1988 and Dignity plan put into action in 1997.
5. The contribution for an increased deforestation is given by the number of hectares of coca, cocaine making and a small amount by the migration process.
6. Cocaine making depends on the number of hectares of coca and policy of eradication; in this case laws are more strongly applied.
7. For making cocaine, it is required sulfuric acid, calcium carbonate, potassium permanganate, acetone, kerosene, benzene and toilette paper, they have adverse effects in the soil and the aquatic systems; the most harmful is sulfuric acid and according to a study case carried out by Hicks, Bowman et al. (1999), 7 200 tons of sulfuric acid can destroy 110 hectares of habitats.
8. The biodiversity loss is estimated by using the species-area relationship (SAR) (Ney-Nifle and Mangel 2000), this equation predicts extinction from extent of habitat reduction. How many species are lost depends on how much habitat is removed; the relationship between the number of species S and the area A of a habitat is $S = CA^z$, where the parameter z is generally <1, typically around 0.1–0.4. Although they are usually treated as constants, it is recognized that the intercept C and exponent z may change as area changes. In our case z and C were considered being constants and were gotten from the graph showed in the Appendix (C=1E10 and z=0.2).
9. Social stability depends on the number of employs and GDP per capita, when social stability tends to one, means that the highest level is being reached. It is assumed that *Social stability = 0.35*(GDP per capita)+0.65*(number of employs).* It is considered that employment is more important that GDP per capita because number of employs promotes more stability to any system.

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Other relevant data:

10. At the beginning, the rural population of Cochabamba (without including Chapare's population) was equal to 260,000 habitants with a birth rate equal to 43/1000 in the beginning to 38/1000 currently.
11. At the beginning, Chapare's population was equal to 40,000 habitants and the global birth rate varied from 35/1000 (starting) to 30/1000 (present).
12. The initial value of coca plantations was equal to 12000.
13. By using multiple regression analysis, a polynomial expression as a function of supply and demand, has been found and it is written as follows:

$$P = (A_1x^4 + A_2x^3 + A_3x^2 + A_4x + k_1) + (B_1y^4 + B_2y^3 + B_3y^2 + B_4y + k_2)$$

A1	A2	A3	A4	K1	B1	B2	B3	B4	K2
0.000453	-0.072316	4.170744	-99.27944	-476063.1	-0.154373	30.90808	-2314.099	76789.71	-476067.8

Where: P = coca price; x=supply; y=demand and the coefficients adopt the following values:

14. To estimate the employment impact, it has been estimated the number of days/hectare needed for one person to make the whole work from the beginning to the harvesting and then this number was divided by 260, which is the number of days in a year with normal activity (without taking holidays). Thus, for coca case implied 1.98 permanent employs/hectare.
15. The production cost per hectare of coca is $US 1300.
16. The amounts of chemicals used for the simulation are based on Table 1, which is found in section 3.2.2.

After the model was run, the following trends are observed:

Demand (Ha)	Hect. Of Coca	GDP	Social Stability	Incomes	Employment	Biod.loss	Cocaine making (Tons)	Deforestation
1 E+05	1 E+05	Percentage	Range 0 to 1	1 E+09	1 E+05	1 E+10	1 E+02	Percentage

(*)To obtain the real amount of every factor multiply, the scale at the figures by the respective factor above

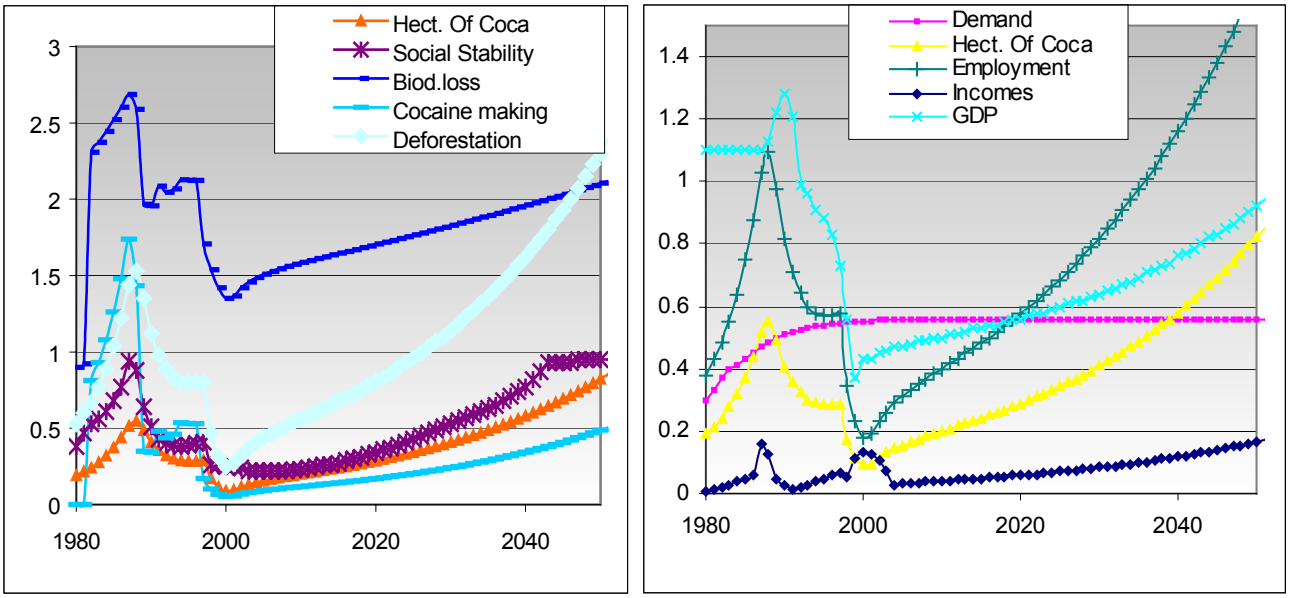

Figure 17 a-b: Coca growing will be going on with low level of control

It is possible to affirm that the model reproduces the coca history since 1980 until now, in order to see what would happen in the future if this situation continued, the model was run until 2050.

As seen, since 1988 when Law 1008 was promulgated, the price begins to get up because the number the production of coca starts to drop successively. This change is accentuated even more when the Dignity plan is applied in 1997. Logically, the more eradication of hectares of coca, the less social stability, the more social problems, which were clearly shown by the obstruction of high-ways, several marches and many confrontations with the policy; activities that were performed by the coca growers in 2001, so by that time the Bolivian government decided to diminish slightly the pressure on the eradication process, for this reason the levels of control of eradication in the model was assumed to get slowly down and the number of hectares of coca is increasing again since 2001. This assumption is even more supported and appears to be closer to the reality by the publication in a newspaper where the last Bolivian president is thinking of giving a pause to the eradication process and also to modify Law 1008[34]. So, if the process of eradication stopped there would be more hectares of coca and the GPD would also be increased.

In terms of social stability and biodiversity loss, Figures 17a-b illustrates that before Law 1008 was promulgated, in 1987, the tendency in all the curves was crescent, however from this year the cocaine industry dropped because the first goal of the government was to stop the production with higher levels of control than the eradication of coca plantations, there was more control in the use of precursors and all

[34] Gonzalo Sanchez De Lozada (Current Bolivian president) declared that would be possible to modify Law 1008, because Sabino Toledo a leader of the coca growers was murdered on the 6th October 2002 (LOS TIEMPOS, 2002)

related to the cocaine making. Due to the Dignity Plan put into action (1997), the biodiversity loss employment, incomes and the social stability decrease; however after this drop, although the incomes factor gets up again, social stability and employment are still getting down. The incomes factor was increased because the coca price was raised but just for a reduced number of farmers who were continuing the coca growing. The model shows that the employment has more importance for getting higher levels of stability. Since 2002, as employment and again incomes are increasing, the social stability tends to move up too in the coming years. Finally, the figures explain how the biodiversity loss is affected by the cocaine making and deforestation due to the increase of hectares of coca. They also show that the trends of cocaine making and biodiversity loss are quite similar. Logically, the model complies with what in theory is stated, the more deforestation and cocaine making, the more biodiversity loss.

b) Coca growing will be going on in the future, but with strict control in the eradication process.

If we consider that the process of eradication will not be stopped mainly due to the pressure that the US government will put on the Chapare region, a scenario like this can happen. The trouble is that the population of Chapare is every time increasing; consequently, the possibility to reduce the number of hectares of coca in the future will be more difficult, because people, who stay there, will want to grow coca as well. In the moment that the Bolivian government tries to decline the coca production, the farmers will make marches, blockades, etc. to avoid the new policies implemented by the government as it has been happening until now.

Hect. Of Coca	Social Stability	Incomes	Employment	Biod.loss
1 E+05	Range 0 to 1	1 E+09	1 E+05	1 E+10

(*)To obtain the real amount of every factor, multiply the scale at the figures by the respective factor above.

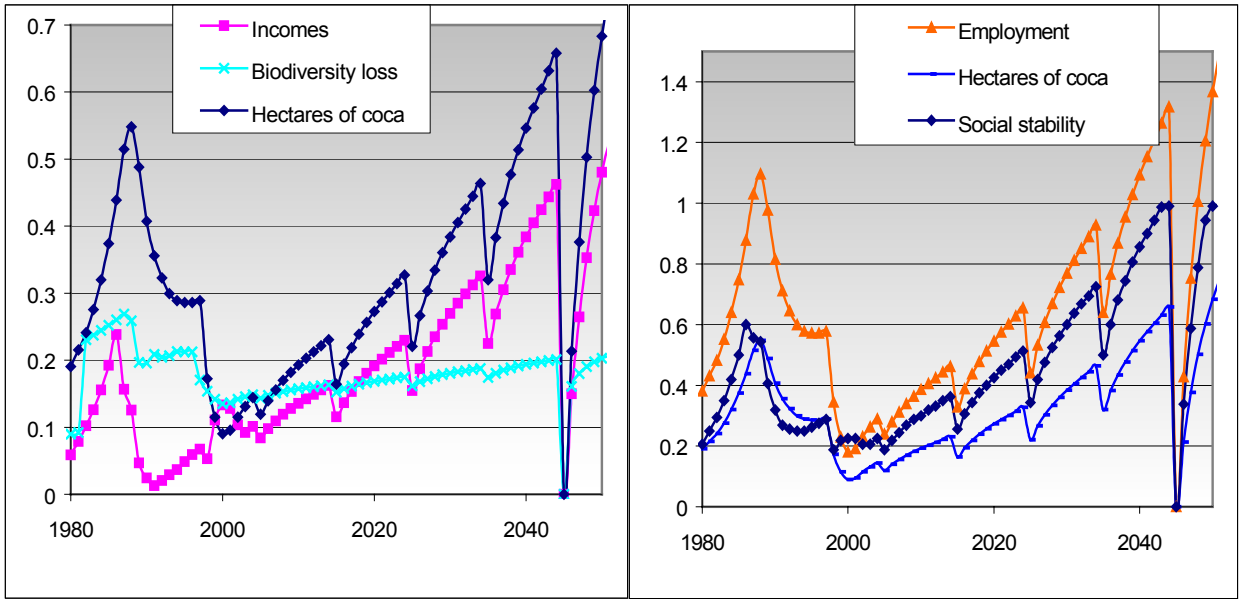

Figure 18a-b: Coca growing will be going with strict control in the eradication process.

So, in figures 18a y 18b, after the year 2000, many fluctuations are observed in the different used indicators, that is because in a given moment when the Bolivian government realize that the number of hectares of coca are getting up; again, it will try to eradicate them and every time with more intensity because the population will be increasing. According to model, a kind of collapse is found by the 2045 because every factor gets abruptly down, the only way to explain this is by saying that a sort of civil war could be started, which will be result of a constant pressure received by the farmers from the government in the eradication process. As observed, this scenario makes evident a big instability in the Chapare region and probably the number of

years, in which this situation could start, would be less. In fact, that depends on what kind of solutions might be proposed by the Bolivian government.

6.4.2. Scenario 2: Locoto is introduced in Chapare

This scenario is basically based on the previous one with the difference that since 2004 the trends have hopefully to change due to the introduction of locoto as an alternative crop. This scenario illustrates how the different indicators behave under some new conditions provided by the shift of locoto by coca.

Additional Assumptions:

1. The project starts in 2004; the initial demand is based on the national e international markets (only the US).
2. The price remains constant; it is equal to $US 0.55 per Kg (the average was taken from section 4.3).
3. The production cost is equal to $US 1017 (Diez 2001).
4. The substitution process of coca plantations by locoto is gradually made.
5. Social stability depends on incomes, employment for the whole population, which changes as a function of the time. The more population the more employment is needed and the more employment the more incomes are needed as well.
6. The demand is increased by year, the estimate was done based on sections 4.3 and 4.4. The increment per year in the demand of fresh locoto starts with 8% and drops until 5.5% in 2014. For dried locoto goes from 3.5 to 4.7% in 2014 and finally for the oleoresin goes from 1.9 to 2.8%. Afterwards, the different products demands remain constant.

Hect. Of Coca	Social Stability	Incomes	Employment	GDP per capita
1 E+05	Range 0 to 1	1 E+09	1 E+05	1 E +3

(*)To obtain the real amount of every factor multiply, the scale at the figures by the respective factor above

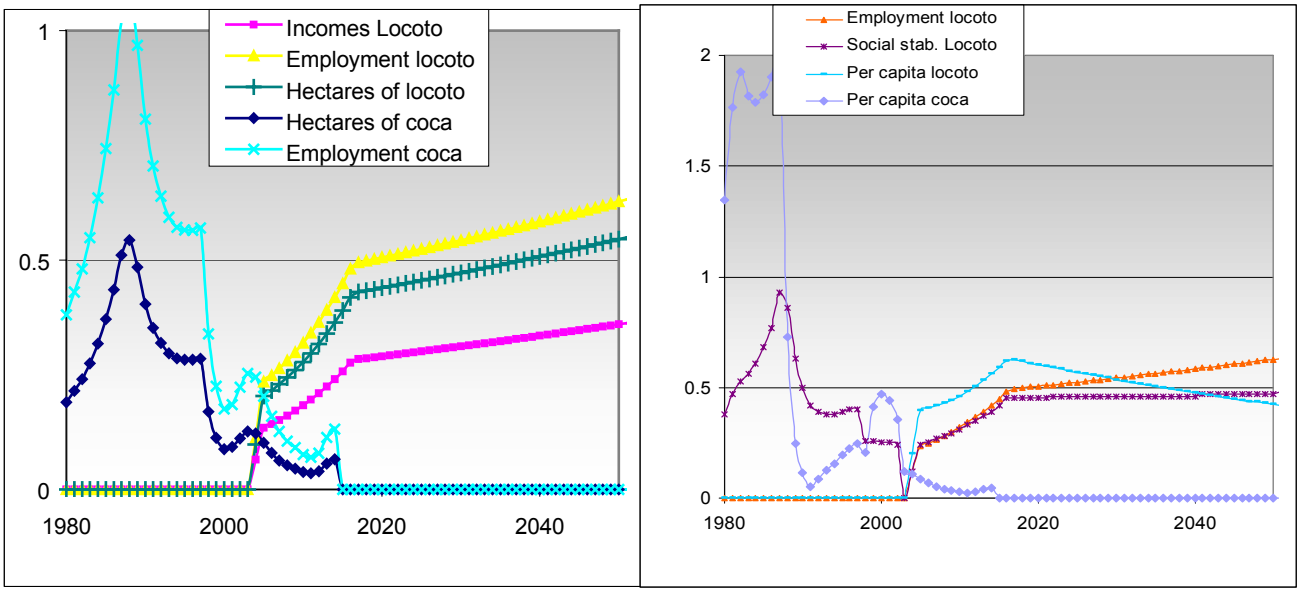

Figure 19 a-b: Trends when locoto is introduced in Chapare

7. Similar criteria as in coca was taken to estimate the number of employs per hectare of locoto, which makes an amount equal to 1.15 (299/260) permanent employs per hectare.

Figure 19 a-b illustrates that after the slight raise in employ-coca between 2000-2003, it is seen that when locoto starts to be introduced in Chapare the number of employs generated by coca growing drops that

is because some farmers would start to grow locoto creating new employs and having a new source of incomes. Naturally this process is slow and by 2013, looking at these trends, there will not be employs and incomes generated by coca. Something important to comment is that as employment is a function of the number of hectares of coca, the trend for this variable will essentially be the same, so the shift coca by locoto will not be a easy task because as seen in Figure 19a before employment get the bottom there is a small crescent tendency, which reflects a kind of resistance to the shift by the farmers.

In terms of social stability, scenario 2 provides a more stable system by tending to go up slightly in the next years, even though locoto provides less employment/hectare that might be because the yield of locoto per hectare is higher than yield of coca. The observed change in the slope with respect to the incomes, employment and number of hectares of locoto is due to the demand, which also changes as a function of time. Looking at 'GDP per capita' (Figure 19b), after the increase of this indicator, it is slowly going down, the reason is that as population increases the demand of locoto is not enough to keep all the people in Chapare.

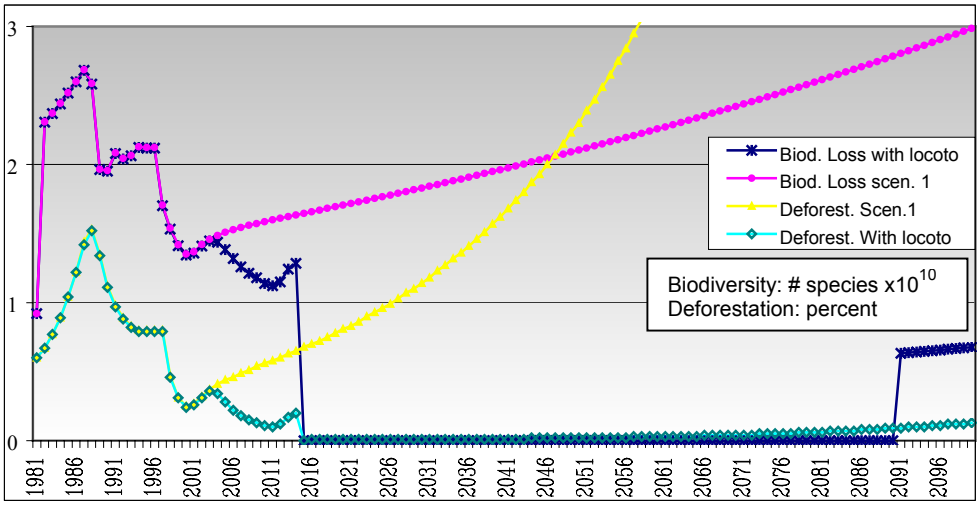

Figure 20: Comparison between scenario 1 and scenario 2

To have a view of a very long term, figure 20 shows how could change the trend with respect to the biodiversity loss and deforestation. If locoto is able to substitute coca plantations and is considered a licit crop to grow, the farmers will not have to look for a new or hidden land to grow coca. However, according to the model a new cause of deforestation might be initiated by 2056; Likely, this problem is a result of two main things; first, the new settlements due to the population growth and second because new land is needed to grow more locoto, for this reason in 2090 biodiversity loss increases abruptly again.

7. RESULTS AND FURTHER DISCUSSION.

7.1. Results

Based on the two built scenarios and the most important years for the whole system from economical, social and environmental perspectives, tables 10 and 11 have been obtained from the simulation:

Logically, the most important years in the coca history were 1987-1997, a lot of people got employment and also the major incomes were achieved, as result high levels of social stability; however, if scenario 1 continued, farmers would grow coca in the coming years, with relative pressure on the eradication though; that is very probable because since different policies were applied by different governments since 1988 the eradication process could not stop the coca production. Thus, under these conditions the social stability for scenario 1 is increasing over time but deforestation, biodiversity loss are consequently getting up as well. Naturally, this can be very well for the farmers and the whole society but to expenses of the environment.

Scenario 1b itself shows high levels of instability mainly due to the eradication process that could continue in the coming years.

Anyway, to reach high levels of social stability, it seems to be a very complicated task; as observed scenario 3 appears to be the more sustainable in terms of environment and socio-economic points of view even though over time the GDP per capita will likely be decreased. To achieve this value; the simulation found that the requirements in terms of market if we just focus on the US market are following:

National market: Initial demand equal to 4500 tons (By 2000) as fresh locoto.
International market: Initial demand equal to 40% of the US imports as dried locoto equal to 16247 tons.
Initial demand equal to 10% of the US imports as oleoresin equal to 12262 Kg.

In 2013 the needed land to grow locoto are 33964 hectares, which will generate almost 40000 permanent employs. The simulation also shows that locoto growing could reduce the cocaine processing and could promote better control on the deforestation; for this reason by 2013 the loss of biodiversity promoted by coca plantations, could get stopped.

The next table summarizes the benefits and problems by comparing coca vs. locoto:

Table 10. Summary of coca-locoto (Benefits & Problems)

	Social Aspect		**Economic Aspect**		**Environment**	
	Benefits	*Problems*	*Benefits*	*Problems*	*Benefits*	*Problems*
Coca	Very good source of employment, it requires a lot of labor. It is relatively easy to grow	Many confrontations with the government, drugs problems, pressure put on Chapare by the US to eradicate it	Very good source of incomes when prices get high	The coca appeared to be very important not only for the farmers but for the whole Bolivian Society	If programs were applied to cultivate coca as licit crop, itself would not bring great problems to the environment	The main are deforestation and the waste generated by the coca making industry, which impacts on the biodiversity loss and many risks with respect to the human health.
Locoto	Good source of employment but it requires less labor than coca	Possible confrontations with people who currently are growing locoto	Good source of incomes and higher yields per hectare than coca.	Currently, it is not considered as a potential crop. .	If it would be able to replace coca plantations, the rate of the deforestation created by hidden plantations of coca decreased. The more locoto growing, the less coca growing.	Risk of deforestation a long term. In regards to locoto processing and the industrial safety, the employed solvent might involve risks due to the inflammability.

7.2. Final Discussion

The problem of growing specific crops with the purpose to make some drugs as end product, it is not only being faced by Bolivia but also in many countries in the world (i.e. some countries in Asia and Africa); if we see and try to identify the main root-cause for this problem, we will realize that again 'poverty' is involved. In the case of Bolivia, two clear motives to increase the poverty were observed in the middle of 1980's; first, the terrible fall in the price of tin, on which the economy had depended for a long time, which provoked the closure of many mines owned by the government and second, the SAPs[35] implemented by the

[35] SAPs (Structural Adjustment Policies) are economic policies which countries must follow in order to qualify for new World Bank and International Monetary Fund (IMF) loans and help them make debt repayments on the older debts owed to commercial banks, governments and the World Bank. Although SAPs are designed for individual countries but have common guiding principles and features, which include export-led growth; privatization and liberalization; and the efficiency of the free market Tanzi, V. (1987).
The principal instruments of stabilization and adjustment have been currency devaluation, reduction of publics spending, price reforms, trade liberalization, reduction of subsidies, privatization of public enterprises, wage restraints, and institutional reforms, among others Panayatou, T. and K. Hupé (1996).

World Bank and the IMF to control the high Bolivian inflation that was followed by increased poverty which affected to the agricultural development system. So, many people got unemployed due to lack of agricultural alternatives in the rural areas and many other miners had to abandon the mines to look for other possibilities to survive, most of them with their families migrated to Chapare and then, they started to grow coca without having the necessary agricultural knowledge and also they began to participate in the illicit activity of making cocaine.

Since then, people have comprehended that the coca business is profitable and source of secure income, encouraging to more farmers to grow it; thus, through the years, this crop has become the favorite of every single farmer who remains or stays in Chapare.

As a result, the environment is being greatly affected by having problems mainly from the deforestation and cocaine making. As cocaine has become an important product in foreign markets, its consumption has been unstoppable and that is the reason why policies of eradication supported by the US government have been applied in Chapare by resulting in a very high social cost.

In spite of the fact that there were created several programs of alternative development, with the purpose to provide new possibilities to the farmers for growing other crops instead of coca, they were not successful mainly because either the markets were not big enough or the purposed crops were perishable.

The two imperative established policies, the Law 1008 (1988) and Dignity Plan (1997) have somehow achieved to reduce the cultivation of coca but the social stability has greatly been affected not only in Chapare but also in the whole country. Due to the constants obstructions in the high-ways and confrontations against military and police entities organized by the farmers, especially the last 2 years in response to these policies, the total eradication has been avoided by increasing in this way the cultivated area of coca again.

Analyzing the current situation and looking at the past failures, locoto has been proposed as new alternative product, but why locoto? Because, it is a product that can be transformed in other products, which can be trade in foreign countries, especially in the US. By transforming locoto in other products the perishability can be avoided and also what Chapare needs, is to grow crops with the ability to get markets outside of Bolivia as coca indirectly does. It has also been found that Chapare complies with the locoto requirements in terms of topography, climate and temperature to be grown.

A study of market shows that there is certain potentiality for exporting locoto as processed product, the market was mainly focused on dehydrated locoto and oleoresin even though there is also an important uncovered demand inside of Bolivia as fresh locoto.

As the US government is somehow part of the problem because it is forcing the Bolivian government to eradicate coca, it was thought that the US should open markets for locoto. Based on the statistics the US could allocate certain percent of its imports to Bolivia, in order to ensure to the farmers that its production will be purchased. However, the time of shifting coca by locoto, according to the model will relatively be a long period of time equal to 9 years starting in 2004. It has been observed that both crops are comparable even though coca appears to bring more benefits in economic terms. To find a competitive crop with the current prices of coca is highly difficult as there is scarcity of coca, the prices have gotten up because the market cannot be entirely supplied. The main findings with respect to the environment provoked by coca are deforestation and the processing of coca into cocaine, which would be reduced if locoto were started to be grown. In this sense, locoto does not have serious problems in relation to the environment but it can involve risks related to the industrial safety when it is processed into oleoresin; on the other hand, it does not show risks of water of soil contamination; the only thing to consider is the release of hexane into the air, which is carried out in small amounts. It is vital to be aware that if locoto is successful in the future, more land will be needed as consequence of the market expansion; it could promote deforestation as normally the cultivation of crops in a big scale, for this point is important to take into account that the government should allocate the land among the farmers by applying the term equity because as seen before there are a few farmers who own most of the land. In addition, every farmer should grow not only locoto but also other crops with an ensured market, by doing this the monoculture is avoided as well even though we should not forget that locoto could also promote certain risk to practice monoculture if it shows pretty good economic results.

Regarding the use of chemical fertilizers for growing locoto, it has been found that its not a normal activity performed by the farmers, today the tendency is to employ organic agriculture that results more expensive but it might help to open new markets outside of Bolivia. What's more, the most of the current locoto growers do not use pesticides or herbicides to control the pests, however it was seen that some of them are used doing that. Anyway, there is no certainty in the amounts that may be utilized either by locoto or coca growing but at least we can believe that due to the agricultural eco-knowledge that many locoto growers possess, it might be grown without using chemicals synthetic compounds and promoting the rotation of crops as well. What is certain is that a solution to the coca problem will only emerge once the existing repressive situation is replaced by participatory institutions engaged in dialogue with coca growers and the principles of sustainability are fully complied to create a truly path way to sustainable development. This must be supported by socialization, actor-ization and Dialogue-ization[36], they are the basis for the elaboration of a sustainable future.

To reach higher levels of social stability in Chapare, the market for locoto must be ensured at least for 10 years; anyhow, this does not imply the reached level of stability will be good enough to avoid future problems among coca growers-government-society at least during the process of shifting. The model has simply shown that it is possible to reach higher levels of stability compared to the current situation under the assumption that coca might continue to be grown; that is scenario 1 compared to scenario 2.

8. CONCLUSION

According to the results this study concludes that locoto could be considered a good option to replace coca plantations which promotes social stability, less damage in the environment and provides relatively good incomes to the farmers if the market is ensured. However, for the success of this project, correct tools of training and education must be provided to the current farmers. This must be done with the Bolivian government support and US government assistance. An important finding of this study is that with a high price of coca, the shifting coca by locoto will be extremely difficult. Therefore, we can affirm that the sustainability could be increased if locoto is grown instead of coca under the conditions mentioned above.

9. RECOMMENDATIONS

Previous to the project implementation field trips in situ should be done, with the purpose to confirm that locoto can be grown in Chapare without changing the expected outcomes in terms of color and capsaicin concentration. Some soil tests may also be carried out to determine pH, salinity and other properties needed to ensure the success of the project.

A cooperative or association might be created with the purpose to increase incomes for the farmers. In an organized entity, they could actively participate in the construction of their own locoto industry, at least to build the needed equipments for the drying and milling process; which is not a complicated task; this could create more employment as well. That is feasible with the support of some NGO's.

In the future, it is strongly recommended searching for more possibilities to open new markets especially in Mexico and Spain, which operate with important amounts of these types of products as well.

The government stimulates to grow locoto attending the requirements of the new locoto growers.

Programs of education and training must be implemented, first to make able to the involved people and second to improve methods for increasing the locoto yield.

[36] In order to promote a sustainable future, it is necessary that some basic transformations take place. Those are Socialization, Actor-ization and Dialogue-ization concerning environmental problems Nelisen, N., J. Van der Straaten, et al. (1997:404-405). Classics in Environmental Studies. Utrecht.

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