COMPETE PROJECT

REPORT ON TASKS 4.2 4.3 & 4.4

AUTHOR:

EMILIO DE LOS RIOS IBARRA

SUPERVISOR:

OMAR MASERA CERUTTI

REVISORS:
RENÉ DELGADO MARTINEZ
MANUELA PREHN JUNQUERA

MEXICO, SEPTEMBER 2007

CONTENT

Task 4.2: Documentation on improved energy crops and agroforestry systems in Mexico

Tables

Maps

Annex 1

Task 4.3: Best practices – Successes and failures from Mexico

Tables

Maps

Task 4.4: Cost benefit analysis of new energy crops and agroforestry systems in Mexico

Tables

Figures

Task 4.2 Documentation on Improved energy crops and agroforestry systems in Mexico

4.2.1. Introduction

The first part of this document describes Mexican landscapes and gives some facts about the use of natural resources, with emphasis on the semi arid and arid lands, where water scarcity has been the main natural selection factor in an otherwise highly diversified environment. This has resulted in many species adapted to live, grow and reproduce in the deserts of what is Mexico today.
People that have lived in these lands for centuries have learnt to manage this environment, through the use and domestication of the available plant species, developing a deep knowledge on plant and animal species and their management. This survival strategy has defined cultural identity and has been the basis of economic development. After a short description of Mexico's main socioeconomic and geographical features, the most useful plant species of arid and semi arid environment are mentioned, some of these plants are not cultivated but gathered in the wild. Others are the basis of industries that have evolved and have persisted through time, in spite modernization to conserve an important cultural indigenous knowledge.
The second part describes briefly some traditional uses of fuel wood, the main energy source for rural populations and cottage industries; this subject is treated more in detail in task 4.3.

The document ends with a presentation of some case studies of traditional agricultural systems, pointing out their importance and why they have persisted. The aim is to illustrate successful strategies that may be deployed to produce fuel crops, with the least interference with food production.

4.2.2. Brief description of Mexican landscape

Mexico is a federal republic of 31 states and a federal capital, with an estimated population in 2005 of 103 263 388 (INEGI Conteo nacional de población y vivienda 2005) of which 23.6 % live in Mexico City and its contiguous State of Mexico and Morelos.
Population has increased almost fourfold during the last 50 years, from 25 million to more than 100 million. Table 1.

Table 1 Mexican Population 1950-2000

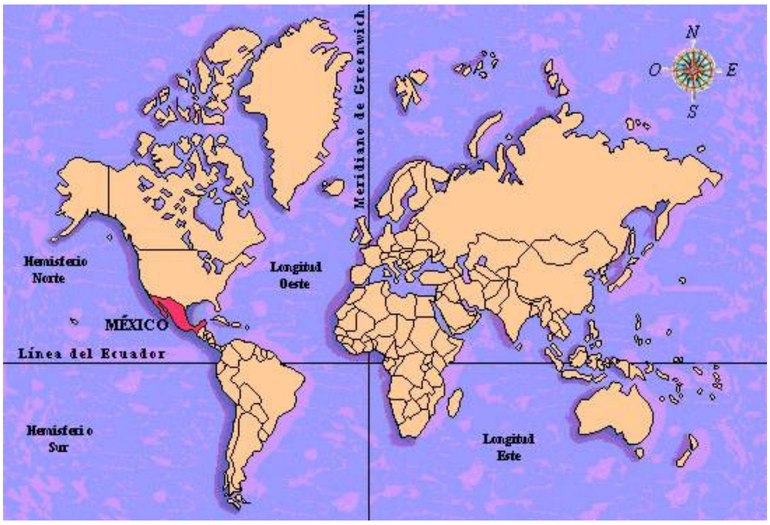
1950	1960	1970	1990	1995	2000
total population					
25,791,017	34,923,129	48,225,238	81,249,645	91,515,290	97,453,412
Proportion living in towns with less than 2500 inhabitants					
57.4%	49.3%	41.3%	28.7%	26.5%	25.4

source: INEGI Censos Nacionales de población y vivienda 1950,1960,1970 1990 2000
Conteo Nacional de población y vivienda 1995

It is important to notice that, though the proportion of the population living in towns of less than 2500 inhabitants, [1] has decreased, in absolute numbers the population living in rural areas has increased from 14,804,043 in 1950 to 24,912,587 in 2000.

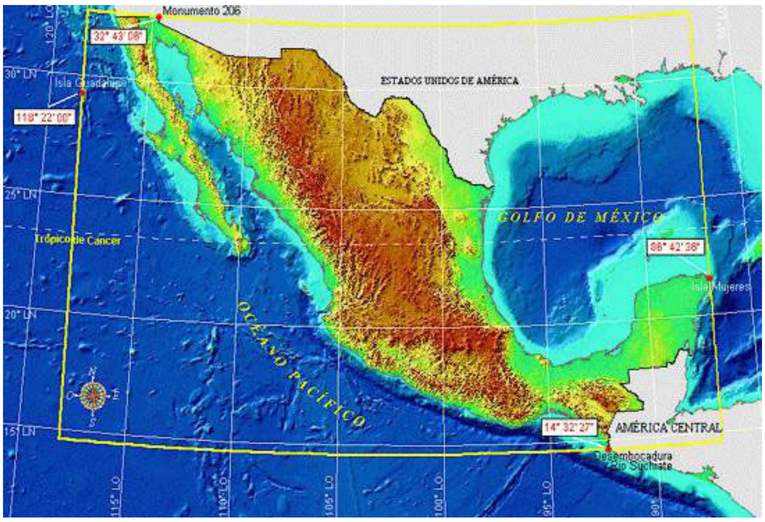
The economic and social development needed to offer education and employment to so many people has not arrived yet. This situation has corresponding effects on resource conservation.

The Mexican territory extends in the northern portion of Central America, from 32° 43‘ to 14° 32’ North, it is crossed by the Tropic of Cancer, this position causes a rainfall gradient which increases from the north to the south.



Map 1 Geographical situation

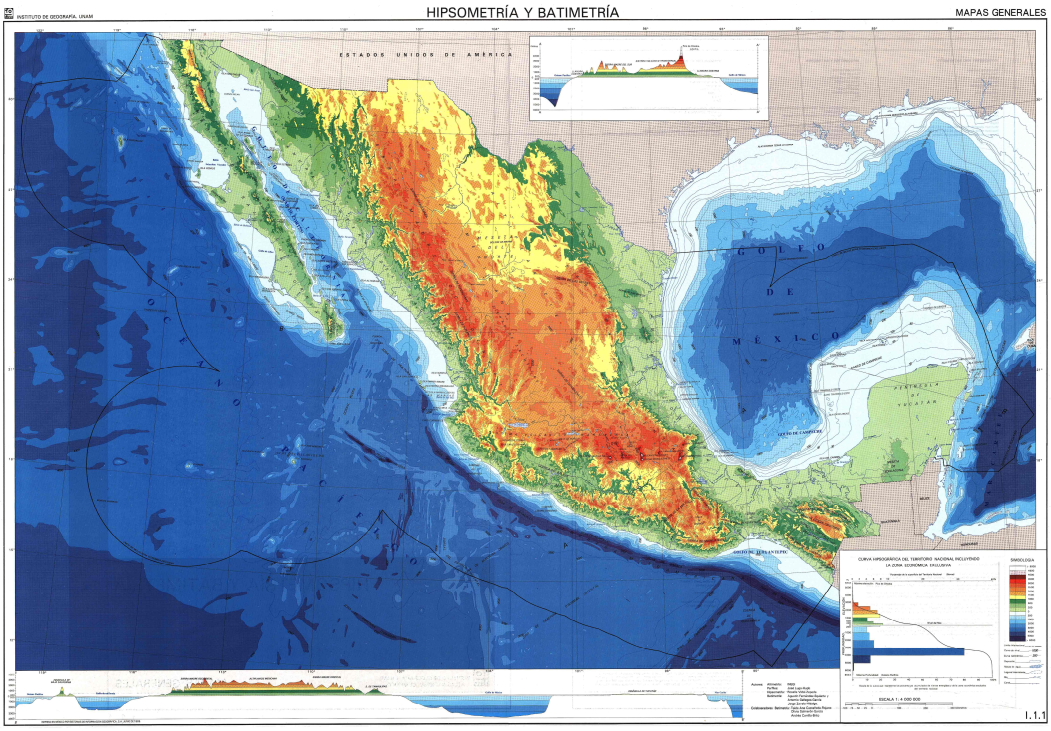
Mexico’s extension is 1 964 381 sq km, 5133 sq km are islands and the rest is continental land. The current population density is 52.57 inhabitants per square kilometer.



Map 2 Extreme coordinates of Mexico (INEGI)

[1] This is the criteria used by INEGI the Mexican Institute of statistics geography and informatics to differentiate urban and rural population.

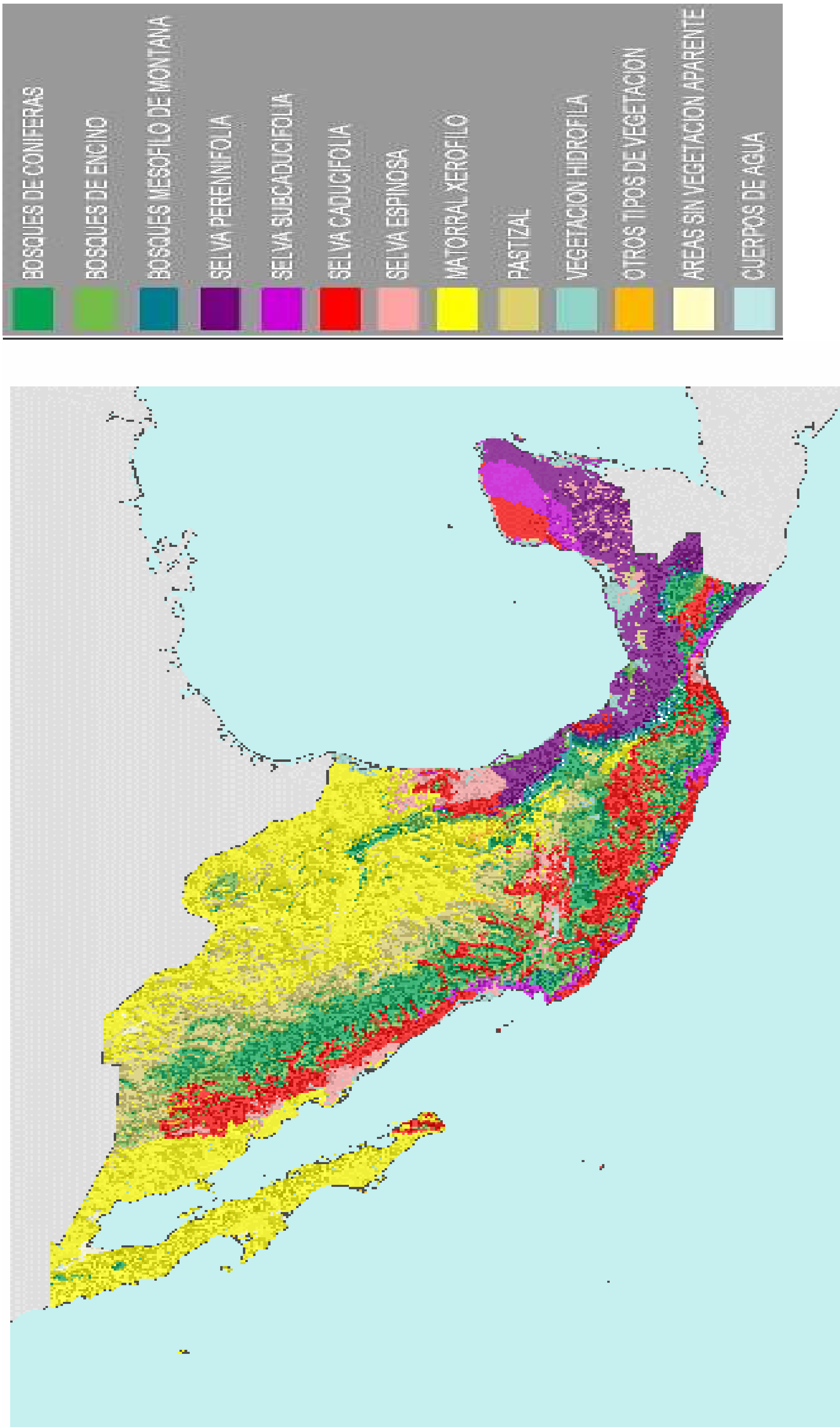
Mexico's western coastline reaches the Pacific Ocean and the eastern coast touches the Atlantic, Gulf of Mexico and the Caribbean Sea. Two mountain ranges, running rather parallel to the coasts, cross Mexico from north to south. In central Mexico, several other mountain chains run in a north west - south east direction. This results in a diversity of landscapes. The varying altitude above sea level influences vegetation, rain fall distribution and climate.



Map 3 Mexico's altitudes

Most of the main vegetation types existing on Earth can be found in Mexico; it is considered the fifth more biological diverse country. Its flora includes more than 30,000 recorded plant species, of which 52% is endemic. Mexico is also one of the world's centers where cultivated plants originated. Among the crops domesticated in Mexico we can find:

Maize*, Zea mays*, tomato *Licopersicum esculentum,* cocoa *Theobroma cacao*, beans *Phaeolus sp.,* squashes *cucurbita sp*., peanut *Arachis hypogea*, peppers *Capsicum sp*. pricking pear and other similar cactus *Opuntia sp* , tobacco *Nicotiana tabacum*, sweet potatoes *Ipomoea batatas*, avocado *Persea americana,* cotton *Gossypium hirsutum*, chayote, *Sechium edule*, soursoup*,* *Anona sp*., guava, *Psidium guajava,* several agaves *Agave sp*. yam bean *Pachyrrhizus erosus,* papaw, *Carica papaya,* pineapple *Ananas sp*., vanilla, *Vanilla planifolia,* annatto, *Bixa orellana,* biznaga, *Equinocactus sp*., chaya, *Cnidosculus chayamansa* , zapodille , *Achras zapota,* epazote, *Chenopodium ambrosoides,* edible "Guajes", *Leucaena sp*., gourds*, Lagenaria siceriana,* hierba santa, *Piper sanctum,* huauzontle, *Chenopodium nuttalliae,* hule, *Castilla elastica,* izote o yuca, *Yucca elephantipes,* yam *, Dioscorea alata,* mezquite *Prosopis spp*., allspice *Pimenta dioica,* marygold, *Tagetes erecta*



Map 4.Primary Vegetation types in Mexico

4.2.3. Primary Vegetation types in Mexico

The various primary vegetation types are mainly related to annual rain fall and its distribution through the year; the major part of the country receives less then 600 mm annual rainfall, which means that arid or semi arid land vegetation types predominate.

As a result there are different types of semi arid and arid vegetation related to an altitudinal gradient that influences mean temperature and frost presence. (Map 4 cartographic annex Vegetation Types)

Among the most common vegetation types in Mexico, natural grasslands and various types of xeric shrub land cover around 50% of the country, with approximately 6000 species, which represent almost 20% of the total flora.

In the past, rain fed agriculture was practised, deploying labor intensive water conservation works. In the 1970's, rain fed agriculture was abandoned to make way to cattle grazing, or where water was available, construction of water management structures allowed irrigated agriculture. Currently Mexico's most productive irrigated agricultural land is located mainly in the arid zones of the north west and the central high plateau.

4.2.3.1 The semi arid and arid vegetation

The semi arid and arid vegetation types can be as follows:

Xeric shrub land with shrubs and plants that are well adapted to arid conditions and very long dry seasons. This vegetation type is quite differentiated in relation to altitude above sea level, which influences seasonal temperature variation; the annual mean temperature varies from 12 to 26 °C. Most of the plant species have modified their leaves to spines or, when present, they are absent almost all year long, but during the short rainy season. Xeric shrub lands present a great diversity of living forms among which the most important is cacti dominated shrub land where (*Carnegia gigantea)* or Sahuaro, *Pachycereus spp*., and the Opuntia sp. shrub land are the most common.

Xeric shrub lands are not useful for agriculture; at present the major area covered by this vegetation type is used for animal production under range land grazing, or for collection of various commercial plant species, managed as a non timber forest resource. This constitutes an important income source for arid land inhabitants. The most important under this type of products are:

Palmilla (*Yucca schidigera*)

Palmilla is a rather woody shrub with several stems, it reproduces by root stocks and by seeds. In Mexico, its geographical distribution covers the states of Baja California. It covers more than 200,000 ha, from which more than 64,000 tons could be commercially exploited to produce 15,000 tons each year.

A juice that is contained in palmilla's stem is exported to the United States for producing a foaming agent that is used in soft drinks, steroids and food canning industries. It also produces compounds to reduce the level of ammonia and sulfhydric acid in livestock facilities. The bagasse is used as cattle feed.

In Baja California there are four industries specialized in Yuca's juice extraction. They produce 7 660 tons per year. But since this production is not enough to satisfy Mexican demand, some enterprises have to import this juice.

The 3 090 tons produced in 1993, represented a value of 400,000 dollars, the benefits were distributed among 1250 Mexican families.

Candelilla (*Euphorbia antisyphillitica*)

Candelilla is a prennial plant with almost no leaves, it reproduces from root shots, stem cuttings and seeds and it grows in semidesertic areas of the States of: Durango, Zacatecas, Chihuahua, Nuevo León, San Luis Potosí, Tamaulipas and Coahuila. In this last State 80% of the nacional production takes place.

There are more than 630,500 ha. in which this plant could be grown and by which more than 16 thousands families could beneficiate. Today this plant is grown only in 152,520 ha., which is less than 25% of the potential area.

A wax obtained from candelilla is used in multiple industries, among them cosmetics. Thanks to its chemical composition, its demand has been stable over the years, even though many substitutes for this wax are offered in the market.

Mexico is the main and almost the only producer of this wax in the world. Its level of production is determined by international demand, which depends on the price of substitutes, particularly oil derived parafinnes.

In 1993, candelilla wax exports accounted for 2,208 tons, in value more than 3.6 million dollars. Between 60% and 80% of the exports were to the United States, the United Kingdom and Spain.

Oregano (*Lippia berlandieri*)

The common name "oregano" is given to fourteen species of the Labiatae, Astraceae and Verbenaceae family, which grow in arid and semiarid regions of Mexico.

The species *Lippia berlandieri* represents 90% of the Mexican oregano production, which is found in the states of: Querétaro, Guanajuato, Hidalgo, Oaxaca, Jalisco, San Luís Potosí, Zacatecas, Chihuahua, Durango, Sinaloa, Baja California Sur y Coahuila. Worldwide oregano can be found in the United States. In the Mediterranean Bassin, Greece, Turkey, Israel, Egypt, Lebannon, Morocco oregano is produced from other species *Origanum vulgare*.

The leaves of these plants are used to condiment dishes and in herbal therapy, in a smaller degree they are used to obtain essential oils for soft drinks, cosmetics and alcoholic beverages.

At least 4000 tons of oregano could be collected yearly in Mexico, but due to climatic and economic factors only 50% of this potential is actually harvested. More than 90% of the oregano produced in Mexico is exported to the United States. The economic benefit from oregano harvest is more than a million dollars and exports double this figure.

Other species of economic importance that are managed as non timber resources are cacti *Pereskiopsis spp.,Hylocereus spp. Mammillaria spp., Lophophora williamsii*, gobernadora, *Larrea tridentata*, jojoba *Simmondsia chinensis*, yuca (*Yucca carnerosana*, damiana (*Turnera diffusa*), "zarzaparrilla" (*Smilax spp.*) and "cortadillo" *(Nolina cespitifera* . (FAO 1995)

The above mentioned plants are mainly collected, and of local importance. Two other genus of semi arid and arid origin have been widely used and some species have been domesticated: Opuntia and Agave. It is important to mention that this genus has abundant useful species in various regions of Mexico, some of which are managed as non timber forest resources and others are cultivated even beyond their natural range, as they have been incorporated in peasant [2] and commercial cropping systems.

Prikling pears *Opuntia sp*

Prickling pears are an important wild and also managed resource in arid and semiarid environments. Various species supply edible fruits, modified stems called clados are consumed as vegetable, used as animal feed and as support for growing insects of economic importance. Different wild and cultivated species are used in various regions for this purposes; the genus has two sub genus: platyopuntia and cylindropuntia.

Among the most important products of the first sub genus is the fruit of Platyopuntia, known as "tuna" when its flavor is sweet and as "xoconoxtles" when it is acid. The fruits are consumed fresh or serve as base for sauces, dishes and conserves. "White tuna" is obtained from *Opuntia amyclaea* and "yellow tuna" from *Opuntia megacantha*. Both species are cultivated and even often found wild in the central high plateau that covers the states of Zacatecas, Jalisco and Durango.

Besides consumption of their fruits, *Opuntia streptacantha* and *Opuntia leucotricha* are used for producing Mexican sweets and alcoholic beverages such as: "melcocha" and "colonche". Cladode of the first species that are mentioned is also used as cattle feed. *Opuntia robusta* is used for making beverages as well.

[2] Peasant is used for designating a household involved in agriculture, which consumes a part of its production, so the decision making involves two criteria: as a producer and consumer, usually partially integrated in an incomplete or imperfect market as described by Ellis F.1988

Cladodes of various species are commonly consumed as vegetables and they are an important ingredient of Mexican cuisine. High quality varieties are produced in mountainous areas near Mexico City to supply an ever growing market and help controlling soil erosion, where once was forest land.

Cladodes of *Opuntia jaliscana* serve as feedstock to raise a cochineal insect *Dactylopius coccus*. (Costa) *Dactylopiidae, Hemiptera* from which “grana”, a red natural dye, is produced. During the 18th century “grana” export value was on second position, only after silver. Today it is still under production and it is exported as organic colorant for food and sausages.

Photo 1 Grana Cochinilla production and sample

Agaves

Agaves have been widely used for centuries in northern Mexico as a wild resource and several species have been domesticated to supply fiber, food, raw materials for cottage industries and fermented alcoholic drinks and destilates. The most important economic wild species is:

Lechuguilla (*Agave lechuguilla*)

Lechuguilla is an indigenous species in the semi desertic central high plateau, its distribution covers the states of Chihuahua, Coahuila, Durango, Nuevo León, San Luis Potosí, Zacatecas and parts of Hidalgo, Oaxaca and the State of Mexico. In the United States it is present in the south of New Mexico, west Texas and south east Arizona.

The main production states are San Luis Potosí, Tamaulipas, Nuevo León, Cohauila, and Zacatecas. Potential production of these areas is estimated in 5,000 tons of fiber per year. The plant produces a fiber commonly called "Ixtle" which is used to make ropes, handcrafts and as raw material in glass, steel, paint and match industries. By-products of fiber extraction are used in car filters, carpets and as mattress stuffing. Sapponinne is extracted from the sludge of the defibration process and the root.

In 1993 only 1,062 tons where produced, which represent only 20% of the potential production. Most of the ejidos that produce lechugilla, extract and process ixtles, are organized in cooperatives. There are three firms that transform ixtle, and which have capacity to produce 23,640 tons per year. The most important of them is "Forestal FCL", which groups 642 ejido cooperatives and 30,000 producers.

About 52,000 families living in semi arid lands depend on ixtle production and trade. Products made with this fiber are exported to 49 countries incluiding Argentina, Brasil, Chile and Uruguay.

Cultivated agaves

Henequen (*Agave furcoydes), (Agave sisalana)*

Henequen or sisal produces a hard fiber of which agricultural twine and ropes are made. Henequen production and processing started in Yucatan, in the south east of Mexico, during the late 1860's. The mechanical reaper's invention, a machine that increased labor productivity by a factor of three in cereal harvesting, allowed production's expansion in North American plains.

Sisal production was one of the most successful plantation economies for about 80 years, reaching history records, as very efficient methods to transport and defibrate the plant were developed. Once fiber industrialization was integrated, it led to a very profitable industry. Introduction of the combine harvester first, and round bales after, caused a diminution of the demand for agricultural twine. Current production is at a minimum fraction of what it was and the remaining local industry processes import fiber from Brazil.

Some other agaves uses and cultures are described under land management examples, in Task 4.3.

4.2.3.2 Forests

4.2.3.2.1 Dry deciduous forests

Among semi arid vegetation types, dry deciduous forests are named according to the dominant or most important economic tree species. Some examples of are: "Mezquital" where *Prosopis sp* and "Huizachal" where *Acacia spp*. are the dominant species. Dry deciduous forest is present from sea level to 1900 m above sea level, generally in a microclimate. This gives a high diversity of floristic composition. Most of the dry deciduous forests in central Mexico were cleared, during the 17 and 18 centuries in order to produce lumber for mine tunnels and fuel wood, and later to produce charcoal to supply the growing cities with.

In general there is not a strict limit of arid or semiarid vegetation types. As rainfall and other ecological factors change, there is a transition from dry deciduous forests to other forest types.

Dry deciduous forests lead to a tropical low land forest with decreasing altitude and increasing annual rainfall and shorter dry seasons. When altitude and rainfall increase transition is towards temperate forest types.

4.2.3.2.2 Temperate forests

Beyond 1200 meters above sea level, with adequate rainfall, temperate oak forests appear; at higher altitudes oaks disappear and a coniferous forest appears. Coniferous and oak forests cover 21% of the country's surface with around 7000 species, which represent almost one fourth of the flora (24%).
Oak forests are very diverse ecosystems. According to Rzedowski J 1973 more than 200 oak species may exist in Mexico's temperate lands. Most oak forests lie between 1200 and 2800 m above sea level. Oak forests have been the most important source of fuel wood and charcoal, reason why oak forests have disappeared in the central part of Mexico making way for marginal agricultural land or graze land.

As altitude increases oaks become scarcer and conifers appear, at first in combination, and afterwards conifer forest predominates. Among Mexican conifers there are various genuses, Pinus, Abies, Pseudotsuga and Picea, and also a great diversity of environments where these forests grow, mostly in mountainous areas, where a difficult access has contributed conservation.
Conifer forests have been used for timber production not always in a sustainable manner; various protected areas have been declared with little success as the economic value of this forest has induced logging, even some times illegally. This subject will be treated in further detail in a section of task 4.3, that describes forest management in Mexico.

4.2.3.2.3 Low land tropical forests

In the southern portion of Mexico, rainfall increases and tropical forests with a variation in the number of species and life forms appear, from tropical deciduous forest to tropical evergreen forest. These various types of low land tropical forest once covered 30% of the country and contain more than 10,000 species which represent ± 35% of the flora. Aquatic or sub aquatic vegetation hold the remaining 10 % of the plant species.
Among the hot tropical forest, one of the most important types due to its extension is the sub deciduous tropical forest. It occurs where annual mean temperature goes from 10°C to 28 °C and where an annual rainfall of 1,000 a 1,600 mm. is registered. These forests have economic species that can reach heights of 15 to 40 m., among them *Enterolobium cyclocarpum*, "guanacaste",

Cedrela mexicana red cedar and several trees belonging to the *Ficus* and *Ceiba* genus.
These forests cover patches in the Pacific coast from Sinaloa in the north to Chiapas in the south, along the Pacific Ocean coast. In the Gulf of Mexico they cover parts of Yucatán, Quintana Roo, Campeche, Veracruz and Tamaulipas.

4.2.3.3. Forest management in Mexico.

Mexico, as already explained, has very diverse forest landscapes. This section deals with the economic, social and environmental importance of forestry.

In order to help reader's comprehension, a brief explanation of land tenure regimes in Mexico is necessary. Apart from private property, according to the Agrarian Law, ruled by the constitutional modification of 1992, two other land tenure regimes exist in Mexico: communal land, which replaces the figure of "Indigenous community" and the Ejido.
Indigenous community lands are recognized in Mexican law as belonging to indigenous communities, and they are based on colonial time land grants or ancestral rigths, which are in many cases difficult to prove. Since communal rigths certification has been difficult, some of the communities have been legally titled as ejidos.
There are an estimated 12 million indigenous people of different ethnic groups, based on the criterion of speaking an indigenous language. Under the communal regime, all land is managed as common property; a family can farm a plot allocated by customary law on communally held land.
An ejido is a land-holding consisting of either indigenous or non-indigenous members with rights to use land, that originally could not be sold. Law reforms now allow the selling of ejido lands. There are two types of land within an ejido: communal resources which are used by communal decision by an individual family or a group, and the parcels in which a fixed plot of land is allocated by communal decision to a particular ejidatario. [3]

According to a document in which for the first time the National Forest Commission (CONAFOR) undertakes a review of forests' situation in Mexico and delineates a long term strategy: "The various types of temperate and tropical forests in Mexico cover 55.3 million ha, 28.3% of the country's territory, 80% of forest area is under ejido or indigenous communal property, 15% is private property and the remaining 5% is national land. 12 million people live in forest areas, of which 5 million belong to 43 different indigenous ethnic groups. And most of them live under poverty." (CONAFOR 2001)

The fact that most of forest land belongs to ejidos or indigenous communities has historic roots. After the Spanish conquest, the best agricultural lands were taken by the conquerors; indigenous communities were forced to flee to the mountains to resist indent labor and evangelization. Yet population was scarce and large forested areas were not touched till the nineteenth century, when trade of colonial tropical products acquired importance.

---

[3] See the document in annex 1 for an historic account of Mexican land tenure regimes.

Commercial forest production was practised near urban centers that had developed gold and silver mines. Most of the oak and mezquite forests of the central high plateau disappeared to produce timber for mine tunnels and charcoal.

During the first half of the 20th century, when the first ejidos were formed, descendants of those who resisted colonial rules received forest land.

In 1926 the first forest laws where issued and national parks were established to promote conservation under ground water resource replenishment.

National parks near Mexico City included all water shed for the valley, under a long term vision concerning the need of water sources protection within the valley. Some years later national parks extension was reduced in order to allow a paper factory access in the preserved woodland.

Forestry was organized under two schemes: In national property lands with no population, the government gave a “deslinde” concession to private companies that surveyed a piece of land in order to get the rights to cut timber, collect non wood forest resources and /or fuel wood to make charcoal. When land belonged to an ejido or indigenous community, a contract was signed between the land owner and the private firm.
Vast areas of forest in ejidos where logged by private contractors, with the only requisite of a meager participation of the land owner, ejidos or communities, through a levy called “derecho de monte” (Forest rights).
Law stated that the contracts had to be renewed every year; such a short term inhibited planning and investment for a rational use of forest and promoted an extraction rate far above natural growth. Forests were mined, not without the complicity of authorities.
Under such arrangements remarkable fortunes were built. During the early 1970’s state intervention in the forest sector through state owned forestry companies was organized in temperate pine forests. These companies had the objective of ending with abusive contracts and allowing organization of ejido members for forest management. The companies were formed by the state, Profortarah in Chihuahua,[4] Protinbos in the State of Mexico, some others in Durango, Chiapas and Oaxaca. These companies had little success in rational forest use due to inefficient management, leading to a reduction in forest production.
This scheme included tropical forests accessible by river in Chiapas and Tabasco and easily accessible land in the Yucatan Peninsula.

Till the 1950’s, tropical forest in the south had a scarce or even any population, but during the 1960’s a drop in cotton prices caused a social crisis in cotton producing areas of northern Mexico, so that landless agricultural workers and share croppers suddenly with outincome claimed for land. Tropical forest in the south east was accessible by the recently completed South East Railway that linked Coatzacoalcos in the Gulf of Mexico to Mérida, in Yucatan. Land claims were satisfied in an effort to colonize the southern tropical lands; a massive

[4] For more details on temperate forest see Weaver 2000

directed migration of cotton farmers of northern Mexico arrived to Río Candelaria basin near the Mexico Guatemala border, to become peasants.
The news of available land spread rapidly and a spontaneous land colonization movement started in the rich forested area of the south east, especially the Lacandon forest in Chiapas, the new comers could provide the labor for timber extraction, and the government built roads to link the new settlements. So the infrastructure was set to enable the remaining timber extraction on those places far away from the rivers used to drift timber on previous logins.

Only a legal framework was needed. So the 6th of March 1972 a presidential decree was published in the official diary declaring 614,321 ha of the richest tropical moist forest in Chiapas as belonging to the Lacandon indigenous community, an isolated ethnic group of only 66 families. The existence of an indigenous community allowed "legal" extraction of mahogany (Swytenia macrophyla) that remained in the Lacandon area in Chiapas. Most of the timber was exported with a little or no transformation at all.

This example gives a clear picture of forest industry in Mexico that has been organized around timber extraction and completely separated from the wood working industry. It is evident that the productive chain's conformation is incomplete, inhibiting integrated industries and long term planning. This situation still prevails today. In consequence, forest owners, as it has been said, are among the poorest people in Mexico.

According to the National Ministry for the Environment quoted (CONAFOR 2001), forest production accounted for 1.3% of the GDP in 1987 and only 0.5% in 1996. During 1999, forest production value was approximately 1700 million US dollars and accounted for 1,2 % of GDP. In the latest FAO report on the world's forest state, Mexico is still losing forests at an alarming rate.

The environmental consequences of forest mismanagement and forest clearing for grazing and agricultural purposes, has led to various attempts to transform forest policy and legislation. Forest Law has been changed in 1986, 1992 and 2003, so its application rules in 88, 94 and 2005.

In 2001, the National Forest Commission (CONAFOR) was created; forests and water were declared as national security affaire. CONAFOR made funds available for investment and capacity building in the forest sector.

The National Forest Commission has a broad mandate to promote sustainable forest production and the conservation of forest resources, based on a Strategic Forestry Program with a 25-year horizon, and a National Forestry Program, (2001-2006). The new plan for the period 2007- 2012 is currently under elaboration.

An annual budget for 2002 of 1,500 million pesos (approximately US$135 million) was assigned to CONAFOR to:

(a) Stimulate forest producers' organization and assist them in associations creation under applicable legislation.

(b) Promote forestry by supporting viable projects to contribute to job creation and income generation in forest communities or communities that have an aptitude for forest production.

Through the implementation of the following programs:

PROCYMAF Mexico Community Forestry Project for Conservation and Sustainable Management
(Proyecto de Conservación y Manejo Sustentable de Áreas Forestales en México)

PRODEFOR Forestry Development Program
(Programa de Desarrollo Forestal)

PRODEPLAN Commercial Forestry Plantations Program
(Programa para el Desarrollo de Plantaciones Forestales Comerciales)

PRONARE National Reforestation Program
(Programa Nacional de Reforestación)

4.2.3.4. Fuel wood consumption and use

There are 28 million Mexicans, out of a population of 105 million, who depend on fuel wood as their energy source for cooking, heating and various cottage industries.

Before 1980 in the major part of the country, but the central high plateau, timber was abundant, so that not much attention was given to fuel wood consumption. Especially at that time, progress and economic growth allowed optimism and promoted expectations for poverty eradication within a short time span; in this way every Mexican would have access to modern living standards.

The first serious study of fuel wood consumption in Mexico was made in 1982 by Ana Maria Ortiz de Montejano, under the supervision of Ivan Restrepo at the Centro de Ecodesarrollo. (Ortiz de Montejano personal communication 1994)
By 1988, fuel wood was included in the National Energy budget. In 1995 a first attempt to regulate fuel wood use was made, by the issuing of what became the "**NORMA Oficial Mexicana NOM-012-RECNAT-1996",** that indicates the procedure, specifications and criteria to use fuel wood for domestic purposes. (DOF 26 June 1996)

Latter as the subject became fashionable, many studies have been made with regional or national coverage among which, the most important are: (Diaz Jimenez R. 2001) [5] according to this study in 1990 fuel wood supplied 316 PJ/year, which represents 46% of the final energy consumed by Mexican households.

[5] This document provides a very good general coverage of fuel wood studies in Mexico in its references.

Expected fuel wood contribution for year 2000 was 320 PJ/ year.

By 1990, 27 million Mexicans used fuel wood, nine out of ten rural inhabitants, and eleven out of a hundred urban used fuelwood as energy source for cooking. Between 1960 and 1990, population that used exclusively fuel wood decreased from 23 to 18 million but those who used fuel wood and other fuel increased (kerosene, LP gas), rising from one to eight million in the same period. This means that LP Gas is not replacing fuel wood, but complementing its use. Fuel wood consumption is concentrated in the following states:
Campeche, Chiapas, Guanajuato, Guerrero, Hidalgo, Michoacán, Oaxaca, Puebla, Querétaro, Tabasco, Veracruz and Yucatán. These states together consume 66% of the fuel wood energy.
For 1990 fuel wood atmospheric emissions accounted 10 million metric tons CO_2, which represents 2% of national GHG emission.
Work in the subject by Omar Masera and his group at CIECO, UNAM and the Mexican Bioenergy Network (REMBIO) should be mentioned in this matter.

At rural level, most ejidos use their forest resources marginally, extracting fuel wood as construction material for domestic purposes. Sometimes they produce charcoal, with little or no profit. As they are involved in imperfect markets and inefficient commercialization chains, price setting is beyond their control. So by selling their products, they usually only receive retribution of the labor priced at the local opportunity cost, in general very low.

Photo 2 Charcoal production in Huechenbalam, Yaxcaba, Yucatan

Photo 3 a burning charcoal pit Yaxcaba, Yucatan

Primary vegetation types have been cleared to make way for different indigenous agricultural systems; some of the most remarkable for their use of resources will be described.

4.2.4. Indigenous agriculture and agro forestry

During the years after the Second World War, Mexico experienced a period of high economic growth that was driven by an industrial sector development due to an import substitution policy. This period coincided with the starting of what came to be known as the “green revolution”, where plant breeding to develop varieties that could respond to chemical fertilizers and pest control products use, produced a rapid increase in agricultural output. During many years Mexican agricultural production grew faster than population, and it was not till 1967 that limits of green revolution became apparent, and for the first time population grew faster than food production. Nevertheless, the green revolution had created a polarized agricultural sector, with an input intensive highly productive sector and a peasant sector that wisely stuck to traditional methods as their lands were not suitable for the “modern” systems. As it is clear many different ecosystems that form Mexican landscape and its biodiversity have been the basis for the development of multiple cropping systems that go back to the origin to many of the world’s cultivated plants.
The general strategy deployed by Mexican indigenous farmers has focused on diversifying crops and natural resource use. In the major part of Mexico they exploit three spaces:

A plot of land for “milpa” to produce the staples, maize, beans and some other crops that varies from one place to the other.
A plot around the house where trees and perennial crops are grown to provide fruits, herbs and some vegetables, for sale or self consumption. Domestic animals are also kept in this place known as family orchard (huerto familiar). This “huerto” exhibits an extraordinary variation and diversity, between regions and personal knowledge. Besides “milpa” and “huerto” peasants obtain many natural products, including fuel wood from non cultivated areas, based in an ancestral traditional knowledge.

Photo 3 A growing milpa in Pustunich, Ticul, Yucatan

The traditional milpa is much more than a maize field, where corn grain is produced; it is a quite complicated system, usually intercropped: maize, beans and squash is the most common combination, but many others exist.
Milpa provides various products; maize grain for different foods: tortillas, tamales, atole, pozol, stalks are used as animal feed, spathes “Totomoxtle”, that cover the corn cob, are used as food wrapping and also for handycrafts and rituals, the corn cob “olote” from the nahuatl or bacal in maya is used for fuel, and aslo as stoppers for bottles and gourds. In central Mexico, most of the weeds associated with maize are used as greens for meat dishes, even some of the fungi that grow in corn, which are considered diseases in other places, are consumed, such is the case of corn smut (*Ustilago mayidis*), a local delicacy.

Though, in the south of Mexico milpa is still managed under slash and burn system, and literature on the subject is abundant. See Jarvis, J. et als 2002, especially for the Yucatan Peninsula, where slash and burn system remains dominant, which does not means that the system is not practised elsewhere.

In general, in low input traditional agriculture intercropping perennial and annual crops has been common, dealing with the spatial and temporal distribution of several crops to achieve production with an integrated soil fertility and pest management strategy, under systems recently grouped under the term agroforestry.
Mexico offers multiple examples of such systems in most of the regions. Though, apart of some remarkable exceptions: under story shaded coffee plantations, most of these systems are not well suited to a commercial agriculture context, and remain as part of survival strategy for peasants. Its greatest inconvenient refers to the long maturity period to get a profitable production and the great need of labor to perform the daily maintenance tasks, as there has been very scarce research and development of specific machines and tools to enhance labor productivity.
Since the early 60’s research priorities have stayed very far from efforts to improve traditional systems. Since at the time, Mexico was in the center of an international aim to breed maize and wheat varieties to respond to industrial inputs, chemical fertilizers and pest control chemicals. This gave origin to the green revolution. Some visionary agronomists alerted on the consequences and limitations of green revolution, nevertheless its impulse left a heavy influence in Mexican agricultural science.

The Green revolution movement had deep consequences for the traditional agricultural systems, increasing the productivity gap between peasant agriculture and those areas apt for an industrial input intensive agriculture, which normally are the areas with irrigation.

4.2.5 References

USDA Forest Service. 1986. Management and Utilization of Arid Land Plants. Symposium Proceedings, General Technical Report RM -135 Fort Collins Col. Feb. 18-22, 1985 Saltillo, Coahuila. Mexico.

Rzedowski, J. 1973. Vegetación de México. Ed Limusa México D.F.

FAO. 1995. Memoria - Consulta de expertos sobre productos forestales no madereros para América Latina y el Caribe, Santiago, Chile, 4 al 8 de Julio de 1994. Dirección de Productos Forestales, FAO, Roma, Oficina Regional De La FAO Para América Latina y el Caribe, Santiago, Chile1995
http://www.fao.org/docrep/T2354S/t2354s0y.htm
acceso 2 jul 2007

Weaver T. (2001) Changes in Forestry Policy, Production, and the Environment in Northern Mexico: 1960--2000
http://jpe.library.arizona.edu/volume_7/Weaver00.pdf
accessed 3 jul 2007

FAO 2004 Estudio de tendencias y perspectivas del Sector Forestal en América

Latina Documento de Trabajo ESFAL/N/2. Informe Nacional “México”. FAO Roma
ftp://ftp.fao.org/docrep/fao/009/j2215s/j2215s00.pdf
acceso 2 jul 2004

FAO 2001 Analisis De La Informacion Sobre Productos Forestales No Madereros En Mexico. Responsables: Marisela Zamora, Juan Manuel Torres. Santiago, CHILE 2001
www.rlc.fao.org/proyecto/rla133ec/PFNM-pdf/PFNM%20Mex.PDF
acceso 2 jul 2007

Deininger KW Minten Bart 2003 Poverty, policies, and deforestation:
The case of Mexico*. The World Bank International Food Policy Research Institute. Washington DC
http://www.worldbank.org/research/peg/wps05/mexico.pdf
access 2 jul 2007

FAO 2003 Estado de la diversidad genética de los árboles y bosques en el Norte de México; Preparado para el Taller Regional sobre los Recursos Genéticos Forestales de Centroamérica, Cuba y México. CATIE, Turrialba, Costa Rica, 24 al 29 de noviembre 2002. Documento de Trabajo FGR/60S
ftp://ftp.fao.org/docrep/fao/007/j0529s/j0529s00.pdf
access 2 jul 2007

Diario Oficial de la Federación, 26 junio 1996. NORMA Oficial Mexicana NOM-012-RECNAT-1996, Que establece los procedimientos, criterios y especificaciones para realizar el aprovechamiento de leña para uso doméstico. Secretaría de Gobernación, México D.F.

CONAFOR. 2001. Programa Estratégico Forestal 2001-2025. CONAFOR Guadalajara Jalisco.

Díaz Jiménez R. 2001. Consumo de leña en el sector residencial de México, Evolución histórica y emisiones de CO2. Tesis de Maestría en ingeniería, Fac Ingeniería, UNAM. México D.F.

Ellis F. 1988. Peasant Economics, Farm households and agrarian development Wye Studies on Agricultral and Rural Development Cambridge University Press Cambridge

Chávez-Servia, J.L., L.M. Arias-Reyes, D.I. Jarvis,J. Tuxill, D. Lope-Alzina, C. Eyzaguirre. 2002. Proceedings of a Symposium, 13–16 February 2002, Merida, Mexico Managing crop diversity in traditional agro ecosystems. IPGRI Rome

Annex 1

Land Tenure Systems in Developing Countries: Case Study Mexico.
SIE 526, Cadastral and Land Information System
By Vincenzo Marotta
www.spatial.maine.edu/~onsrud/emergingeconomies/country_reports/mexico.html - 44k -accessed 27 jun 07

Task 4.3 Best practices, successes and failures from Mexico

4.3.1 Introduction:

In Task 4.2 Mexican landscape is described, pointing out its rich biological diversity and how people that have lived for centuries in these lands have based on this diversity, their strategy for survival and economic development. In the following pages we will describe some remarkable examples of successful strategies, placing them within their social, environmental and economic context.

The first part offers a general description of the institutional, regulatory and policy context of Mexican agriculture, presenting the land tenure regime in a historical perspective, water use regulatory framework and a description of current policy instruments for agricultural support.

The second part describes some successful agricultural systems that have evolved in Mexico, starting with an ancient and original production system that originated before the arrival of Europeans in America and allowed Mexico's City urban development. The fact that this system is still practised today, more than 500 years later, gives an idea of its sustainability. Then we will describe how waste water irrigation systems in Valle del Mezquital have contributed to solve the environmental problems caused by urban growth in Mexico City for more than a century, in the world's oldest waste water irrigation district. In the same region agaves are planted in non irrigated lands for "pulque" production and soil conservation works for protection. The section ends with the description of other agaves and cactus use, in traditional and input intensive agricultural production systems, as examples of the economic and cultural importance of semi arid plants. We will end with some facts about the potential of other less known arid and semi arid plants as a source for oil and other industrial products, in order to emphasize the vast opportunities that research could open in the benefit of semi arid and arid land people.

The third part deals with short comings and failures of agricultural development projects in Mexico under bioenergy's development context.

4.3.2 Institutional framework for Mexican agriculture

4.3.2.1 Land tenure

Land tenure system in Mexico is derived from two different arrangements: (1) the system developed by the native indigenous population and (2) the system brought by the Spanish. The land tenure system of native societies was a patriarchal village-type landholding with a communal character. However, the communal system went under an extensive modification, gradually creating individual holdings. During the colonial period, the trend moved towards the accumulation of land in few hands. This unequal distribution of land and other minor factors were responsible for Mexico's War of Independence at the beginning of the 19th century. Around fifty years later under Porfirio Diaz rule, rapid economic growth brought industrialization, flourishing plantation economies and natural resource exports. Landholding concentration became an even more important social unrest factor. Together with industrial worker conditions were the origin of the 1910 revolution. Land redistribution became part of the commitments of the post revolutionary government.

Land redistribution was slow at first and proceeded throughout Mexico for more than 80 years. During this time labor productivity in farming evolved to allow a larger surface to be worked by a farming family, the surface that was considered too big for a family farm in 1940 was not the same in 1980.
In Mexico a maximum limit on privately owned land is set by law to avoid latifundia, as stated by Article 27. of the 1917 constitution.

Land distribution occurred gradually over decades. However, since the 1940's a new agrarian bourgeoisie started to monopolize high productivity lands, which became available when irrigation infrastructure was completed. This was possible thanks to legal loopholes and political and financial acquaintances. Corruption of state officials also facilitated extra legal land grabbing.
So, currently in Mexico a small minority number of powerful, well capitalized enterprises hold the best land, control the country's agricultural economy and export markets. In contrast to a vast majority of impoverished small holdings of ejidos and indigenous communities who lack technology, financial resources, credit, access to markets, information and training. [6]
Under the Agrarian Law, ruling the constitutional amendments of 1992, ejido and community legal rights and obligations are stated, giving the ejido or community general assembly the legal right to decide on two regimes of land use within the ejido: Common use or individual parcels use. The under common use land cannot be sold; on the contrary, individual parcels that get the status of private property can be sold.

There are 29,942 agrarian properties in Mexico, of which 8000 concern indigenous peoples, 63% of these are ejidos and the other 37% are communal lands. With population increase the surface per tenant in the ejidos has been atomized. This fact poses a great challenge for agricultural development, in particular in a context of scarce employment opportunities in rural and urban areas. In high production areas, land leasing, contract agriculture and other arrangements have grouped areas to increase agricultural operation efficiency.

At present, most of the support programs of Mexico's government tend to support the entrepreneurial development of ejidatarios. This subject will be treated later in this document.

4.3.2.2 Water resources

Mexico has a mean annual rainfall of 780 mm, about 27% of which becomes runoff of about 410 billion m^3 per year. Renewable groundwater is estimated at

[6] An account of historical evolution of land tenure regimes in Mexico is provided in annex 1 task 4.2

63 billion m^3 per year, 48 billion from natural recharge and another 15 billion from deep percolation associated with irrigation projects. Additionally there are an estimated of 110 billion m^3 of non-renewable ground water that could be available for one-time use. Climatic regions vary greatly from tropical rainforests with over 3000 mm of annual rainfall in the south to arid deserts with less than 100 mm in the north. Runoff variation is even more extreme, from over 2 million m^3 per square kilometer per year in the wettest areas to essentially zero in the dryest.

In the dryer parts of the country, precipitation and runoff are highly erratic with large variations from year to year and extreme seasonal differences. In these areas, rainfall occurs during a 2- to 4-month period and it is related to thunder storm and hurricane activities which can be very intense and cause flash flooding. Runoff is directly associated with precipitation events and most streams and even rivers dry up during periods of no rainfall.

Mexico is a country of approximately two million square kilometers with about 103 million inhabitants at the end of 2005, compared to a population of about 25 million in 1950. Population has increased in each part of the country, but it has been more important in the northwest, northeast and central regions, precisely the areas with most severe water scarcity. So population and economic activity are not located where water is available. Less than a third of total runoff occurs within 75% of the territory where most of the country's largest cities, industrial facilities and irrigated land are located. Consequently, water from surface runoff or groundwater is increasingly in short supply to support economic growth. This causes conflicts over the available surface water and over pumping of underground sources. Environmental degradation and water pollution problems worsen the situation. In some sites, paradoxically, water management structures have changed runoff regime, and water abundance causes severe problems of land drainage and flooding.

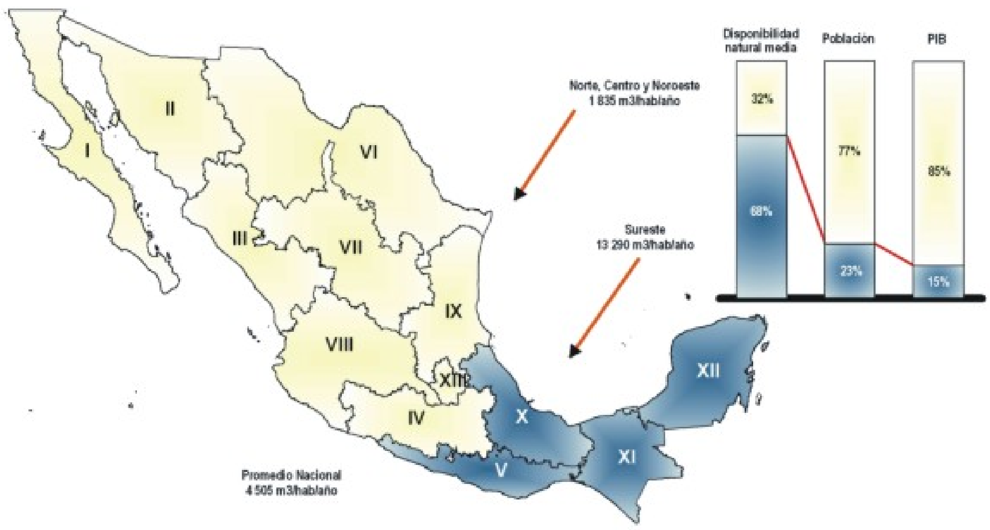
In this context it is evident that management, conservation and allocation of water resources are a complicated task. The increasing demand on the nation's water has reached the limit of its availability in many regions. Continued growth will depend on making water available to those sectors that require it in sufficient quantity and adequate quality, managing conflicts between urban and rural users, neighboring cities, and between states sharing a watershed.

Surface water has played a crucial role in Mexico's national and regional development. For over 60 years, the expanding use of surface water for irrigation, municipal and industrial purposes has been based on the development of hydraulic infrastructure. Further dam and other hydraulic infrastructure construction will be increasingly difficult, as the most economically viable water resources developments have been completed.

Two million hectares of irrigated agriculture, 55 million city dwellers and more than half of the industrial production in the country are dependent on groundwater for their supply. In most cases alternative sources of water are either not available or too costly. This has led to extraction in excess of recharge for most aquifers, which represents a major problem in the arid and semi-arid regions of Mexico, where not only most of the population and industrial production is located but irrigation is also a major water consumer.

The National Water commission has identified and characterized 600 aquifers and performed hydro geological assessments on many of them. They have determined that 100 of these aquifers are presently overexploited. (World Bank 1996)

Contraste entre el desarrollo y la disponibilidad de agua



Fuente: Integrado por la Subdirección General de Programación. CNA.

Map 1 Water resource localization in contrast to population and economic activity.

4.3.2.2.1 Water Legal and Institutional Background

Before the Spanish conquest in 1521, the relationship of the Mexican people to water was both religious and practical. On the one hand, worship to water deities was common and, on the other, practical situations generated rules stating who could use water, how to solve conflicts among water users and how to cope with floods. The social organization allowed the construction of water supply, irrigation and flood control works and navigation systems.

During the 300 years after the conquest, water belonged to the Spanish crown and a royal grant was required to access to its use. Management of grants passed under Mexican government control after independence in 1821.
The current law and regulations have their legal support on the Mexican constitution issued in 1917, the most important points relevant to water resources management are:

- The State shall ensure that all social and economic activities will be undertaken with due care of the environment.
- Article 27. Water within Mexico’s territory is national property, water management is a state responsibility and the state can grant “concessions” for water use.
- Article 115. Municipal governments, with assistance from state governments, are responsible for municipal water supply systems.

As a state owned resource in the past, water resource development had two driving forces which were not always compatible: urban water supply and irrigation and hydroelectric power development. Back in 1926, the National Irrigation Commission was established and some years later, in 1937, the National Power Commission (CFE) to develop power utilities, as electrical energy generation, still a state monopoly, that only recently has allowed some exceptions.
Both entities developed hydraulic infrastructure for irrigation and power.
Irrigated lands were developed in most parts of the country. To manage these irrigated lands, the National Irrigation Commission became the Ministry of Water Resources (SRH). This ministry continued building infrastructure and operated irrigation districts within a regional organization, on the basis of watersheds, that includes territory of several states. These authorities called Commissions after the countries main rivers.
The watershed authority or commission had among its responsibilities the operation and maintenance of hydraulic infrastructure and irrigation district management, with ample power and budget, resulting in a heavy state influence. While the agriculture ministry dealt with rain fed traditional agriculture, the ministry of hydraulic resources dealt with irrigated agriculture, increasing the technical and productivity gap between both systems.

With a growing population urban water supply started to compete with irrigation for scarce water resources, with growing water scarcity, increasing water pollution by sewage and industry became an issue during a period of economic crisis in the 1980’s. A body was created, the “National Water Commission” (NWC), in February 1989 to facilitate structural reform in the water sector. During 1992 a new water law was enacted, which defined the NWC as “the sole federal water authority in the country.” Initially, it remained attached to the Ministry of Agriculture and Water Resources, but in 1995 it moved to the new Ministry of the Environment. The 1992 law incorporated structural reform in water management. The law was based on a combination of regulatory and economic instruments to enhance sustainable water management. In April 2004, the water law was substantially amended and set the base for water rights management. The new law includes following regulatory, economic, and participatory instruments:

Water Concessions: water use by individuals or legal associations needs a concession granted by the federal executive through the NWC for a period of 5–50 years. This concession concerns a specific water source and a specific water use; in the case of irrigation a specific plot and to be transferred it needs NWC’s agreement. Table 1 presents the different categories of freshwater use

in Mexico for 2002 in terms of annual concessions, volume and number of users in the Water Rights Public Registry.
The range of water users is very wide; for instance, a user in agriculture can be an individual farmer or an irrigation system of more than 10,000 hectares, an urban/domestic user can be a few households sharing one single water source or Mexico City's supply system, including hundreds of water wells and transferred surface water from a neighboring watershed hundreds of kilometers away. By 1992, there were an estimated of 300,000 users. However, only 2,000 of these users had a formal water use concession. Ten years later, 327,650 users have been granted with a formal concession. Among Mexico's slightly over 100 million inhabitants, more than 20 million live in Mexico City and water supply for the city is a growing challenge.

Water Rates: Rates were set for water use as a public good and for the services provided by the state. This means setting the rates for concessions and sewage discharge permits on the basis of economic instruments –such as the "user pays" and "polluter pays" principles- operational. In principle as in practice there are still short falls in the coverage of such payments.
The rate for water charges depends on the specific use and the relative scarcity of the water source, the rate for wastewater disposal charges depends on the pollutant load and the risks involved.
Concessions for irrigation have a preference rate but they are set in a volume per area basis which does not induce water efficiency. Excessive regulation makes it difficult to comply with the law and it is still the NWC who decides in case of conflict. Since water rights tradebility is limited, the short duration of concessions may restrain investment.
In conclusion, water regulations have still to be enforced correctly, to really provide a rational and sustainable water management system. Irrigation administration has its pitfalls and some regions face water scarcity for irrigation and urban water supply. Waste water treatments are not at the required levels.

Table 1 Water use concessions in Mexico according to Water Rights public register 2002

Category	**Volume (billions of cubic meters/year)**	**Estimated number of users**
Hydropower	145.6	88
Agriculture and livestock	56.1	185,856
Urban and domestic (a)	9.6	133,404
Industry (b)	6.9	8,302
Total	218.2	327,650

(a) Includes industry supplied by water mains.
(b) Self-supplied industry, including thermal power plants. Source: National Water Commission.

In major areas of Mexico water availability is limited and biofuel production is going to compete with food production for this scarce resource. A water opportunity cost and benefit analysis is needed to judge the feasibility of using water for a specific purpose in a certain place. This won't be easy given the legal framework for water management.

4.3.3 Agricultural and Rural policy instruments

4.3.3.1 Background for recent agricultural policy

During 1976 an economical crisis caused the Mexican currency a loss of half of its value, ending a period of steady economic growth. Two important factors underlied this crisis: country's wealth had concentrated in few hands and a rapid population growth led to the concentration of vast proportion of the population impoverished in growing urban slums. Securing food supply for these slums became a national issue, shifting the focus from agricultural policy to food policy, under the name "Sistema Alimentario Mexicano" (Mexican food system), Food self sufficiency was abandoned as an objective to support an agricultural trade balance. Food supply for the growing urban population needed grain imports; in order to pay for them, those agricultural products in which Mexico had a comparative advantage had to be exported.

Six years later, in March 1982, a second devaluation, due to excessive debt service, almost collapsed Mexican economy. The exchange rate rised from 22 pesos per dollar to 150 pesos per dollar in a few months with a hyperinflationary process.

This crisis gave way to a structural adjustment policy with the intervention of the IMF, International Monetary Fund. Structural adjustment aimed to reduce government expenditure. For agriculture, it implied dismantling government owned enterprises and government institutions related to agriculture.

These firms and institutions were involved in input supply: fertilizers and seeds, financial services: credit and insurance, commodities: coffee, tobacco, sugar cane, cereal and pulse storage, agricultural research and extension, water management and irrigation infrastructure maintenance.

Within the food sector the State was involved in the marketing chain of some commodities, milk, maize, pulses and maize flour. Some of these state owned firms were involved in subsidies distribution to farmers and consumers.

After the dismantling, some of the services once provided by state firms and institutions were taken over by the private sector, though the coverage was restricted to those sectors and geographic areas where these activities could be profitable, leaving most of the least favored peasants unattended. An illustrative example is agricultural research, which has not yet recovered from the 1982 crisis. Links between research, farmer's problems and needs are weak. Extension service is not directly linked to research, as it is done by private individuals or firms, nor does it have the needed influence from organized farmers. Infrastructure and service supply in rural areas is poorly developed; in particular schooling level of rural population is certainly a limiting factor to new ideas and innovative forms of farmer organization. (See table)

Table 2 Schooling for population of 15 years and older

% of population 15 years and older	Rural	General Population	Mexico City
illiteracy	21 %	9.6 %	3 %
average schooling years	4.8	7.6	9.7
primary education	24.6 %	51.6 %	71.6 %
population 15-19 years in school	28.9 %	46.7 %	64.4 %

source 2000 census INEGI

In this context it is not surprising that most of rural population currently lives under severe poverty.

During the years after 1982 agricultural exports, mainly fruits and vegetables, increased as the exchange rate made exports very attractive. Mexico joined the GATT and started signing free trade agreements, the most important among them being North American Free Trade Agreement, signed in 1994. This agreement will bring complete liberalization of agricultural imports by January the 1st 2008, till now there has been a gradual withdraw of tariffs and taxes. In a free trade context, Mexican agriculture dwells in a much more competitive environment, though most of Mexican farmers lack a support structure to succeed.

4.3.3.2 Poverty eradication programs

A poverty eradication program has huge influence in rural areas; it is intended to bridge the inter-generational transmission of poverty by helping the young generation through the difficulties to advance in schooling. The program, currently called “Oportunidades”, started as “Programa de Educación, Salud y Alimentación (Education, Health, and Nutrition Program), known by its Spanish acronym, PROGRESA.
The program has a multiplicity of objectives and it aimed primarily to improve the educational, health, and nutritional status of poor families, particularly of children and their mothers. PROGRESA provides cash transfers linked to children’s enrollment, regular school attendance and clinic attendance. The program also includes in-kind health benefits and nutritional supplements for children up to age five and for pregnant and lactating women.
Program’s expansion across localities and over time was determined by a planned strategy that involved the annual budget allocations and logistical complexities associated with the operation of the program in very small and remote rural communities (such as verification that the localities to be covered by the program had the necessary educational and health facilities).

The program started in August 1997, incorporating 140,544 households in 3,369 localities. In its final phase during early 2000, the program covered nearly 2.6 million families in 72,345 localities in all 31 states. This constituted around 40 percent of all rural families and one ninth of all families in Mexico. The program’s total annual budget was in 1999 around $777 million, equivalent to just under 20 percent of the federal poverty alleviation budget or 0.2 percent of gross domestic product (GDP). After 2000, when the government changed, the program received a new name, “Oportunidades”, and since 2006 it includes a payment of $250.00 pesos a month for adults above the age of 70 years old in beneficiary households.

As part of an overall strategy for poverty alleviation in Mexico, PROGRESA works in conjunction with other programs that are aimed towards developing employment and income opportunities (such as Programa de Empleo Temporal [PET]) and facilitating the formation of physical capital, such as the “Fondo para la Infraestructura Social Municipal” (FISM).[7] In Mexico, PROGRESA represents a significant change in the provision of social programs. First, in contrast to previous poverty alleviation programs, PROGRESA is aimed at the household level to ensure that the resources of the program are directly delivered to households in extreme poverty; that is, households that can most benefit from the program. General food subsidies, such as the tortilla price subsidy (Subsidio a la Tortilla [TORTIBONO]) are widely acknowledged to have had a high cost on the government budget and a negligible effect on poverty because of the leakage of benefits to non-poor households. In addition, more decentralized, community based, demand-driven programs such as the earlier anti-poverty program Programa Nacional de Solidaridad (PRONASOL) during 1988 and 1994, were thought to be susceptible to local political influences and not very effective at reaching the extreme poor.

Under PROGRESA, communities are selected using a marginality index based on census data. Then, within the selected communities, households are chosen on the basis of socioeconomic data collected for all community’s households. The program acts simultaneously upon health, education, and nutrition, delivering its resources to mothers, recognizing their potential to use resources effectively and efficiently to address immediate family needs.

4.3.3.2.1 Description of the Educational Benefits and Program Requirements

Education is seen as a pivotal component of PROGRESA, reflecting the strong empirical link between human capital, productivity, and growth, but especially because it is seen as a strategic factor in breaking the vicious cycle of poverty. Investments in education are therefore viewed as a way of facilitating growth while simultaneously reducing inequality and poverty. The program’s stated objectives are to improve school enrollment, attendance, and educational performance. This is intended to be achieved through four channels:

1. A system of educational grants
2. Monetary support for the acquisition of school material
3. Strengthening the supply and quality of education services
4. Cultivation of parental responsibility for, and appreciation of the advantages stemming from, their children’s education.

These are obviously interrelated, so that each is thought to enhance the effectiveness of the others in improving attendance and performance. The system of educational grants is intended to encourage regular and continuous attendance, especially for females. This is reflected in two crucial design

[7] For a more detailed description of the various anti-poverty programs in Mexico, see Skoufias E. (2005) IPFRI

features. First, the size of the grant increases through grade levels. Second, at the secondary level, grants are higher for females. This last feature is meant to address the cultural gender bias against female social participation, as well as being an attempt to internalize education externalities that accrue to other families after women' marriage. The level of the grants was set with the aim of compensating for the opportunity cost of children's school attendance.

4.3.3.2.2 Description of the Health and Nutrition Component

The health and nutrition component can be seen as a collection of a number of interrelated subcomponents, namely:
1. A basic package of primary health care services
2. Nutrition and health education and training for families and communities
3. Improved supply of health services (including annual refresher courses for doctors and nurses)
4. Nutrition supplements for pregnant and lactating mothers and young children.

Although the general focus is on improving the health and nutritional status of all household members, special emphasis is placed on the welfare of mothers and children.

4.3.3.2.3 Monetary Transfers Received by PROGRESA Beneficiary Households

For 2006 the program covered 5 million families. Under 2007 operation rules for "Oportunidades" payments are as follows:

Food support month 180.00 pesos /family

Monthly Scholarships:

3th grade primary 150.00
4th grade primary 240 year
secondary 350 boys 370 girls
High school 585 boys 675 girls
655 boys 760 girls

Plus a payment of 160 pesos for school materials in September and 80 pesos at school year. A payment of 250 pesos for any adult of more than 70 years

Currently several federal programs exist to fight poverty and support farmers by direct payments or subsidize small farmers, to promote the integration of farming with industry and to increase added value to crops.

The most important agricultural support program is Procampo.

PROCAMPO was implemented in Mexico in the winter 1994, the agricultural season following NAFTA's commencement. The program was designed as a 15-year transition to free trade and it is expected to end in 2008. Eligibility, and therefore the maximum level of PROCAMPO transfer payments, vary across

households and they are based on household behavior during the pre-PROCAMPO period. PROCAMPO provides eligible agricultural producers with a fixed payment per hectare. This payment is decoupled from current land use and it is the same across the whole country. Eligibility's level is dependent on the total hectares of nine key crops (corn, beans, rice, wheat, sorghum, barley, soybeans, cotton and safflower) that were planted during the three agricultural years prior to and including August 1993. Latter in 2001 the program was extended to any licit crop or ecological project under the ministry's of environment supervision.
Eligibility was actually given to land parcels and those with usufruct over these land parcels, not particular farmers, and payment should go to whom ever is planting the property, whether owner, renter or sharecropper. The eligibility roster was fixed prior to commencement of the program. Theoretically, the farmer who receives a payment for a particular property may change depending on who is using the land, though in practice most benefits accrue to the owner, either directly or through the rental price. Since there are potentially two agricultural seasons per year, PROCAMPO payments may be received up to twice a year, though in general only farmers with access to irrigation can take advantage of the second agricultural season. Payments correspond to the amount of land currently under production, which cannot exceed the amount of land registered in the eligibility roster. Farmers must prove that the parcel is currently under production, but monitoring of actual planting is haphazard, and many devices are employed to skirt this requirement. However, given that the program is based on past agricultural production and the requirement that farmers continue producing or that they participate in an official environmental management program, the intervention is closely and intentionally linked to agricultural production.

Since PROCAMPO is distributed on a per hectare basis, larger farms have tended to get higher total transfers. SAGARPA (1998) data state that households with less than 5 hectares make up 45 percent of recipients, but receive only 10 percent of total transfer payments. However, PROCAMPO provides a uniform payment per hectare regardless of yield or if the output was sold on the market. PROCAMPO thus over compensates smallholders who may have had limited yields and reaches households who did not benefit from pre-NAFTA price supports since they had no marketed surplus.
Current changes to the program include moving payments to prior to planting, so that farmers are able to directly use the transfer for the purchase of inputs and thus avoid paying high interest rates. This enhances the value of PROCAMPO as a mechanism to overcome credit market failure and increases the likelihood that the transfer will be used for agricultural investment. A new plan allows farmers with an investment plan to move forward in time all future PROCAMPO payments into one large payment (PROCAMPO, 2001).

Beneficiaries are defined in the operation rules published in the DOF (Diario Oficial de la Federación) on February the 20th, 1994, and regulations are published every year.

The end of Procampo is programmed for December the 31st, 2008.

4.3.3.4 Farmer support programs

Other programs include subsidies for investment in more productive machines or processes, risk sharing in new enterprises and facilitating small farmer's access to credit by helping small farmer organizations overcome high transaction costs and get warranties needed to borrow money.
Coverage and scope of these programs are quite limited, as often the research to support innovation is lacking, which increases investment risk. In an expensive credit environment, this results in chronic shortage of productive employment in most of the agricultural regions of the country, especially in the south.
Young generations are forced to migrate towards cities or to the United States, remittances from abroad are now the second national source of foreign currency for the Mexican economy and an important source of income for rural families. A more detailed analysis of current agricultural policy can be found in OECD 2007.

4.3.3.5 Forestry support programs

Since 2001 the National Forest Commission manages several support programs for the forestry sector, see Task 4.2. Since 2007 the various programs for forest development have been united in an only program known as "PROARBOL"

The program includes direct transfer payments for the following concepts to the owners of forest land:

Forest planning and development

Regional forest management studies: this category supports the elaboration of forest appraisal and planning studies, at regional level. These studies are the required technical instrument for forest management; it is a legal requirement for forest use.
Forest management programs: this category supports the elaboration of forest management studies at plot level. These are a legal requirement for forest use. They include the payment for environmental impact assessment study in the case of native forests.

Forest development and organization: this category deals with forest development and enhancing forest owner organization.

Forest production and productivity: Including following concepts:

Forest management: for execution of forest management and silvicultural management practices and operations to increase forest productivity as thinning, replanting, clearing and follow land management.

Forest land use diversification: This support is foreseen for promoting alternative use of forest resources as nature tourism, hunting activities, wild life and flora conservation and other similar practices.

Commercial forest plantations: For the establishment of commercial wood plantations

Conservation and restoration of forest lands: for realization of soil and water conservation structures or soil restoration.

Reforestation: to promote tree planting and forest vegetation for restoration and conservation purposes

Soil conservation: for soil conservation, restoration and fertility management

Forest fire prevention and control: to support forest fire control and prevention

Forest pest management and control

Environmental services: to promote and develop environmental service markets in forest ecosystems

Increasing the competitivity level

Equipment and infrastructure: For investment in equipment, tools or infrastructure to increase forest productivity or value added to forest products

Productive chain development: For investment in the development of forest product productive chain development

Technical and preventive audit and forest certification: To promote sustainable forest management certification, including studies and the necessary investment to increase forest protection and to facilitate entrance to national and foreign markets

Training and forest sector capacity building: for human resource development in forest management and productive activity diversification to enhance value added to forest resources and forest industry.

The program is in its seventh year and it has had some pitfalls, especially in the states where forest personnel for undertaking studies are scarce. Sometimes forest management has found some resistance from environmental authorities, especially in tropical forests where an environmental impact assessment is necessary and the duties to pay to environmental authorities for the paper work are very high. This has prevented many management plans authorizations.

Another problem has to do with small scale forest management, which lacks efficient industrialization equipment and limits the integration of forest operations with industry. (DOF 20 Feb. 2007)

4.3.4 Case studies of innovative agricultural systems.

4.3.4.1 Valley of Mexico and Chinampas

The Valley of Mexico, a land locked basin of approximately 7000 Km^2, where Mexico City, one of the largest cities of the world spreads today, has been inhabited since prehistoric times. At the time of the Spanish conquerors arrival, during the early sixteenth century, Tenochtitlán, the Aztec empire's capital, was the largest city in the new world.

Valley of Mexico's ancient map

It is evident that for urban development to take place not only an ample food supply is needed, but also a system to handle wastes and excreta to avoid the risk of epidemics. An ample food supply implies an efficient method to manage soil fertility. These two conditions were met with an agricultural system called "Chinampas" developed in the lacustrine environment of the Valley of Mexico.

The name chinampa derived from the nahuatl word chinamitl, which means reed fence or hedge, and it designates a square plot surrounded by water in at least 3 sides. The plot was made by limiting an area on the lake with reed fences and adding mud from the shallow lake, till the land emerged from the lake's surface, then willow trees were planted to hold the borders of the field.

Chinampas allow an intensive agriculture; fertility is maintained by periodically adding mud that is rich in organic matter from the sediments of the lake bottom. Periodic removal of sediments and the aquatic plants growing on the lake's surface allowed water treatment and kept an ecological equilibrium. The lake produced an ample population of crustaceans and fish that complemented the diet. Water weeds and insect larvae were used as fowl feed. The aquatic fauna attracted migratory birds.
During the dry season the chinampas are irrigated with lake water. Mild winters allow a continuous cropping throughout the year; land use intensity is increased by producing crop seedlings in a small plot and transplanting. Seedlings are grown, by preparing a seed bed consisting of a 5 cm layer of mud exposed to the sun to dry. When it is almost dry, it is cut in squares of 5 cm wide and long. A seed is planted in the center of each block, which is called chapin; seedling develops during the initial phase of the crop to be later transplanted.

The chinampas have allowed continuous cropping during centuries, complemented with the availability of clean water from springs and streams flowing from surrounding mountains and they made a healthy environment in the valley.
By the end of the 19th century the system still provided most of the vegetables and horticultural crops needed for the 541,000 inhabitants of Mexico City; some portions of chinampas survive today producing ornamental plants and other crops to remain profitable.

Urban growth expansion in the Valley has always been linked to hydraulic works. The first one was the construction of a dike to separate the salted waters of Texcoco Lake from the fresh water lakes, which made one only lake during the rainy season. This dike was constructed before the Spanish conquest.

As population expanded during colonial times, a waterway was opened to drain the lakes and make more land available to build or farm and also for flood control.

At the beginning of the 20^{th} century, a second waterway was opened to expand the water extraction capacity. These waterways transport run off and waste waters to the Mexquital Valley where they are used for irrigation since then.

The remarkable environmental management in the Valley of Mexico continues to address the needs of one of the largest cities in the world; the agricultural system that allowed the region to become an urban center is still practised, thus Mexico City's population has grown from 1,776,000 in 1940 to 22 million today. Chinampa area is now a natural reserve which still produces many local crops to prepare delicacies, with local plants as capulín *Prunus mexicana* and white zapote *Casimiroa edulis,* a native avocado, among the most important.

4.3.4.2 Agave use and pulque industry in the Mexquital Valley of Hidalgo

The Mexquital Valley is a semi arid valley in the state of Hidalgo; it is located 60 km north of Mexico City. It is formed by three plains of different altitude, separated by mountain chains. The north plain lies at 1700 to 1850 meters above sea level, the central plain which lies at 1900 meters above sea level and the southern plain at 1950 m above sea level. The valley is the home for the Otomi ethnic group, and it has a population of 495,000 inhabitants, most of them involved in agriculture. There are two irrigation districts: “Distrito 03 Tula” and Distrito 100 Alfajayucan; both of them use waste water from Mexico City for irrigation.
The irrigated area amounts 83,000 ha. (See table 1). Waste water irrigation started with the completion in 1903 of the canal de Tequisquiac, which drains runoff and sewage from Mexico City to the Mezquital valley, together with “Tajo de Nochistongo”, that was constructed years before.

Table 3. Irrigation data for the Valle del Mezquital, 1993-94

IRRIGATION SYSTEM	IRRIGATED AREA (HA) 1	ÁREA UNDER CULTURE[2]	USERS	WATER VOLUME (106 m^3/a)	PRODUCTIÓN VALUE (MILLION US$)
Distrito 03 (Tula)	45,214	55,258	27,894	1,148	73
Distrito 100 (Alfajayucan)	32,118	22,380	17,018	651	24.3
Private Units	5,375	5,450	4,000	96	0
TOTAL	**82,707**	**83,088**	**48,912**	**1,895**	**97.3**

1. Irrigated area refers to areas with irrigation infrastructure
2. Area under crops includes areas with more than a culture in the year

Source: Comisión Nacional del Agua (CNA), Distritos de riego, Mixquiahuala, Hidalgo, México, 1995.

Most of this waste water receives no treatment. Until the 1960’s, sedimentation in water ways and storage period in reservoirs provided treatment and allowed the water to be used without major health risk to produce vegetables. But Mexico City’s population growth increased the organic and chemical load which resulted in health problems. To avoid health hazards the cropping pattern changed from vegetables to alfalfa and maize. The dissolved organic matter in irrigation water enhances fertility and irrigation districts are on average more productive per area than other similar lands. (See table 4)

Table 4. Crop yield in tons/ha in the Mezquital Valley 1990-92

CROP	NATIONAL MEAN	MEAN IN MEZQUITAL	IIN IRRIGATED AREA OF HIDALGO	RAIN FED AGRICULTURE
Maize	3.70	5.10	3.60	1.10
Beans	1.40	1.80	1.30	0.49
Oats	4.70	3.70	3.60	1.70
Barley	10.80	22.00	15.50	13.50
Lucerne	66.30	95.50	78.80	0.00

Source: Secretaría de Agricultura y Recursos Hidráulicos (SARH), México 1994 (valores nacionales). CNA, Distritos de riego, Mixquiahuala, Hgo. México 1995 (datos del Valle del Mezquital).

As it has been said, at first waste water from Mexico City received treatment as settling solids sedimentated during its flow in channels and natural oxygenation occurred during storage in reservoirs, but by 1980 concentration and quality of waste water started producing health problems. As this coincided with the UN WHO Water and sanitation decade, studies where made to asses the consequences of waste water irrigation on farm workers health.

Shuval et al., made a review on a World Bank document of several experiences around the world concluding that there are both: environmental benefits and health risks associated to waste water irrigation. The fertilizing value and its effect has been mentioned; health problems associated in the Mezquital Valley have been studied by Cifuentes et al. (1993). He studied the relation of waste water exposure and intestinal parasite and diseases among farm workers by two cross-sectional surveys, the first during the dry season and the second during the rainy season. The total studied population in the dry season included 2049 households: 855 families that work in raw waste water irrigated plots, (high exposure), 965 families that work in plots irrigated with water that comes from the Endho Reservoir (intermediate exposure) and 930 families working rain fed plots, so that they are not exposed to waste water (control).

The study indicates that the risk of *Ascaris lumbricoides* infection is much higher in the exposed group than in the control group (95% CL= 4.0-67.3 and 4.7-78.8). Children from exposed households were at higher risk of Diarrhea disease than controls (95% CL= 1.03-2.03).

Table 5. Prevalence of *Ascaris lumbricoides*, *Giardia lamblia* and *Entamoeba histolytica* among the studied population.

Table 1 Intestinal parasite prevalence according to exposure and age.			
Age group	Exposure Groups		
	High	Low	Intermediate
	Waste water	Control	1st storage reservoir
	Ascaris lumbricoides		
0-4 years	10 34/341	0.6 2/327	11.7 42/357
5—14	12.5 94/759	1.0 8/809	8.5 67/795
15 + years	4.5 60/1394	0.0 0/1243	2.5 39/1515
	Giardia lamblia		
0-4 years	21.2 46/217	20.5 67/327	16.5 38/230
5-14 years	13.5 60/442	12.5 101/809	14.0 66/480
15 + years	4.5 16/347	4.0 48/1243	6.0 28/472
	Entamoeba histolytica		
0-4 years	6.5 22/341	6.7 22/327	6.4 23/357
5-14 years	17.0 127/759	14.0 113/809	20.5 161/795
15 + years	16.5 229/1394	15.0 188/1243	17.5 262/1515

Source: dry season survey Valle del Mezquital 1991

Table 6. Diarrheic disease prevalence in relation to waste water exposure and age group.

	Exposure groups		
Age group	High	Low	Intermediate
	waste water	Control	1st storage reservoir
0-4 years	19.6 56/285	13.6 55/404	15.5 47/302
5-14 years	6.5 42/656	4.5 45/1028	8.0 51/631
15+ years	8.0 43/546	7.0 119/1749	8.5 53/631

Source: dry season survey Valle del Mezquital 1991

Waste water microbiology

The study reports that raw waste water has a high concentration of indicator microorganisms. 108 *Faecal colliforms* /100 ml and 70 *Ascaris lumbricoides* eggs/l; the content diminishes in water from Endho.

Non Irrigated agriculture in the Mezquital Valley

In non irrigated areas of the Mezquital Valley there is an ample cultivation of various varieties of agaves belonging to the species *Agave americana* and *Agave malpisaga*. Their culture is mainly to produce "aguamiel", a sweet liquid

used for drinking or fermented to produce “pulque”. Pulque production is part of an ancient tradition and besides extraction of aguamiel all parts of the agave find other uses.
Aguamiel is also concentrated by evaporation to produce “aguamiel” honey; the small flowering shoot (quiote) is eaten as a vegetable; fully developed and dry is used as construction material or burnt as fuel; the tender leaves or pencas of some species are eaten, the flowers are eaten as vegetables, the penca’s cuticule is used to wrap the “mixiotes”, a traditional meat based dish, prepared in a buried oven. The terminal spine is used to make jewelery and some authors relate that the spine and its attached fibers served as suture in prehispanic times. Even the insect’s larvae that feed in the maguey are considered a delicacy, the white maguey worm *Cossus redtenbachi* and the red maguey worm *Acantrocneme hesperians* Lepidoptera .

Agaves are also present in soil conservation practices, as they are planted along contour lines to hold the border of terraces.

Nevertheless pulque has found a new market with the development of a In other regions of the state of Hidalgo in the late 19th century large pulque production states were formed to supply Mexico City’s demand for this drink. With the arrival and popularization of breweries in Mexico, the “pulquerias”, bars where pulque was served in Mexico City, have almost completely disappeared.

4.3.4.3 Agave use in the central valleys of Oaxaca and Mezcal production

Another important zone of agave production is located in the central valleys of Oaxaca, a mountainous state in central Mexico, home of several ethnic groups who have a rich traditional knowledge of managing natural resources.

The central valleys of Oaxaca are three rich agricultural valleys at different altitudes in the region surrounding the city of Oaxaca. Their mean altitude above sea level is 1500 m. It is a naturally rich region and has been site of human settlements since 400 BC when Monte Alban was funded.

The region comprises three valleys at different altitudes: “Etla” to the northwest, “Tlacolula” to the southeast and Zaachila-Zimatlan-Ocotlan to the south; surrounding mountains reach 2050 m above sea level. Climate in the region varies from hot dry to temperate humid; the mean annual rainfall is 727 mm, with rains during summer. The driest valley is Tlacolula and Etla is the most humid. The valleys have rich and fertile alluvial soils, and a high water table to provide water for irrigation. Nowadays water is pumped by motor pumps, but some years ago the plants were still watered using a “cántaro”, a ceramic or metal container of approximately 14 liters capacity which was used to fetch water from the well and pour it to the growing crops. This labor intensive method had been used for centuries.
Agriculture is also practised in the mountain slopes; success of crops is highly dependent on the availability of irrigation water. The environmental diversity within the valleys and its region has allowed a very diversified agriculture, in which the main products are maize and beans, population’s staple foods, but as

trade and markets are well developed within the region, multiple horticultural and industrial feed and food crops are grown under irrigation and also without.
Slope farming needs soil conservation structures; terraces are formed following contour lines to prevent erosion, terraces are secured by planting agaves on the borders. Agaves, *Agave angustifolia* and *Agave karwinskii,* are used in various ways, among them mezcal production, a spirituous drink, being just another element in the agricultural production system where animal husbandry is an important element to supply dietary proteins, the manure for fertility management and traction force for wooden plows.
Farmers in the central valleys of Oaxaca have breed many maize varieties, by selecting them under multiple criteria: yield, drought resistance, post harvest loss, water logging resistance, fertility needs and also quality to produce processed food products, tortillas, tamales and many other dishes, eaten every day or during special occasions or even for rituals.
Most of the plots are planted to multiple crops, maize, beans and squash being the most important, but many others may be found. Maize is not only intercropped with other crops, but also different varieties are managed in the same plot, as the farmer may plant in the same field several varieties to reduce the risk of losing the harvest, if rains are scarce during the season or other environmental cause arises.
Land tenure in the region is very fragmented; most peasants have very small plots of land, measured by the length of planting row. With this constraint it is not surprising to see a diversity of handcrafts and almost all land owners have multiple economic activities.

In the mountains nearby, oak and pine forest still provide timber for agricultural tools construction and firewood.

4.3.4.4 Tequila industry in Jalisco

Tequila is a spirit made by distillation of fermented juice obtained from the “piñas“ of the blue agaves *Agave tequilana.* Traditionally the tequila region was restricted to the Valley of Tequila in Jalisco, formed by two municipalities, Tequila and Amatitlan. Tequila production has grown to be an important industry, since 1974 when the certificate of origin was first issued. This legal instrument certifies that tequila is produced according to a standard, from a particular plant grown in a limited area and it is regulated by an industry body, the Tequila Regulatory Council (CRT) by its initials in Spanish.
The certified zone of origin now includes 180 municipalities in five Mexican states: Jalisco (124), Tamaulipas (11), Michoacan (30), Nayarit (8) and Guanajuato (7). Only on these municipalities blue agaves can be grown for tequila production.

The certificate of origin has been an instrument to differentiate tequila in the international market and it has allowed increasing profits in the industry, some part of the extra profit has been invested in research and development to enhance field productivity (CRT 2002). Securing a profitable market for agave producers, blue agave production is now almost completely in the hands of industry, in a vertically integrated agro industry.

Nevertheless, it is the best example of how a natural resource traditionally used can, with proper organization, become a profitable industry.

Tequila production is an example of how plants from the arid and semi arid lands can also be cropped under high input commercial systems.

Conclusion

Through the examples mentioned so far, it is evident that the arid and semi arid plant resources can be the base of economic activity. Many species are currently managed in Mexico, other species have a potential as resource and could be used for fuel or raw material production, if research is done in this direction. Some short notes taken from a research report done in the United States and published in 1990 will be quoted to show the potential of some species, the full report can be accessed in:
(**http://www.hort.purdue.edu/newcrop/proceedings1990/V1-232.html**)

4.3.4.5 Semi arid and arid plants with potential to produce oils.

Jojoba [*Simmondsia chinensis* (Link) Schneid, Buxaceae]

Jojoba is an evergreen woody shrub native of Sonoran Desert in southern Arizona, California and Baja California. In Mexico it is becoming one of the first new arid-land industrial crops to reach commercialization. Jojoba seeds contain 40-60% of a chemically unique oil, which is more accurately characterized as a long straight-chain liquid wax of non-glyceride esters. Its chemical structure is very similar too and it can substitute readily sperm whale oil, the importation of which has been banned in the United States since 1971.

Commercial plantings of jojoba have only been made within the past 10 years. By 1982, over 10,500 ha were planted in Arizona and California. Prior to this, the limited amount of jojoba oil came from hand-harvested wild stands in Arizona, California and northern Mexico. Most of this production was utilized by the cosmetic industry, and because of the limited supply, the oil commanded a relatively high price. Currently, plantings are estimated at over 16,000 ha, many of which are coming into full production.

Lesquerella, Bladder Pod [*Lesquerella fendleri* (Gray) Wats, Brassicaceae]

Vegetable oils containing hydroxy fatty acids are of industrial importance as chemical feedstocks for the production of lubricants, plastics, protective coatings, surfactants and pharmaceuticals. The United States and other industrial nations depend completely on imported castor oil for their total supply of hydroxy fatty acids. For various economical reasons in addition to problems associated with seed toxicity, allergenic reactions of field and processing workers and disposal of toxic seed meal after oil extraction, castor beans are no longer commercially grown in the United States. Because of its high content of hydroxy fatty acid (ricinoleic acid), castor oil is classified as a strategic material.

The annual cost of importing some 40-45 thousand metric tons of oil is usually around $40-45 million.
Recently, attention has been given to species of Lesquerella as possible new domestic sources of hydroxyl fatty acids

Lesquerella seed meal composition and quality were comparable to those of other cruciferous oilseeds including rapeseed and crambe. The meals are thought to be potentially useful protein supplements for feed grains since they are relatively high in lysine. Glucosinolates were found in quantities similar to that of other cruciferous seed meals, but goitrogenic substances (thiooxazolidones) were not found to be present. Thus, potential for seed meals for animal feeds usage greatly enhances the economic viability of lesquerella as a new crop.

Buffalo Gourd [*Cucurbita foetidissima* HBK, Cucurbitaceae]

The possibility of domesticating and utilizing buffalo gourd along with other perennial cucurbits as new sources of vegetable oils and proteins was first suggested by Dr. L.C. Curtis (1946). There was a brief flurry of interest in this regard in the late 1940s and early 1950s. The attractive potential for production of edible seed oils, seed proteins, root starches and other by-products in one plant under environmental conditions stimulated a new burst of activity in the early 1970s. This research was spearheaded by the late Dr. William P. Bemis and coworkers at the University of Arizona, Tucson. Buffalo gourd's potential as a new arid-land crop was clearly enunciated and reviewed by Bemis et al. (1978, 1979) and Hogan and Bemis (1983). Results of the various facets of about 15 years of excellent multidisciplinary research have been well summarized: composition and functionality of potential food ingredients (Scheerens and Berry 1986); agronomic research (Nelson *et al*. 1983, 1988); and domestication (Gathman and Bemis 1990). In spite of this sustained effort, essentially all research activity on buffalo gourd's development as a new crop has ceased.
The question about why such a developmental program should fail after such a good, sustained research effort that was spent on species with such potentially desirable characteristics arises. Buffalo gourd seemed to be tailor made for providing these essential food components plus starch, which could also have industrial implications. In addition, three unique factors were combined in this one species: perennial plant habit; an asexual mode of reproduction in addition to normal sexual reproduction through seeds and a method of producing hybrid seed using gynoecy, and multiple yield components consisting of seed bearing fruits for oil and protein, roots for starch production, and vines for animal fodder.

Grindelia, Gumweed (*Grindelia camporum* Greene, Asteraceae)

University of Arizona's Bioresources Research Facility conducted extensive research that surveyed and evaluated a wide array of desert plants for their biocrude production potential (Hoffmann 1983, McLaughlin and Hoffmann 1982, and McLaughlin et al. 1983). Biocrude is the hydrocarbon and hydrocarbon-like chemical fraction of plants that may be extracted by organic solvents and upgraded to liquid fuel and chemical feedstocks. They demonstrated that plants

producing either latex or resinous exudates had the highest percentage of high energy extracts. On the basis of these observations, attention was focused upon those plants that produced resins.
One of the most promising of numerous species investigated was Grindelia camporum, which is an arid-adapted, herbaceous perennial found in the Central Valley area of California. Preliminary agronomic, breeding and genetic research was initiated in 1981. Hoffmann and McLaughlin (1986) reported that tetraploid lines of G. camporum will produce about 11,350 kg/ha-year of biomass by harvesting the stand twice and applying about 750 mm of irrigation water. This level of irrigation is low compared to the amount of water applied to most crops currently grown in the Southwest (McLaughlin 1985).
G. camporum also has other characteristics that favor domestication. It has an upright, herbaceous growth habit. Many accessions have an annual life cycle and the ability to regenerate growth from the root crown to produce two crops in a single growing season. The species has good tolerance to salinity and diseases as well as drought.

Euphorbia, Gopher Plant (*Euphorbia lathyris* L., Euphorbiaceae)

Euphorbia lathyris, a latex-bearing plant, received world-wide attention for several years as a possible source of liquid fuels. Dr. Melvin Calvin (1978, 1979) first brought attention to the plant as a candidate for "petroleum plantations" since he believed it to be adapted to dry, semi-arid lands. He estimated that energy plantations of this species would produce annual yields of at least the equivalent of 25 bbl of crude oil per hectare. He reasoned that cultivation of marginal semiarid arid and lands would make good use of the long growing season and the highly intense solar radiation in these regions. Another positive factor would be that such a cropping system would not be directly competitive with conventional food, feed, and fiber production systems. Unfortunately, the high hopes and expectations were not realized.
A rather comprehensive three-year research program was undertaken in 1979 at the University of Arizona in Tucson. The results of this research are well summarized by Kingsolver (1982). In brief, the developmental program was initiated with a logical, multidisciplinary approach. Germplasm was collected worldwide from 50 sources on six continents. Germplasm evaluation was conducted in greenhouse and field studies in 1980 and 1981. Agronomic studies were conducted to determine various cultural and water requirements. The first planting as a summer crop was a complete failure. It was found that euphorbia could be grown more successfully as a winter crop. Under these growing conditions it used 710 mm of water (irrigation requirement of about 1,000 mm) to produce a maximum of 15 tons of dry biomass and the equivalent of 7.5 bbl crude oil/ha. This yield was only about 30% of that originally estimated by Calvin, and clearly uneconomical.
Another factor concerning euphorbia’s failure to develop into a successful new crop was the limited usefulness of the plants chemical composition. The oil of E. lathyris is similar to crude oil, so that it can be catalytically cracked to produce a significant portion of fuel fractions (Kingsolver 1982). However, since fossil fuel crude oil was and still remains relatively low priced and in good supply, competitive market factors effectively dampened enthusiasm and support to continue funding research on euphorbia and other potential plant oil sources. To

have a fighting chance of reaching commercialization, a bioenergy crop needs to contain a chemical composition useful as a product or a feedstock for products that are in some way unique and significantly more valuable than crude oil. Unfortunately constituent analysis of *E. lathyris* did not identify any potentially useful bulk specialty chemicals.
The limited supply of fossil fuels may one day confer an economical and energetic advantage to the utilization of such plants as *E. lathyris*. When this point is reached, research and development may succeed in domesticating *E. lathyris* for commercial production of biocrude oil.

4.3.5 Mexican indigenous agriculture

4.3.5.1 Evolution of Mexican indigenous agriculture

The different ecosystems that form Mexico's landscape and its biodiversity are the base for multiple cropping systems development and, as it has been said, they gave origin to many of the world's cultivated plants.
The strategy deployed by Mexican indigenous farmers has been to diversify crops and natural resource use. In most parts of Mexico peasants have a plot to farm, which in some places is still managed under slash and burn system. They also grow trees and perennials in the space surrounding their home and obtain many natural products from the non cultivated areas, based in an ancient traditional knowledge. This strategy has been presented in the case studies.

In general, in low input traditional agriculture intercropping perennial and annual crops has been common, dealing with the spatial and temporal distribution of several crops, to achieve production, with an integrated soil fertility and pest management strategy, under systems recently grouped under the term **agroforestry.**
Mexico has multiple examples of such systems in most of the regions. Though, apart from some remarkable exceptions, most of these systems are not well suited to a commercial agriculture context, and they remain part of the survival strategy for peasants. Its greatest inconvenient being the long maturation period to get to a profitable production and the great need of labor to perform the daily maintenance tasks, as there has been very little research and development of specific machines and tools to enhance labor productivity in these systems. Research priorities have been very far from the small peasant since the 1960's, when an international effort to breed maize and wheat to respond to industrial inputs, chemical fertilizers and pest control chemicals, originated the green revolution. This movement had deep consequences for the traditional agricultural systems and increased the productivity gap between peasant agriculture and those areas apt for an industrial input intensive agriculture, which normally are the areas with irrigation.

From 20 million ha cropped in Mexico, 6 million have irrigation; the value of crops in the irrigated areas represents 55 percent of the total crop value, which means that in irrigated land productivity is 3.7 times higher than rain fed areas. Thus, it must be noted that some production of non irrigated lands is to supply the farm house hold, and it is not traded or counted in national statistics.

3.3 million ha of irrigated lands belong to 86 irrigation districts that currently operate in Mexico, 58% this land is social property under the “ejido” regime, the rest is private property. There are 560,000 registered water users, a mean of 5.893 ha per tenant.

The most important crops in the irrigated areas are: maize, wheat, sorghum, cotton and sugar cane.

Although irrigation infrastructure is owned by the Government of Mexico, since 1989 the responsibility for operating many of the irrigation delivery Districts had been transferred to the irrigators, with management via a Board of Management comprising landowners with irrigation farms in the respective Districts. The Board is chaired by the President, who is also a landowner.

The irrigation land is generally cropped in commercial input and mechanized agriculture, sometimes under contract agriculture, as the land tenure structure in Mexico did not allow land concentration to form large farms. This fact has influenced labor productivity and mechanization. Plowing, other seed bed preparation operations and sometimes harvest is done by custom machine contractors; weed control is done by animal traction and crop spraying, by men with knapsack sprayers.

In conclusion, Mexican agriculture faces enormous challenges to supply the needed food and raw materials for the fast growing population. In this context bioenergy opens a new opportunity field, whose full potential needs a consensus among different economic agents, which is not easy to achieve.

4.3.6 References

Cepal 2006 Mexico; Crecimiento agropecuario TLCAN, capital humano y gestion de riesgo.

Comisión económica para América Latina, México D.F.
http://www.eclac.cl/publicaciones/xml/5/23905/L686.pdf

Cepal 2000 The adjustment strategies of Mexican ejidatarios in the face of neoliberal reform. by Benjamin Davis. CEPAL REVIEW 7 2

CEPAL / United Nations Food and Agriculture Organization (FAO), Rome
http://www.cepal.org/publicaciones/xml/9/20139/lcg2120i_Davis.pdf

Cifuentes E., Blumenthal U., G. Ruiz-Palacios, M. Bennett Quigley, A. Peasey, H. Romero-Alvarez. 1993. Problemas de salud asociados al riego agrícola con agua residual en México. Salud Publica, INSP Cuernavaca Mor. 35: 614-619.

Shuval HI, Adin A, Fattal B, Rawitz E, Yekutiel P. 1986. Wastewater irrigation in developing countries: Health effects and technical solutions. Washington D.C.: The World Bank, 1986. World Bank Technical Paper, No. 51. Integrated Resource, Recovery Series, UNDP Project Management Report No. 6.

FAO. 2001 Proyecto Información y Análisis para el Manejo Forestal Sostenible: Integrando Esfuerzos Nacionales E Internacionales En 13 Países Tropicales en América Latina, (Gcp/Rla/133/Ec), FAO Roma

Skoufias, E. (2005) PROGRESA and Its Impacts on the Welfare of Rural Households in Mexico. Research Report 139 International Food Policy Research Institute, Washington, DC
http://www.ifpri.org/pubs/abstract/139/rr139.pdf

Ruiz-Arranz, M., B. Davis, M. Stampini, P. Winters, H. Sundhashu. 2000. More calories or more diversity? An econometric evaluation of the impact of the PROGRESA and PROCAMPO transfer programs on food security in rural Mexico". FAO Rome
ftp://ftp.fao.org/docrep/fao/007/ae028e/ae028e00.pdf

Granados Sánchez D.1993 Los agaves en Mexico. Universidad Autonoma de Chapingo (UACH), Chapingo México

World Bank. 2005. Water Resources Management in Mexico: The Role of the Water Rights Adjustment Program (WRAP), in Water Sustainability and Rural Development. Sustainable Development Working Paper No. 24, August 2005 Washington D,C.
http://go.worldbank.org/ODJ01ZRHP0
accessed 3 July 2007

World Bank. 1996. Mexico, Water Resources Management Project, Report No. 15435-Me Staff Appraisal Report. Washington D.C,
http://www-wds.worldbank.org/external/default/WDSContentServer /WDSP/IB/1996/05/31/000009265_3961214131804/Rendered/PDF/multi0 pag**e.pdf** accessed 3 July 2007

Cantú-Suárez, M., and H. Garduño. 2003. Anexo 2. México. In *Administración de derechos de agua: experiencias, asuntos relevantes y lineamientos,* ed. H. Garduño. FAO Estudio Legislativo 81. Rome: FAO.

Garduño, H. 2001. *Water rights administration: Experience, issues, and guidelines.* FAO Legislative Study 70. Rome: FAO.

Diario oficial de la federación 20 feb 2007, Reglas de operación de PROARBOL Sria de Gobernación México D.F.

TASK 4.4 Cost Benefit analysis of new energy crops and agroforestry systems in Mexico.

4.4.1 Introduction

In Mexico crop production for energy is a relatively new idea, opposite to Brazil, where it is the result of a policy decision and a coordinated effort of several decades towards reducing imported oil dependence.
The experience and data available to figure the cost benefit analysis of fuel crops is scarce. Our analysis will be based on the resource efficiency use from the opportunity cost of production factors as labor, land, capital and inputs.

First we will examine the crops, which the Ministry of Agriculture is considering as feasible for biofuel production. These are:

For ethanol production:

Sugar cane, from traditional sugar production areas
Sugar beet south of the Mexico USA border
Sweet sorghum in Tamaulipas and other Gulf Coast states
Maize, being considered for the state of Sinaloa
Cassava *Manihot sculenta* in the tropical low lands of the south east

For biodiesel production:

Oil palm in Campeche, Tabasco, Veracruz and Chiapas
Castor oil *Ricinus communis* in the hot semi dry lowlands along both coasts
Jatropha curcas in the semi arid low lands

Besides sorghum, maize and sugar cane, there is a scarce experience in intensive production of cassava, and only a few trials in sugar beet.
Most of oil palm plantations are initiating their productive stage and they were established to cope with a recurrent shortage in edible vegetable oils and fats.
Castor oil is produced in multiple crop systems for self supply in medicinal uses or soap making. Jatropha is found growing wild in some parts of Mexico; in Yucatan it has been cultivated with medicinal purposes as its sap is a traditional remedy for diarrhea.

A brief account of the available information of yields and agronomic data for these crops in Mexico or in similar environments would be given.

Then, for ethanol production crops an analysis would be made using the production cost data from the 2002 survey in ethanol costs (USDA 2005), considering a sensitivity analysis with varying interest rates and capital recovery period and production costs at farm level in various regions of the country.

For biodiesel production two scales would be considered, small scale for auto supply production in isolated villages where traditional fuels are not readily available and large scale projects. The mainly difference being that in the small scale process biodiesel does not necessarily need to conform to international quality standards as biodiesel would not be exposed to extremely cold temperatures. Finally we will end with an analysis of the feasibility of wood as industrial fuel.

4.4.2 Ethanol producing crops.

4.4.2.1 Sugar cane

Ethanol has been and is produced in some of Mexico's sugar mills, as a by-product using molasses and secondary syrups. Production is not enough even to satisfy domestic demand of ethanol for other uses than gasoline additive or engine fuel. According to an industry spokesman, a deep restructuring is needed (Enriquez Poy M. 2007) if ethanol production is to be competitive in an international context. A brief description of the Mexican sugar sector situation follows.

Mexican sugar industry is under trouble, inherited from a long history of state intervention and a period of scarce capital and very high interest rates, during which sugar mills were not even maintained, so that most of the industrial equipment is obsolete.

Mexican sugar industry viability as a whole is a political imperative. Sugar is Mexico's largest agricultural industry. Sugar cane is the fifth largest cultivated crop, supplying raw material to over 60 mills located in 15 of the country's poorest states. Industry as a whole accounts for more than 300,000 jobs, including cane cutters, seasonal field workers and factory workers. Consequently, over 2.2 million people depend on the Mexican sugar industry for a living. There are 158,000 cane growers averaging nearly 4 hectares per grower, delivering about 300 tons of cane. This compares to Queensland, Australia where output is about the same but the number of growers is 6,500 working an average of 85 hectares. This comparison demonstrates the current inefficiency of the Mexican industry. It is not the lack of mobility or alternative employment that keep people growing sugarcane, but some social advantages they receive as cane growers (social security access) that keep a large number of growers with very small plots. Government controlled prices, which over the last few years have been between $28 and $32 per ton, also help keeping people on the farm. Mexico controls domestic prices through a system of marketing allotments. Domestic supplies are limited by the legal requirement that millers supply no more than a pre-determined allocation of sugar each year. Any production over these allocations must be held over as stocks, sold for non-food uses or exported. This policy constrains supply ensuring high domestic prices. Mexican imports tariffs contribute to defend these price levels. Mexican sugarcane price is higher than the U.S. price; almost double the price in Guatemala and three times the price of Brazilian sugarcane. Consequently, the income per hectare from sugar cane is well above that of rice, cotton or corn.

Over the last 40 years the Mexican sugar industry has experienced a progression of government interventions, motivated to provide inexpensive sugar to consumers, but resulting in bankruptcy and technological stagnation. The mandated marketing prices forced mill operators to postpone maintenance

and depend on government-supported loans for operating expenses. Eventually, debts exceeded the mills asset values forcing the mills into government receivership. Instead of annually exporting half a million tons of sugar, Mexico became a substantial importer.
The North American Free Trade Agreement (NAFTA) appeared to be the vehicle to revitalize the Mexican sugar industry. Initially, it seemed that Mexico would be the exclusive beneficiary to export a substantial additional quantity to the high-priced U.S. sugar market. The Mexican government offered the old mills, then under receivership, for sale. The price for these mills was bid up by newly organized conglomerates looking for quick profits. However, last minute changes during the final negotiations of the treaty failed to open the U.S. as much as was expected. With the advent of increased production, three factors contributed to crisis of 2001/02. First, the U.S. quota for Mexican sugar remained far below the additional 250,000-ton minimum they hoped to be negotiated; second, Mexican imports of high fructose corn syrups HFCS from the U.S. rapidly increased, displacing domestic sugar used in soft drinks; and third, the government issued a large number of import permits thus allowing large quantities of lower price world sugar to enter the domestic market. All these factors together increased the quantity of Mexico's exportable surplus sugar.
Thus, the scene was set for the 2001 expropriation of 27 bankrupt mills and beginning a repeat of the pre-1980 period. Inefficient operators borrowed expensive money for operating capital and sold sugar destined for export into the domestic market at low prices. Owners fell behind in payments to cane growers and eventually mill employees. In the summer of 2001 the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) together with the Treasury Secretariat (SHCP) funded 1.2 billion pesos ($131.1 million) for liquidating mills production debts. These debts were backed by the mills with certified deposits of sugar stocks. Later that summer, the government expropriated 27 mills to ensure against further mismanagement.

Shortly after expropriating the mills, the government moved to reduce imports of HFCS and thus increase the demand for domestic sugar by industrial users. In January 1998, the government imposed a countervailing duty on the 250,000 tons HFCS imports from the United States. These duties effectively closed off imports and raised the domestic sugar price. Eventually both NAFTA and WTO panels ruled against these duties. However, these duties were replaced with a tariff rate quota of 148,000 tons in April 2002 which was preceded in January, with a tax of 20 percent on soft drinks not sweetened with sugar. This later action affected negatively Mexico's producers of HFCS and reduced imports of U.S. corn destined for the manufacture of HFCS. It also eliminated Mexico's exportable surplus as defined by NAFTA.

At present about 60 mills are operating in Mexico. From the 27 expropriated by the government, four were returned to their owners and 13 are under government ownership. The remaining mills are under government supervision and on definite track toward re-privatization. The industry should be restructured and downsized to be competitive. However, downsizing is not likely going to take place. First, private capital, costing between 12 to 15 percent, is too expensive for a low priced commodity constrained by high cost government mandates. And second, the Mexican government is not likely to authorize investment for modernization and expansion.

By January the 1st 2008, the United States staged tariff reduction on all sugar imported from Mexico will reach zero. There will be no U.S. barrier to sugar imports from Mexico. However, to compete in the U.S. market Mexicans will have to be more price competitive. Currently the Mexican domestic price is above the U.S. domestic price so even if Mexico had an exportable surplus and a zero duty rate it would be more profitable to stay in the domestic market.

In this context the production of ethanol from sugar cane has been seen as an option, particularly as it would allow to break price fixation scheme under Mexican sugar cane production law, which fixes the farm gate price paid to farmers per ton to a 57% of the reference standard sugar price according the yield of sugar per ton of cane.

Ethanol production may be an alternative to this scheme for price fixation, but it will still face industrial inefficiency within Mexican sugar mills, sugar market distortions and low field productivity, factors that restrain profitability for ethanol. The above section is been based upon USDA FAS (2004)

4.4.2.2 Sugar Beet

Sugar beet in Mexico has been produced on limited surface on a test basis in Sinaloa. Other potential region is the Valley of Mexicali, the Mexican portion of the Imperial Valley Agricultural District in California, USA, where there is a vast experience in sugar beet production. To assume that just because sugar beet is produced with profit in California, the crop is viable south of the border in Mexico, is an over simplification. As seen in the study by Mir B. Ali (2004) various factors differentiate the agricultural regions in the United States and obviously at either side of the border. Firstly, with the relative prices of capital and labor, which in the Valley of Mexicali tend to favor labor intensive crops. Then, the agricultural support services organization, which influence the supply and price of custom machine services and land conservation works. In particular, land drainage, which is very important in the region for soil salinity control. So a farm budget based on American figures is considered unrealistic. Much more experimental data should be gathered before an informed decision can be taken over the feasibility of sugar beet production as ethanol feedstock in Mexico.

4.4.2.3 Sweet Sorghum

In Mexico, sorghum for grain or fodder has been extensively cultivated in many regions; mainly because its water demand is lower than maize, so the crop is better adapted to short erratic rainy seasons in semi arid regions. The production started back in the early 1970’s as a farmer led initiative to supply grain sorghum as an ingredient for poultry and pig feed. Today, several seed companies supply Mexican farmers with high yielding sorghum varieties, for grain or fodder, adapted to the different regions and cropping seasons.

Fodder sorghum is cultivated for hay or silage. To our knowledge, the crop has not been used in Mexico for ethanol or syrup production, but sweet sorghums differ little from fodder varieties. Fodder productions of 80-100 tons green mater per hectare have been reported in experimental station conditions for Guanajuato, (SDA 2004). The mean rural price reported in Tamaulipas, the main producing state, is $499 pesos ton green fodder; the average price during the last 10 years is $815.00 pesos ton. SAGARPA (2004). Sorghum bicolor races have a wealth of variation which could be used to breed high yield sugar producing sorghum varieties, adapted to Mexican environment. At the international level ICRISAT has done extensive research on sweet sorghum

Cost benefit analyses would be done with data from India (Ak Rajvanshi 2001) where the following materials balance is reported.

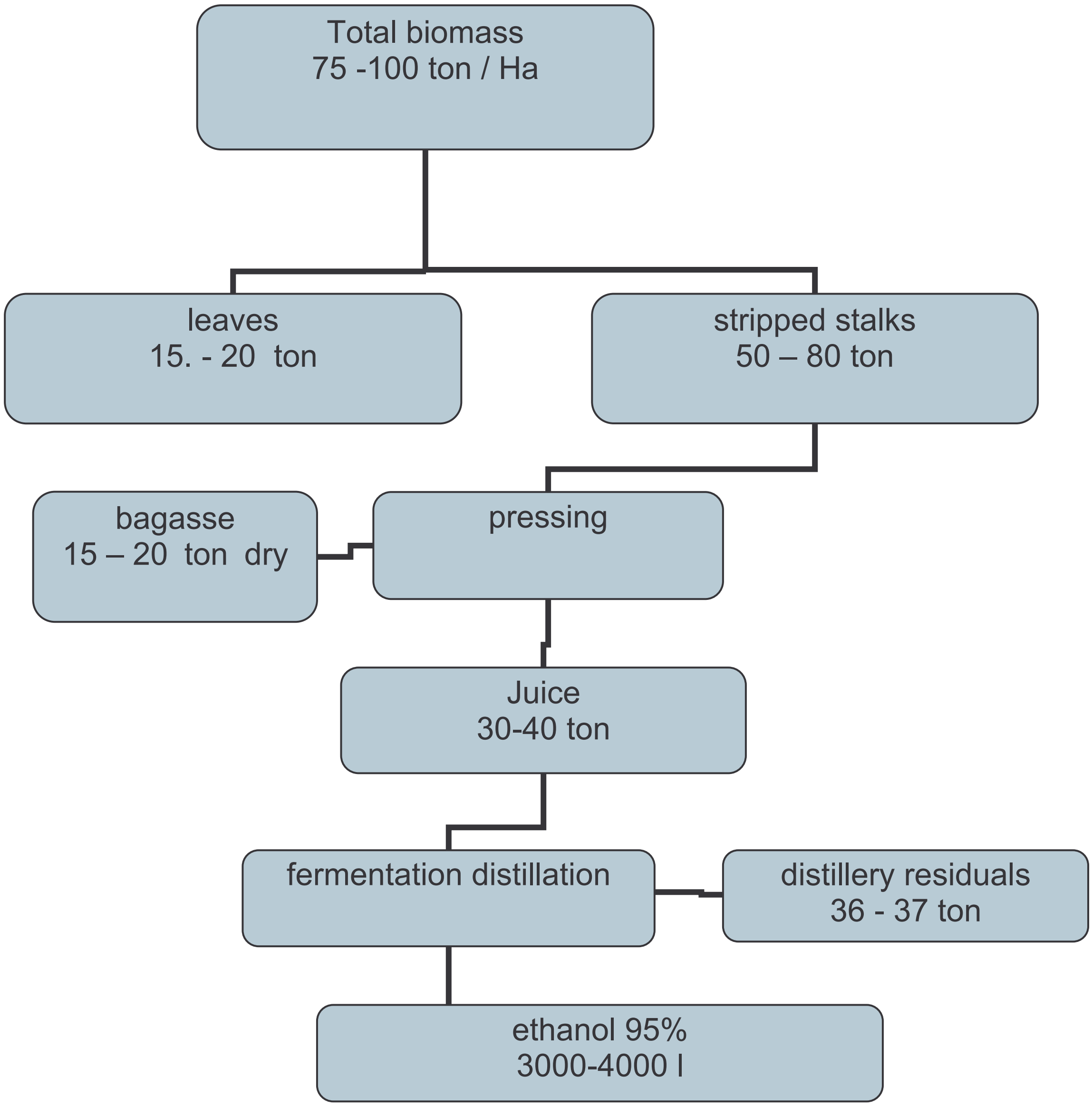


FIGURE 1 MATERIALS BALANCE FOR ETHANOL PRODUCTION FROM SWEET SORGHUM

According to this materials balance one ton of sorghum green biomass would produce 40 liters of ethanol; bagasse could serve as fuel for the process or for animal feed. Production of ethanol 95% proof could arrive to 4000 liters per hectare.

4.4.2.4 Cassava

Cassava is a traditional staple in the Mexican low land tropics, where it is mainly intercropped with other crops or grown in small plots. Its production is currently labor intensive, as mechanization has proved difficult. Several trials to produce cassava on a commercial basis in the Mexican tropics have failed due to harvesting labor costs. Efforts to mechanize harvest have failed (Bergeret Alain 1990 personal communication). More recent efforts have succeeded in the design of a plough to dig out the roots, but still collection is done by hand. Commercial cassava production is done in Colombia where cassava is the raw material for a sour starch powder known as Gari used in traditional cuisine.

The production and increase of labor productivity in Gari production has been extensively investigated and it is part of an international effort between Africa, Colombia and CIRAD - CIAT at Montpellier (**www.Cirad.fr**).

In Mexico cassava is consumed cooked as vegetable or in syrup, which means that no tradition of a cottage industry transformation exists. Cassava's planting and production on a large scale for ethanol production has not been tried. It may be feasible, but the scale of operation needed for a profitable ethanol industry may disrupt traditional agricultural systems in the Mexican low land tropics, where cassava has a potential production land and may lead to increased production costs beyond profitability; in particular it could compete for land with other very profitable crops as bananas.

4.4.2.5 Maize

Maize is the main ingredient in Mexican traditional cuisine; it is not only the base for making tortillas, the country's bread, but also many other highly appreciated dishes. So Mexicans have a highly elaborated taste and quality criteria for the different maize varieties; even some of them have been breed with a particular dish in mind, as is the variety called "Cacahuazintle" grown in central Mexico to make a stew "Pozole". The use of maize for human consumption has created market niches that justify high production costs for maize in some regions, which would simply not be profitable in a commodity market. This fact is very important to design maize production, consumption and use policies in Mexico.
Ethanol production using maize as a feedstock is in consequence a far more complex matter, as it deals with deep cultural issues and implies much more than just profitability.

Scales and cropping systems for maize production vary widely, as it can be seen from the data in table 1

Table 1 Maize production costs for different regions in Mexico for 2005-2006

Production cycle	State	cost/ha pesos /ha	Yield ton/ha	Cost pesos/ton
OI 05-06	SINALOA	$ 5,592.00	9.15	$ 611.15
PV 2005	SINALOA	$ 5,697.00	7	$ 813.86
PV 2005	JALISCO	$ 6,738.00	7	$ 962.57
PV 2005	E MEX	$ 6,683.00	6.5	$ 1,028.15
PV 2005	JALISCO	$ 5,888.00	5	$ 1,177.60
PV 2005	TAMPS	$ 5,014.50	3	$ 1,671.50
PV2005	YUC	$ 5,461.00	3	$ 1,820.33
OI 05-06	SON	$ 11,126.50	5.5	$ 2,023.00
PV 2005	VER	$ 4,930.00	2.1	$ 2,347.62
PV 2005	E MEX	$ 5,870.60	2.5	$ 2,348.24
OI 05-06	GRO	$ 8,744.00	3	$ 2,914.67
PV 2005	TAB	$ 4,188.00	1.38	$ 3,034.78

Source SAGARPA. 2007

A brief analysis of these data evidences two issues: maize production costs in peasant systems are high but maize is produced under a risk management strategy to secure food supply using available labor that would not have other source of productive employment.
Urban maize supply needs high productivity and cheap maize for social peace and dealing with these conflicting issues has been part of Mexican reality for at least 40 years. Its influence in politics is quite important. Ethanol production, using maize as a feedstock, will only add energy policy to these issues to complicate them a little more.

4.4.3 Biodiesel crops

4.4.3.1 Oil palm

Palm oil is derived from the oil palm *Ellaeis guinesnsis,* a crop native of the equatorial zone of Africa, where it is widely cultivated. According to the "Memento de l'Agronome" (Ministère de la Cooperation 1990) African palm has its ecological niche situated in the low lands 10 degrees north and south of the Equator, a region with no low temperatures and bi modal rains. These ecological requirements are not found in Mexico, though oil palm has been planted in Mexico since the late fifties. The oldest productive plantations in Mexico are in Chiapas on the Pacific Coast, in the Soconusco region, a place shielded by mountains from the quite frequent winter cold north winds that blow into the Gulf of Mexico's coast. Around 10 years ago, under a plan to expand vegetable oil production, plantations started in the Gulf of Mexico coastal plain on the states of Campeche, Veracruz, Tabasco and Chiapas.

The oil palm plantations were an alternative production for large areas opened for mechanized farming by clearing tropical forest under ambitious plans and huge investments made during the 1970's. Initially the land should serve for rice production, but after several failures when finally a cropping system was found, rice could not compete with international prices in a free trade environment.

The highest yield for mature plantations in the Soconusco is around 20 tons of fresh fruit bunches per year per hectare. Far below the yield reported for equatorial plantations of 32 tons. Yields in the Gulf of Mexico coastal plain could be lower, as temperatures do get colder than in the Soconusco, when north winds blow during December and January. Biodiesel from palm oil should be in concurrence with edible oil production, a commodity which Mexico imports.

4.4.3.2 Higuerilla Castor bean

Castor bean (Ricinus communis) is quite frequently found growing wild in abandoned fields in Mexico; it is an introduced species; seed served as raw material to produce oil for lanterns and soap. In some parts of the country the oil is still prepared for therapeutic purposes. The fact that the castor oil plant grows wild should encourage research in good yielding varieties susceptible for biodiesel, especially as it can be grown in marginal lands.
The main challenge for castor oil production is labor productivity. Though it can produce small quantities of oil to fuel irrigation pumps and other machinery for local use in rural areas where fuel availability is missing and labor, with low opportunity value, it is available.
Intensive production is still far from being assessed with enough information to be trustworthy.

4.4.3.3 Jatropha curcas or sikilte

Jatropha curcas, "sikilité" in mayan language, is a shrub native of southern Mexico and Central America. It is sometimes cultivated near the house as its latex is used in traditional medicine. The genus Jatropha has been studied by Jimenez J from Biology Institute UNAM. In Mexico several wild species can be found. There is little if any experience in its production as oil production crop.
An experience in Yucatan to grow plants in a nursery failed because of an insect pest attack. The fact that the plant is seldom found in the wild allows to raise the hypothesis that population is checked by insects. Thus there is a potential source of pest problems.
There is currently some crop research done in Mexico and also many independent trials in relatively small areas in response to quite an important coverage of the crop in the media. But it is certain that there is still quite a lot of information to be gathered to correctly assess the feasibility and profitability of Jatropha oil production and its transformation in biodiesel in Mexico. Especially as the regions where it could be grown are currently under peasant agriculture, where infrastructure for transport, storage and management of an industrial crop are scarce and thus costs could be higher than expected.

As a conclusion: an intensive and large scale project to grow oil producing plants for energy purposes in Mexico is still far away, much data and experimentation needs to be done. There is a potential danger in extrapolating results form other places, especially for tropical crops, and many examples can be given of great mistakes and problems caused by this practice in Mexican tropics. Several land development projects turned to be failures, as is the case for Uxpanapa, Chontalpa, Balancan-Tenosique, Valle de Edzna among others. For further information see Toledo, A(1984), Ewell P.T, Poleman, T.T. (1979)

4.4.4 Wood fuel

Wood fuel is the main energy source in rural Mexico, more than 20 million Mexicans rely in wood fuel for cooking, heating their homes and many cottage industries. There are extensive studies on the subject, one of them, Diaz Jimenez R. 2003, is provided in the bibliographical Annex.

After the wood fuel scarcity alert in the 70's, by Ekholm, "The other fuel crisis", financial resources were available for research, and some work has been done to reduce fuel wood consumption through the design, development and diffusion of improved wood fuel stoves. The most successful program has been in the area near the lake of Patzcuaro, in Michoacan, where an holistic strategy was undertaken to understand the factors that were driving deforestation, high household energy consumption, social needs and resources to cope with the problem. As result, strategies were implemented to remedy the crisis (See GIRA documents).
Nevertheless, Mexico is still losing forest at an alarming rate, with much attention given to fuel wood as a cause, but which is not the case. Forest loss in Mexico has two main causes: the impossibility to add value to forest products in the benefit of forest owners, in spite of the recent implementation of policy instruments to do so. And forest clearing for agricultural or grazing purposes. Fuel wood use is just a related issue.

Table 2 Forest area loss for Mexico 1990-2005

Forest area	1990	2000	20005
1000 ha	69019	65540	64238
Forest area lost 1000 ha		3479	1302
Percentage of forest area declared as			
multiple use	production	protection	conservation
91.5	0.1	1.5	6.8

Source FAO (2007) 2005 World State of Forest report.

As an example, charcoal production in the Mexican south east just transforms forest resources in wages, as the forest owners lack the power and means to market their charcoal directly to consumption centers and are forced to participate in distorted commercialization circuits. Receiving $1.23 pesos/kg of charcoal that is sold in Mexico city for restaurant use at 4 to 7 pesos Kg when transport cost is less than 0.33 pesos /kg.

For the Administration wood fuel consumption is considered a sign of poverty and something that would just disappear with poverty as Mexico would become a "modern country". Though this view is changing with the global warming threat, this belief is still prevalent among the urban public opinion. So a change in policy to promote the efficient and sustainable use of wood fuel has yet to convince the public of its feasibility and cope with the notion of modernity that every Mexican bears deep in its heart.

Nevertheless, fuel wood production is an option. Let's consider that a semi deciduous forest in Yucatan has at least a mean annual increment of 3 cubic meters per ha, value that can get to 6 m^3 under good management. If wood density is of 600 kg / m^3 and lower heat value is 17 Mj / Kg, then in a year this forest will produce :

600 kg/m^3 X 3 X 17 M j /kg = 30,600 M j year

If heat value of diesel is 36 M j / l , then this is equivalent to:

30,6000/ 36 = 850 liter of diesel per year.

Wood fuel can be used competitively in boilers and other heat producing use to generate electricity.

4.4.5 Case studies

Cost Benefit Analysis

Ethanol Production

Preliminary notes

The following tables compare ethanol production cost with the price of gasoline based in published data for the United States, taking several case studies with different oil barrel prices, the feed stock price is given by the production costs reported by the SAGARPA Mexican Ministry of agriculture, livestock, rural development, Fisheries and food supply, in the following table.
The ethanol production cost, excluding feedstock, is taken from the USDA ethanol plant survey.

The letters who follow the crop name indicate some inputs used:
BCF pump irrigation - traditional variety seed - fertilizer
BCS pump irrigation - traditional variety seed –no fertilizer
BMF pump irrigation – improved seed – fertilizer
BMS pump irrigation – improved seed – no fertilizer
GCF gravity irrigation – traditional seed variety - fertilizer
GCS gravity irrigation – traditional seed variety – no fertilizer
GMF gravity irrigation – improved seed - fertilizer
GMS gravity irrigation – improved seed - no fertilizer
TCF rain fed, gravity irrigation – traditional seed variety - fertilizer
TCS rain fed – traditional seed variety – no fertilizer
TMF rain fed – improved seed - fertilizer
TMS rain fed - improved seed – no fertilizer

To compare ethanol and gasoline prices the following**. Volume energy equivalent** was used **1.4103**
Which results from the following ratio. High heat value ethanol /High heat value gasoline.

EXAMPLES OF CROP PRODUCTION COSTS IN MEXICO

	crop	cycle	state	cost/ha	yield ton	cost / ton PESOS	cost / ton USCy
1	SORGO GRANO	OI 05-06	TAMPS	$ 5,179.00	5	$ 1,035.80	$ 95.73
2	SORGO GRANO	PV 2005	NL	$ 5,325.00	4.5	$ 1,183.33	$ 109.37
3	CAÑA AZUCAR	PV 2005	CHIS	$16,206.00	90	$ 180.07	$ 16.64
4	CAÑA AZUCAR	PV 2005	COL	$18,919.00	80	$ 236.49	$ 21.86
5	CAÑA AZUCAR	PV 2005	JAL	$15,184.00	97	$ 156.54	$ 14.47
6	CAÑA AZUCAR	PV 2005	VER	$19,409.00	70	$ 277.27	$ 25.63
7	CAÑA AZUCAR SOCA	PV 2005	OAX	$ 9,743.00	65	$ 149.89	$ 13.85
8	CAÑA AZUCAR SOCA	PV 2005	PUE	$ 5,077.50	32	$ 158.67	$ 14.66
9	CAÑA AZUCAR	PV 2005	SLP	$25,016.00	83.5	$ 299.59	$ 27.69
10	COPRA BCF	PV 2005	GRO	$10,439.00	3	$ 3,479.67	$ 321.60
11	COPRA TCS	PV 2005	GRO	$ 5,783.00	2.25	$ 2,570.22	$ 237.54
12	COPRA TCF	PV 2005	TAB	$ 3,729.60	1	$ 3,729.60	$ 344.70
13	SORGO GRANO	PV 2005	GRO	$ 6,141.96	4.27	$ 1,438.40	$ 132.94
14	BETABEL	PV 2005	JAL	$22,588.40	32	$ 705.89	$ 65.24
15	CANOLA BMF	OI 05-06	SON	$ 6,545.00	2.5	$ 2,618.00	$ 241.96
16	ALGODÓN	PV 2005	BC	$14,526.20	3.28	$ 4,428.72	$ 409.31
17	TRIGO	PV 2005	BC	$ 9,785.00	6.4	$ 1,528.91	$ 141.30
18	MAIZ FORRAJERO BMF	PV 2005	CHIH	$ 8,560.00	38	$ 225.26	$ 20.82
19	MAIZ FORRAJERO GMF	PV 2005	CHIH	$ 9,184.80	36	$ 255.13	$ 23.58
20	ARROZ GMF	PV 2005	COL	$12,073.00	6.5	$ 1,857.38	$ 171.66
21	AVENA FORRAJE	OI 05-06	E-Mex	$ 8,414.00	30	$ 280.47	$ 25.92

source: www.siap.sagarpa.gob.mx.viocs

exch. rate pesos /US Cy **$10.82**

OI stands for autumn-winter, growing season from October to March PV stands for spring summer growing season from April to September.

MAIZE PRODUCTION COSTS

	Crop	Cycle	State	Cost / ha	Yield ton	COST TON PESOS	COST TON USCy
27	MAIZ GRANO GMF	OI 05-06	SINALOA	$ 5,592.00	9.15	$ 611.15	$ 56.48
28	MAIZ GRANO GMF	PV 2005	SINALOA	$ 5,697.00	7	$ 813.86	$ 75.22
29	MAIZ GRANO GMF	PV 2005	JALISCO	$ 6,738.00	7	$ 962.57	$ 88.96
30	MAIZ GRANO GMF	PV 2005	E MEX	$ 6,683.00	6.5	$ 1,028.15	$ 95.02
31	MAIZ GRANO TMF	PV 2005	JALISCO	$ 5,888.00	5	$ 1,177.60	$ 108.84
32	MAIZ GRANO GMS	PV 2005	TAMPS	$ 5,014.50	3	$ 1,671.50	$ 154.48
33	MAIZ GRANO	PV2005	YUC	$ 5,461.00	3	$ 1,820.33	$ 168.24
34	MAIZ GRANO BMF	OI 05-06	SON	$11,126.50	5.5	$ 2,023.00	$ 186.97
35	MAIZ GRANO TCF	PV 2005	VER	$ 4,930.00	2.1	$ 2,347.62	$ 216.97
36	MAIZ GRANO TMF	PV 2005	E MEX	$ 5,870.60	2.5	$ 2,348.24	$ 217.03
37	MAIZ GRANO GCF	OI 05-06	GRO	$ 8,744.00	3	$ 2,914.67	$ 269.38
38	MAIZ GRANO TMS	PV 2005	TAB	$ 4,188.00	1.38	$ 3,034.78	$ 280.48

SOURCE: www.siap.sagarpa.gob.mx.viocs

exchange rate **$10.82**

For the crops for which production costs were not available, the following data was assumed.

From the previous production costs we asumed the following

				rendimiento		
22	for sweet sorghum grain sorghum costs	tamps	$ 5,179.00			
23	plus the transport from sugar cane costs		$ 2,000.00			
24	fodder sorghum with yields as fodder maize		$ 7,179.00	38	$ 188.92	$ 17.46
25	sweet sorghum with fodder yields for Gto SDR 2004		$ 7,179.00	65	$ 110.45	$ 10.21
26	cassava in Tabasco as sugar cane in Chiapas		$16,206.00	40	$ 405.15	$ 37.44

Cost benefit analysis ethanol different feed stocks (1)

data

price of crude US Cy barrel	53	dollars
exchange rate pesos/ US Cy	10.82	pesos/dollar

production cost per liter gasoline

	USCy /liter
crude	$ 0.3334
reffining and profits	$ 0.0618
dsitribution and marketing	$ 0.0577
total cost before taxes	**$ 0.4529**

production cost of ethanol

interest rate	12%
capital recovery period years	15

capital cost asuming mid range	$ 0.0785
operating costs	$ 0.1089
total cost of production excluding feedstock	$ 0.1875

Cost benefit analysis ethanol different feed stocks (1)

		feedstock cost USCy /liter	total cost USCy /liter	energy equivalent cost USCy /liter
gasoline before taxes			$ 0.4529	$ 0.4529
sugar cane second or third harvest OAX		$ 0.2123	$ 0.3998	$ 0.5638
sugar cane JAL		$ 0.2217	$ 0.4092	$ 0.5771
sugar cane second harvest PUE		$ 0.2248	$ 0.4122	$ 0.5814
sugar cane CHIAPAS		$ 0.2551	$ 0.4426	$ 0.6241
sweet sorghum grain sorghum cost, fodder sorghum yield		$ 0.2552	$ 0.4427	$ 0.6243
cassava		$ 0.3015	$ 0.4890	$ 0.6896
sugar cane VER		$ 0.3928	$ 0.5802	$ 0.8183
sugar cane SLP		$ 0.4244	$ 0.6119	$ 0.8629
sweet sorghum grain sorghum yields fodder maize		$ 0.4365	$ 0.6240	$ 0.8800
sugar beet costs and yield beet in jalisco		$ 0.7660	$ 0.9535	$ 1.3447
Maize	SINALOA	$ 0.1354	$ 0.3229	$ 0.4553
gasoline before taxes			$ 0.4529	$ 0.4529
Maize	SINALOA	$ 0.1803	$ 0.3677	$ 0.5186
Maize	JALISCO	$ 0.2132	$ 0.4007	$ 0.5651
Maize	E MEX	$ 0.2277	$ 0.4152	$ 0.5856
Maize	JALISCO	$ 0.2608	$ 0.4483	$ 0.6322
Maize	TAMPS	$ 0.3702	$ 0.5577	$ 0.7865
Maize	YUC	$ 0.4032	$ 0.5907	$ 0.8330
Maize	SON	$ 0.4481	$ 0.6356	$ 0.8963
Maize	VER	$ 0.5200	$ 0.7075	$ 0.9977
Maize	E MEX	$ 0.5201	$ 0.7076	$ 0.9979
Maize	GRO	$ 0.6456	$ 0.8331	$ 1.1748
Maize	TAB	$ 0.6722	$ 0.8597	$ 1.2123

Cost benefit analysis ethanol different feed stocks (2)

data

price of crude US Cy barrel	68	dollars
exchange rate pesos/ US Cy	10.82	pesos/dollar

production cost per liter gasoline

	USCy /liter
crude	$ 0.4277
reffining and profits	$ 0.0618
dsitribution and marketing	$ 0.0577
total cost before taxes	**$ 0.5472**

production cost of ethanol

interest rate	12%
capital recovery period years	15

capital cost asuming mid range	$ 0.0785
operating costs	$ 0.1089
total cost of production excluding feedstock	$ 0.1875

Cost benefit analysis ethanol different feed stocks (2)

		feedstock cost USCy /liter	total cost USCy /liter	energy equivalent cost USCy /liter
gasoline before taxes			$ 0.5472	$ 0.5472
sugar cane second or third harvest OAX		$ 0.2123	$ 0.3998	$ 0.5638
sugar cane JAL		$ 0.2217	$ 0.4092	$ 0.5771
sugar cane second harvest PUE		$ 0.2248	$ 0.4122	$ 0.5814
sugar cane CHIAPAS		$ 0.2551	$ 0.4426	$ 0.6241
sweet sorghum grain sorghum cost, fodder sorghum yield		$ 0.2552	$ 0.4427	$ 0.6243
cassava		$ 0.3015	$ 0.4890	$ 0.6896
sugar cane VER		$ 0.3928	$ 0.5802	$ 0.8183
sugar cane SLP		$ 0.4244	$ 0.6119	$ 0.8629
sweet sorghum grain sorghum yields fodder maize		$ 0.4365	$ 0.6240	$ 0.8800
sugar beet costs and yield beet in jalisco		$ 0.7660	$ 0.9535	$ 1.3447
Maize	SINALOA	$ 0.1354	$ 0.3229	$ 0.4553
Maize	SINALOA	$ 0.1803	$ 0.3677	$ 0.5186
gasoline before taxes			$ 0.5472	$ 0.5472
Maize	JALISCO	$ 0.2132	$ 0.4007	$ 0.5651
Maize	E MEX	$ 0.2277	$ 0.4152	$ 0.5856
Maize	JALISCO	$ 0.2608	$ 0.4483	$ 0.6322
Maize	TAMPS	$ 0.3702	$ 0.5577	$ 0.7865
Maize	YUC	$ 0.4032	$ 0.5907	$ 0.8330
Maize	SON	$ 0.4481	$ 0.6356	$ 0.8963
Maize	VER	$ 0.5200	$ 0.7075	$ 0.9977
Maize	E MEX	$ 0.5201	$ 0.7076	$ 0.9979
Maize	GRO	$ 0.6456	$ 0.8331	$ 1.1748
Maize	TAB	$ 0.6722	$ 0.8597	$ 1.2123

Cost benefit analysis ethanol different feed stocks (3)

data

price of crude US Cy barrel	74	dollars
exchange rate pesos/ US Cy	10.82	pesos/dollar

production cost per liter gasoline

	USCy /liter
crude	$ 0.4654
reffining and profits	$ 0.0618
dsitribution and marketing	$ 0.0577

total cost before taxes	**$ 0.5850**

production cost of ethanol

interest rate	12%
capital recovery period years	15
capital cost asuming mid range	$ 0.0785
operating costs	$ 0.1089
total cost of production excluding feedstock	$ 0.1875

Cost benefit analysis ethanol different feed stocks (3)

		feedstock cost USCy /liter	total cost USCy /liter	energy equivalent cost USCy /liter
sugar cane second or third harvest OAX		$ 0.2123	$ 0.3998	$ 0.5638
sugar cane JAL		$ 0.2217	$ 0.4092	$ 0.5771
sugar cane second harvest PUE		$ 0.2248	$ 0.4122	$ 0.5814
gasoline before taxes			$ 0.5850	$ 0.5850
sugar cane CHIAPAS		$ 0.2551	$ 0.4426	$ 0.6241
sweet sorghum grain sorghum cost, fodder sorghum yield		$ 0.2552	$ 0.4427	$ 0.6243
cassava		$ 0.3015	$ 0.4890	$ 0.6896
sugar cane VER		$ 0.3928	$ 0.5802	$ 0.8183
sugar cane SLP		$ 0.4244	$ 0.6119	$ 0.8629
sweet sorghum grain sorghum yields fodder maize		$ 0.4365	$ 0.6240	$ 0.8800
sugar beet costs and yield beet in jalisco		$ 0.7660	$ 0.9535	$ 1.3447
Maize	SINALOA	$ 0.1354	$ 0.3229	$ 0.4553
Maize	SINALOA	$ 0.1803	$ 0.3677	$ 0.5186
Maize	JALISCO	$ 0.2132	$ 0.4007	$ 0.5651
gasoline before taxes			$ 0.5850	$ 0.5850
Maize	E MEX	$ 0.2277	$ 0.4152	$ 0.5856
Maize	JALISCO	$ 0.2608	$ 0.4483	$ 0.6322
Maize	TAMPS	$ 0.3702	$ 0.5577	$ 0.7865
Maize	YUC	$ 0.4032	$ 0.5907	$ 0.8330
Maize	SON	$ 0.4481	$ 0.6356	$ 0.8963
Maize	VER	$ 0.5200	$ 0.7075	$ 0.9977
Maize	E MEX	$ 0.5201	$ 0.7076	$ 0.9979
Maize	GRO	$ 0.6456	$ 0.8331	$ 1.1748
Maize	TAB	$ 0.6722	$ 0.8597	$ 1.2123

CASSAVA ETHANOL CONVERSION	
	TON /AÑO
CAPACITY FACTORY CASSAVA	555,000
	M3 / AÑO
FACTORY CAPACITY ETHANOL M^3 / AÑO 95% VOL	226,707.351

		TON /AÑO
	FACTORY CAPACITY ETHANOL	185,000
		TON/HA
	YIELD TON / HA	15
		HA
	CRIOP AREA NEEDED	37,000
	CULTURE COEFICIENT	0.25
	TOTAL AREA HA	148000
	STARCH CONTENT FRESH TUBERS	33.60%
	100 kg de TUBERS 27 kilos starch	27%
		LITROS TON
	CONVERTION LITRES/TON	408.481714
PRECIO		
26	COSTO SEED STOCK LITER ETHANOL	$ 0.0917
		kilos /ton
	STARCH CONTENT FRESH TUBERS	270
	CONVERSION RATE STARCH SACHAROSE	95%
	sacHarose kilos /ton cassava	256.5
	production ethanol liters /ton sacharose	484.199523
	litres ethanol ton cassava	124.1972
	cost feed stock per liter ethanol	$ 0.30

SWEET SORGHUM ETHANOL CONVERSION

source: LEOPOLD CENTER SUSTAINABLE AGRICULTURE

	LBS /ACRE	KG/HA
Yiel dry matter	15,982.00	17,913.33
moisture	75%	
		KG/HA
yield wet basis		71,653.33
	Lbs/acre	
sugar yield	7411	8,306.58
	GAL/ACRE	LITROS HA
ethanol yield	504	4,714.38
yield ethanol liters /ton		65.794
yield ethanol liters / ton according to Ak Rajvanshi 2001		40
		USCy /LITRO
24 feed stock cost under code 24 production cost		$ 0.44
25 feed stock cost under code 25 production cost		$ 0.26

SUGAR BEET ETHANOL CONVERSION

	TONS/ACRE	Ton/ha
CROP YIELD	42	94.151
	GAL/TONS	LITROS/TON
ETHANOL YIELD IN LITRERS ETHANOL /TON	24.8	85.164

Source Imperial Valley sugar beet costs UC Davies Extension Service 1998

		kg/azucar/ton
Sugar yield %	14.70%	147
	GAL/TONS	litros/ton
ethanol / sacharose conversion	141	484.200
		US CY/LITRO
feedstock cost considering beet jalisco production cost code 14		$ 0.77

fuente cost study corn etanol production 2002 usda

					USCy/LITRO	
27	FEEDSTOCK COST	OI 05-06	SINALOA		$	0.14
28	FEEDSTOCK COST	PV 2005	SINALOA		$	0.18
29	FEEDSTOCK COST	PV 2005	JALISCO		$	0.21
30	FEEDSTOCK COST	PV 2005	E MEX		$	0.23
31	FEEDSTOCK COST	PV 2005	JALISCO		$	0.26
32	FEEDSTOCK COST	PV 2005	TAMPS		$	0.37
33	FEEDSTOCK COST	PV2005	YUC		$	0.40
34	FEEDSTOCK COST	OI 05-06	SON		$	0.45
35	FEEDSTOCK COST	PV 2005	VER		$	0.52
36	FEEDSTOCK COST	PV 2005	E MEX		$	0.52
37	FEEDSTOCK COST	OI 05-06	GRO		$	0.65
38	FEEDSTOCK COST	PV 2005	TAB		$	0.67

SUGAR CANE ETHANOL
CONVERSION

	GAL/TONS	LITROS/TON
RENDIMIENTO DE ETANOL TONELADA	19	65.247

fuente
Economic Feasibility of ethanol production
from sugar in the USA
June 2006 USDA

CODE					
				USCY LITRO	
6	FEEDSTOK COST	VER		$	0.39
7	FEEDSTOK COST	OAX	2 HARV	$	0.21
5	FEEDSTOK COST	JAL		$	0.22
9	FEEDSTOK COST	SLP		$	0.42
3	FEEDSTOK COST	CHIS		$	0.26
8	FEEDSTOK COST	PUE	2 HARV	$	0.22

		US Cy/gal	US Cy/liter
PRICE OF GASOLINE 2003 AVERAGE		$ 1.5600	$ 0.4121
distribution marketing	14%	$ 0.2184	$ 0.0577
refinning costs and profits	15%	$ 0.2340	$ 0.0618
federal tax	27%	$ 0.4212	$ 0.1113
crude oil	44%	$ 0.6864	$ 0.1813
	100%		
cost before tax		$ 1.1388	$ 0.3008
distribution marketing	19.178%		
refinning costs and profits	20.548%		
crude oil	60.274%		
	100.000%		

		gal	litres
a barrel of oil makes		42	158.987
gasoline	51.40%	21.588	81.719
distilate fuel oil	15.30%	6.426	24.325
jet fuel	12.50%	5.25	19.873
still gas	5.40%	2.268	8.585
coke	5.00%	2.1	7.949
combustible residual oil	3.30%	1.386	5.247
liquified refinied cos	2.80%	1.176	4.452
asphalt road oil	1.90%	0.798	3.021
other refined products	1.50%	0.63	2.385
liubricants	0.90%	0.378	1.431
	100.00%	42	

	uscy
price oil barrel	$ 74.00
price of gasoline in barrel of oil	$ 38.04
cost crude oil per galon	$ 1.7619
cost crude oil per liter of gasoline	$ 0.4654
cost of reffining per liter gasooline	$ 0.0618
cost of dsitribution and marketing per liter	$ 0.0577
total per liter gasoline before taxes	$ 0.5850

asumptions

The price of each product pays it's share of crude
The cost of reffining and marketing remains constant at 2003 average value

	GAL		LITER	
COST OF GASOLINE BEFORE TAXES	$	2.21	$	0.58
	MJ/gal		Mj/liter	
ENERGY CONTENT OF GASOLINE		124.9182		33

ETHANOL VARIABLE PRODUCTION COSTS

USDA ETANOL PLANT SURVEY 2002

VARIABLE COST (MEAN VALUES)

FOR GALON ETHANOL PRODUCED		CONSUMPTION	MIN	MAX
		kW / h	kW / h	kW / h
ELECTRICITY		1.19	0.6	2
		BTU	BTU	BTU
THERMIC ENERGY		34800	26000	54000
	USCy			
PRICE MILLON BTU	6.65	0.23142	0.17290	0.35910
	USCy			
PRICE kW / h	0.044	0.05236	0.02640	0.08800

2002 PRICES	US Cy / GAL	US Cy /LIT
ELECTRICITY	$ 0.0374	$ 0.0099
FUELS	$ 0.1355	$ 0.0358
WASTE MANAGEMENT AND DISPOSAL	$ 0.0059	$ 0.0016
WATER	$ 0.0030	$ 0.0008
ENZIMES	$ 0.0366	$ 0.0097
YEAST	$ 0.0043	$ 0.0011
CHEMICALS	$ 0.0229	$ 0.0060
DESNATURALIZANTE	$ 0.0348	$ 0.0092
MAINTENANCE	$ 0.0396	$ 0.0105
LABOR	$ 0.0544	$ 0.0144
ADMINISTRATION	$ 0.0341	$ 0.0090
OTHER	$ 0.0039	$ 0.0010
TOTAL	$ 0.4124	$ 0.1089

ETHANOL PRODUCTION (CAPITAL COSTS)

CAPITAL COST						
	US Cy		US Cy		MEDIO	
PLANT COST GALON / YR	$1.05		$3.00		$2.03	
	10^6 GAL/YR					
PLANT CAPACITY	15,000	20,000	250,000	30,000	40,000	60,000
	10^6 US Cy	10^6 US Cy	10^6 US Cy	10^6 US Cy	10^6 US Cy	10^6 US Cy
INVESTMENT MAX	$ 45,000.0000	$ 60,000.0000	$ 750,000.0000	$ 90,000.0000	$ 120,000.0000	$ 180,000.0000
INVESTMENT MID	$ 30,375.0000	$ 40,500.0000	$ 506,250.0000	$ 60,750.0000	$ 81,000.0000	$ 121,500.0000
INVESTMENT MIN	$ 15,750.0000	$ 21,000.0000	$ 262,500.0000	$ 31,500.0000	$ 42,000.0000	$ 63,000.0000
ITEREST RATE	12%					
CAPITAL RECOVERY PERIOD	15	YEARS				
CAPITAL RECOVERY FACTOR	0.1468					

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

i = INTERST RATE
n = YEARS CAPITAL RECOVERY

	10^6 US Cy	10^6 US Cy	10^6 US Cy	10^6 US Cy	10^6 US Cy	10^6 US Cy
ANNUAL COST MAX	$ 6,607.09	$ 8,809.45	$ 110,118.18	$ 13,214.18	$ 17,618.91	$ 26,428.36
ANNUAL COST MID	$ 4,459.79	$ 5,946.38	$ 74,329.77	$ 8,919.57	$ 11,892.76	$ 17,839.15
ANNUAL COST MIN	$ 2,312.48	$ 3,083.31	$ 38,541.36	$ 4,624.96	$ 6,166.62	$ 9,249.93
CAPITAL COST GALON PRODUCED						
MAX	$ 0.44	$ 0.44	$ 0.44	$ 0.44	$ 0.44	$ 0.44
MID	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30
MIN	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15

CAPITAL COST LITER PRODUCED

MAX	$ 0.11636	$ 0.11636	$ 0.11636	$ 0.11636	$ 0.11636	$ 0.11636
MEDIO	$ 0.07854	$ 0.07854	$ 0.07854	$ 0.07854	$ 0.07854	$ 0.07854
MIN	$ 0.04073	$ 0.04073	$ 0.04073	$ 0.04073	$ 0.04073	$ 0.04073

HEAT VALUE 23.4 MJ/L

http://bioenergy.ornl.gov/papers/misc/energy_conv.html

	USCy GAL	USCy l
TOTAL PRODUCTION COST	$ 0.70972	$ 0.18749
PRODUCTION COST PER Mj		$ 0.00801

Biodiesel

To estimate Biodiesel feed stock cost the available data for palm oil in Mexico was used, some data for Jatropha was estimated and the oil liter cost was calculated considering the break even point for direct sale of fresh fruit bunches to the extraction factory, Searching to establish the profitability of small scale extraction.
In the cash flow for palm oil production a subsidy was estimated to make the Internal rate of return (IIR) equal to cero.

With this oil cost we calculated the biodiesel production cost using data from the ITSM biodiesel web page.

The oil extraction cost on the small scale was estimated using data from Indian machinery.

COSTO DE PRODUCCION DE BIODIESEL							
	TIPO CAMBIO			$	11.25	pesos/dólar	
		USCy / 100LTS		pesos /100 lt			
COSTO DE MATERIALES							
METANOL, CATALIZADOR AC. ACETICO		$	15.18	$	170.78		
ENERGIA		$	0.35	$	3.94		
OPERACIÓN		$	13.35	$	150.19		
MANTENIMIENTO		$	1.54	$	17.33		
TOTAL		$	30.42	$	342.23		
COSTO PRODUCCION BIODIESEL POR LITRO		$	0.30	$	3.42		
COSTO DE EXTRACCION LITRO ACEITE				$	1.25		
COSTO TOTAL				$	4.67		
							COSTO BIODIESEL
COSTO LITRO ACEITE PALMA PRECIO LAB PLANTA				$	6.08		$ 10.75
COSTO LITRO ACEITE PALMA DEDUCIENDO TRANSP				$	5.59		$ 10.25

fuente ITSM Biodiesel

CASH FLOW FOR OIL PALM

	0	1	2	3	4	5	6	7	8	9	10	TOTAL
SOIL PREPARATION AND PLANTING	$ 4,930.00											
WEEDING AND PEST MANAGEMENT	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	
FERTILIZER					$ 80.00	$ 80.00	$ 160.00	$ 320.00	$ 480.00	$ 640.00	$ 800.00	
PLANT COST	$ 4,818.00											
HARVEST					$ 1,233.46	$ 1,533.46	$ 1,884.61	$ 2,115.77	$ 2,115.77	$ 2,115.77	$ 2,115.77	
TRANSPORT FIELD -INDUSTRY					$ 92.82	$ 92.82	$ 185.64	$ 371.28	$ 556.92	$ 742.57	$ 928.21	
PRODUCE VALUE					-$ 1,142.79	-$ 2,285.58	-$ 4,571.15	-$ 6,856.73	-$ 9,142.31	-$ 11,427.89	-$ 11,427.89	
SUBSIDY	-$ 13,248.00	-$ 1,750.00	-$ 1,750.00	-$ 1,750.00	-$ 1,750.00							
VALUE BEFORE ACTUALIZATION	$ -	$ 1,750.00	$ 1,750.00	$ 1,750.00	$ 2,013.49	$ 2,920.70	$ 1,159.10	-$ 549.68	-$ 2,489.62	-$ 4,429.55	-$ 4,083.91	-$ 209.47
PRESENT WORTH VALUE	$ -	$ 1,750.00	$ 1,750.00	$ 1,750.00	$ 2,013.49	$ 2,920.70	$ 1,159.10	-$ 549.68	-$ 2,489.62	-$ 4,429.55	-$ 4,083.91	-$ 209.47

INTERNAL RATE OF RETURN 0.0000%

BASIC DATA
YIELD AT MATURITY 10.5 TON FRESH FRUIT BUNCHES / YR

PRODUCTION YEAR 4	10%
PRODUCTION YEAR 5	20%
PRODUCTION YEAR 6	40%
PRODUCTION YEAR 7	60%
PRODUCTION YEAR 8	80%
PRODUCTION YEAR 9	100%

REFERENCE PRICE PER TON
AMIAC AC FOB INDUSTRY $ 1,088.37 PESOS/TON

TIME TO REACH INDUSTRY 1 HOURS

HARVEST AND TRANSPORT COSTS HAVE BEEN REDUCED BY 50%
SUBSIDY PLANT AND SOIL PREPARATION AND 50 % MANTENANCE FIRST 4 YEARS

CASH FLOW FOR JATROPHA

COST OF ESTABLISHING ONE HECTARE

PLANT PRODUCTION	$ 3.00	pesos / plant
PLANTING	$ 2.50	pesos / plant
WEED CONTROL AND MAINTENANCE	$ 800.00	ha
LAND PREPARATION	$ 3,000.00	$ / ha

Population plants ha	2500	1600	1100
Cost of planting and plan production	$ 13,750.00	$ 8,800.00	$ 6,050.00
land preparation	$ 3,000.00	$ 3,000.00	$ 3,000.00
weed control and maintenance 3 times year	$ 2,400.00	$ 2,400.00	$ 2,400.00
total	$ 19,150.00	$ 14,200.00	$ 11,450.00

harvesting cost	$ 150.00	$/ton
hulling cost	$ 120.00	$/ton de fruta
oil extracción cost	$ 1.15	$/kilo
percentage by weigth of seed in fruits	40%	
percentage by weigth of oil in seeds	37%	
percentage of oil extracted by pressing	89%	

Yield in tons when mature	fruits	seed	total oil	oil by pressing
high	25	10	3.7	3.3
medium high	16	6.4	2.368	2.1
medium high	12	4.8	1.776	1.6
medium low	8	3.2	1.184	1.1
low	4	1.6	0.592	0.5

tons produced	25	16	12	8	4
harvest cost	$ 3,750.00	$ 2,400.00	$ 1,800.00	$ 1,200.00	$ 600.00
hulling cost	$ 3,000.00	$ 1,920.00	$ 1,440.00	$ 960.00	$ 480.00
extraction cost	$ 3,786.95	$ 2,423.65	$ 1,817.74	$ 1,211.82	$ 605.91
total	$ 10,536.95	$ 6,743.65	$ 5,057.74	$ 3,371.82	$ 1,685.91
oil cost per kilo	$ 3.20	$ 3.20	$ 3.20	$ 3.20	$ 3.20
anual maintenance	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00
cost per kilo of oil	$ 0.73	$ 1.14	$ 1.52	$ 2.28	$ 4.56
total cost per oil kilo	$ 3.93	$ 4.34	$ 4.72	$ 5.48	$ 7.75
if producing one liter of biodiesel costs	$ 3.42				
total cost of biodiesel	$ 7.35	$ 7.76	$ 8.14	$ 8.90	$ 11.18

NECESARY SURFACE FOR INDUSTRIAL PRODUCTION

INDUSTRY CAPACITY TON BIODIESEL / YEAR		8,000	50,000	100,000
AREA NEEDED IN HECTARES	25 TON HA	2162.2	13513.5	27027.0
	16 TON/HA	3378.4	21114.9	42229.7
	12 TON/HA	4504.5	28153.2	56306.3
	8 TON/HA	6756.8	42229.7	84459.5
	4 TON/HA	13513.5	84459.5	168918.9

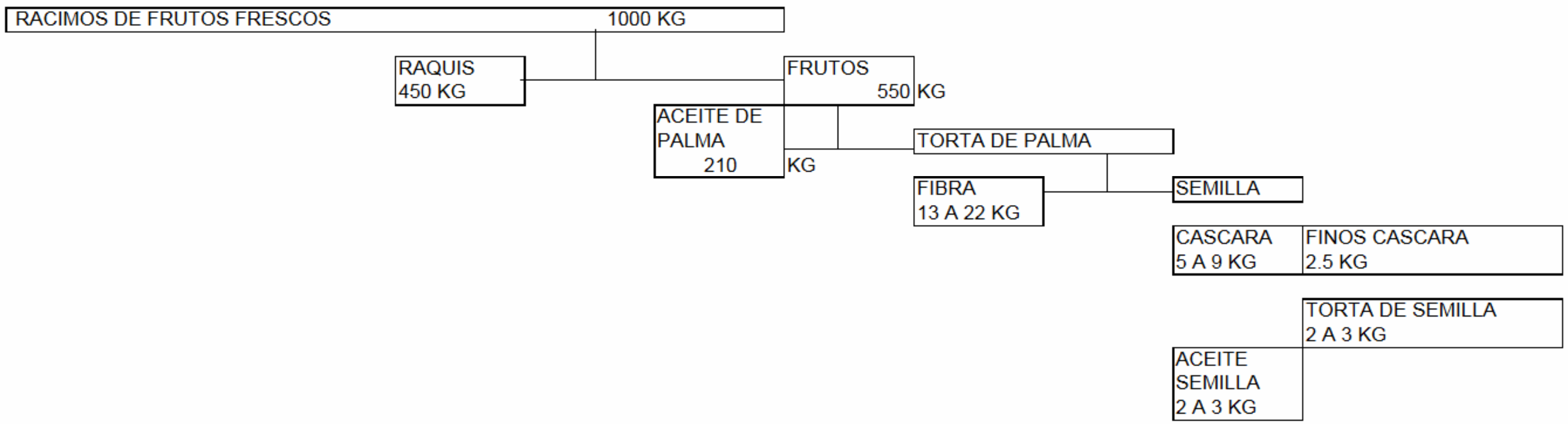
SMALL SCALE OIL EXTRACCION AND BIODIESEL PRODUCTION

COSTO DEL HERRAMENTAL				us cy				
BENEFICIO PALMA				$ 12,000.00				
INSTALACIONES				$ 8,000.00				
PLANTA DE ESTERIFICCION				$ 24,372.00				
ITSM BIODIESEL								
total inversion				$ 44,372.00				
CAPACIDAD EXTRACTORA ACONDICIONADORA				400	KG DE FRUTOS / HR			
				0.727	TON RACIMO hr			
CAPACIDAD PLANTA ESTERIFICACION								
VOLUMEN ACEITE PRODUCIDO HORA				71.607	LTS			
FACTOR RECUPERACIÓN DE CAPITAL				$\frac{i(1+i)^n}{(1+i)^n-1}$	0.1614			
TASA INTERES		12%						
VIDA UTIL		12						
VALOR SALVAMENTO		15%						
TASA DE CAMBIO PESOS DÓLAR	$	11.25						
COSTO FINANCIERO ANUAL				$ 6,088.78	US Cy/AÑO			
COSTO FIN TONELADA PROCESADA				$ 3.21	USCy/TON			
COSTO FINANCIERO LITRO ACEITE				$ 0.0179	US Cy Ton	$	0.20	pesos/litro
COSTO DE PERSONAL DIA				$ 460.27	PESOS DIA			
COSTO PERSONAL TON DE RACIMOS PROCESADA				$ 0.24	PESOS TON			
COSTO PERSONAL LITRO ACEITE				$ 0.80	PESOS LITRO			
COSTO DE OPERACIÓN PLANTA								
potencia 12 hp motores		6.624	kW					
tarifa 3 CFE peninsular					pesos			
consumo $/kW	$	1.28	kW/hr consumo	$ 8.47	costo hora	motores		
iluminacion wats		0.75	kW	0.95925	costo hora	iluminacion y varios		
cargo fijo mensual demanda maxima	$	203.19	$/ kW	$ 2,031.90	costo mes			
demanda maxima		10	kW					
cargo fijo hora 26dias 10 horas dia				$ 7.82	cargo fijo/hr			
				$ 17.25	costo energia hora			
				$ 0.24	costo energia /litro aceite			
costo total extraccion litro aceite				$ 1.25				

PALMA DE ACEITE

		jornales	horas tractor	maquina cosecha	mano de obra cosecha	total	costo cosecha tonelada	valor produccion	ingreso neto
producion 4 año	10%	15	3	$ 666.92	$ 1,800.00	$ 2,466.92	$ 2,349.45	$ 1,142.79	-$ 1,324.13
producion 5 año	20%	20	3	$ 666.92	$ 2,400.00	$ 3,066.92	$ 1,460.44	$ 2,285.58	-$ 781.34
producion 6 año	40%	24	4	$ 889.22	$ 2,880.00	$ 3,769.22	$ 897.43	$ 4,571.15	$ 801.93
producion 7 año	60%	26	5	$ 1,111.53	$ 3,120.00	$ 4,231.53	$ 671.67	$ 6,856.73	$ 2,625.20
producion 8 año	80%	26	5	$ 1,111.53	$ 3,120.00	$ 4,231.53	$ 503.75	$ 9,142.31	$ 4,910.78
producion 9 año	100%	26	5	$ 1,111.53	$ 3,120.00	$ 4,231.53	$ 403.00	$ 11,427.89	$ 7,196.35

PRODUCCION DE ACEITE DE PLAMA OPCION MINI EXTRACCION



PALMA DE ACEITE

ESTABLECIMIENTO DEL CULTIVO				
PALMAS POR HECTAREA				146
		m2		
SUPERFICIE POR PALMA		68.49		
PLANTACION TRIANGULO EQUILATERO 9 m				
costo unitario planta			$	33.00
costo planta			$	4,818.00
costo de jornal			$	120.00
costo hora de tractor			$	222.31
producción de racimos de frutos frescos				10.50 ton /año
precio referencia ton frutos LAB Planta			$	1,088.37
transporte campo planta				
tiempo transporte	hr 1			
				$/ton
costo transporte			$	88.40
ingreso neto productor $/ton racimos			$	999.97
establecimiento de planta				
preparacion de suelo				
desvare			$	800.00
surcado			$	500.00
cruzado			$	500.00
transplante cost unitario	5		$	730.00
fertilización			$	800.00
cosntrol de malezas			$	800.00
control de plagas			$	800.00
			$	4,930.00
fertlizacion suplementaria en produccion			$	800.00
cuidado durante 5 años sin produccion año			$	3,500.00
fertlizacion en produccion				

SMALL SCALE RURAL OIL EXTRACTION UNIT

MATERIALS BALANCE		PALM	
FRESH FRUIT BUNCH (FFB) YIELDS		20	TON /HA
FRESH FRUIT BUNCHES PER PALM		136.99	KG PALM
NUMBER OF PALMS PER HA		146	PALM /HA
OIL IN FRUIT FLESH		210	KG/TON FFB
PRIMARY OIL EXTRACTION	78% TOTAL	163.8	KG OIL /TON FFB
OIL SPECIFIC GRAVITY	0.915	179.02	OIL LITRES PER TON FFB
equilibrium price for oil / direct sale of fruit bunches		$ 6.08	
equilibrium price for oil / direct sale of fruit bunches once transport is paid		$ 5.59	
small scale extraction minytech India			
fruit separator		4	ton /hr
oil extractor strerilizer		400	kg /hora
fiber - kernel separator			
clarifier			
press filter			
equipment approximatte cost		$ 12,000.00	uscy
personal			
supervisor		$ 8,000.00	$mes
assistant		$ 4,000.00	$mes
oil yield assuming		65.52	kg oil/hr
		71.61	liters oil /hr
separator productivity	rachis	1.8	ton hr
	fruits	2.2	ton hr
plant capacity assuming 16 hours day		6400	kilos fruit day
sea de racimos completos		11636.36	kilos day complete bunches
if maximum monthly production is 16 % of total		1896.10	ton year
working days month		26.07	
mean yield per hectare	18.9 ton fruit bunches		
area needed		100.3	ha

4.4.6 REFERENCES

USDA2005 USDA's 2002 Ethanol Cost-of-Production Survey
U.S. Department of Agriculture, Office of the Chief Economist, Office of Energy Policy and New Uses Washington
www.ncga.com/ethanol/**pdfs/031506USDACostOfProduction.pdf**
accessed 3 jul2007

USDA FAS (2004)Mexico and Sugar: Historical Perspective
Report prepared by Robert Knapp
Horticultural and Tropical Products Division
Foreign Agricultural Service, USDA.
http://www.fas.usda.gov/htp/sugar/2004/History%20of%20sugar%20dispute%20final.pdf accessed 3 jul2007

Enriquez Poy M 2007 Ponencia presentada en el foro cadena de valor industria azucarera Veracruz consultado en
http://www.senado.gob.mx/comisiones/LX/agroindustriaazucarera/content/eventos/forocadenadevalor/foro_veracruz/conclusiones_bioenergeticos.pdf

Mir B. Ali (2004) Characteristics and Production Costs of U.S. Sugarbeet Farms Satistical Report 974-8 Economic Research Service USDA Washington
www.ers.usda.gov

Toledo, Alejandro,(1984) Cómo Destruir el Paraíso: el desastre ecológico del sureste". CECODES/OCEANO, México,

Ewell P.T, Poleman, T.T. 1979 Uxpanapa: Agricultural Development in the Mexican Tropics Pergamon policy studies on international development Pergamon Press New York

Jiménez, J. 1991. Especie nueva de Jatropha (Euphorbiaceae) de Oaxaca, México.
Anales Inst. Biol. Univ. Nac. Autón. México, Ser. Bot. 62(1): 83-86.

Jiménez, J. 1992. Especie nueva de Jatropha (Euphorbiaceae) de la depresión de Río Balsas, Guerrero, México.
Anales Inst. Biol. Univ. Nac. Autón. México, Ser. Bot. 63(1): 25-29

Jiménez, J. y R. L. Contreras. 1981. Jatropha galvanii (Euphorbiaceae), especie nueva de la Cuenca del Río Balsas.
Cact. Suc. Mex. 25(1): 1-4.

Jiménez, J. y M. Martínez. 1991. Especie nueva del género Jatropha (Euphorbiaceae) de Michoacán, México.
Anales Inst. Biol. Univ. Nac. Autón. México, Ser. Bot. 61(1): 1-4

Sagarpa (2007) Datos de costos de cultivo, Datos liberados
www.siap.gob.mx

SDA Gto 20004 Alternativas Forrajeras Sorgo
Secretaria de Desarrollo Agropecuario del Estado de Guanajuato
www.guanajuato.gob.mx/sda/articulos/alternativas/sorgo.html

Sagarpa (2004) Estadisticas Agricolas, Estado de Tamaulipas
www.sagarpa.cgob.mx

Annex 1

Land Tenure Systems in Developing Countries:

Case Study Mexico

SIE 526, Cadastral and Land Information System

Vincenzo Marotta

www.spatial.maine.edu/~onsrud/emergingeconomies/country_reports/**mexico**.html - 44k - accesed June 27th 2007

1. ABSTRACT

The evolution of the land tenure system in Mexico is derived by the fusion of two different arrangements: (1) the system developed by the native indigenous population , and (2) the other brought by the Spaniards. The land tenure system elaborated by the Indian society was a patriarchal village-type landholding with a democratic character. However, the communism system went under an extensive modification, which destroyed gradually whatever equally was formerly existed, and creating individual holdings. The general trend of the colonial period was also toward the accumulation of land in few hands. This unequal distribution of land and other minor factors were responsible for the War of Independence in Mexico during the nineteen century. Porfirio Diaz was the most remarkable ruler during the post-colonial period of Mexico. Its regime saw rapid economic growth and industrialization, but landholding became more concentrated than ever. The revolution broke up in 1910, and the new nationalist and populist government was committed to the peasant class. A redistribution of land was proceeded throughout Mexico on the basis of the constitutional principles established by the Article 27. The Agrarian Reform imposed a maximum legal limit on privately owned land to avoid land-feudalism and land distribution occurred gradually over decades. However, since the 1940s the new agrarian bourgeoisie started to monopolize the highest productive regions thanks to their political and financial acquaintances. The corruption of state officials also facilitate illegal land grabbing. Actually in Mexico a small minority number of powerful, well capitalized enterprises holds the best land, controls the country's agricultural economy and export market. In contrast to a vast majority of impoverished small holdings, lacking of technology, financial resources, credit, access to markets, information and training, provide less than the necessary income to sustain the peasant family. Mexican Agriculture is in crisis and the government interventions to assist the ejidos have failed in the past. Mexico needs real land reform that takes into consideration the ability of the Indian population to participate fully in the modernization of rural Mexico. The ejidos and agrarian communities have to be given the resources they need, and empowered with their own decision making.

2. HISTORICAL BACKGROUND

The evolution of the land tenure system in Mexico is derived, as with many of the Latin America Countries, by the fusion of two different arrangements. The first system was established by the native indigenous population (Maya and Aztec), and it reflects their social organization, while the second system, brought by the European invaders (Spaniards), was imposed and adapted to the previous one.

When the conquistadors landed in Mexico, the area was inhabited by 600 ethnic groups living at different stage of social and cultural development. Some were conducting a nomadic existence mostly within the north semi-arid plains and in the mountain of the Sierra Madre. They had no conception of real property rights. Instead, in the central plateau and on the peninsula of Yucatan, where the majority of indigenous population settled, agriculture was the basis for their economy. Cultivable land played an important role inside the community of a village and the lend tenure system was developed for the benefit of the community. This land tenure system had influenced the land tenure patterns throughout Mexican history and some of its features have been incorporated into the agrarian code of contemporary Mexican land reform (Wetten, 1948, 76).

2.1 THE MAYAN CIVILIZATION

Mayan civilization ruled during the 250-1200 D.C. period, and socially it was organized in four classes: nobility, priesthood, common people and slaves (Powelson, 1988, 217). The first two were considered the elite castes, in opposition to the others being the lower ones. Indeed, these two classes had to pay tribute to the rulers, give presents to the local lords and make offerings to their gods through the priests (Powelson, 1988, 217).

Most of the Mayan's land was owned communally and the concept of exclusive ownership was completely unknown to them. The land was distributed to the families and because of the variation in land quality, the allocation was regulated by a powerful individual, called alcaldecol by the Spanish. However, the elites had some kind of ownership to land through each they could buy or sell land but only in certain limits.

All the improvement to land were not transferable: houses, trees, etc. belonged to the person who built or planted them. If the land was assigned to another person, the new designated individual "owned" only the land unless he paid for them.

Noble Mayan families, rather than land, could own only a portion of land surrounding a well, a spring or a depression area to collect water, but boundaries were not delineated. The owners and the rights to land were recognized through the "common knowledge" rule. Land rights also could be extended to family members and inherited through the male successor. However, farmers had only the rights to agricultural activities on communal land, and the rights could be transferred to their heirs (Powelson, 1988, 218).

2.2 THE AZTEC EMPIRE

At the time of Spanish conquest, a powerful empire, rose from the federation of three city-states (Tenochtitlan, Texcoco and Tlacopan). They had successfully conquered and controlled a large portion of the central Mexican region. This empire is well known as the Aztec state (Simpson, 1937,3).

The early democratic Aztec society was organized in tribes, each of them was composed by twenty different clans (called calpulli). Components of a clan were the families whose heads participated in decision-making meetings. The land was free, commonly held, and distributed among the families based on their needs. However, this democratic administration and distribution were being modified by the introduction of class distinctions and vested interests (Simpson, 1937, 4). Indeed, by the 16th century, nobilty was accumulating such quantities of land (and serfs), that the Spaniards recognized it as a feudal system similar to their own.

At the time of Spanish conquest, the Aztecs had become a hierarchical military society, where the most highly valued member was a soldier rather than a farmer and he was awarded for his military heroism with land, wealth and social rank (Powelson, 1988, 218). The emperor, called tlatoany, was the owner of the land on behalf of the empire. The land was distributed among the tehcutli, who were the highest officials in the army and worked by others. Even though they were originally elected, by the 16th century the tehcutli acquired their title by inheritance. The son of tehcutli was called pilli and, although, land was communal, he in practice could inherit the land of the fathers (Powelson, 1988, 218)

The land tenure system elaborated by the Aztec society was a village-type landholding. It was developed with a democratic character, in which each Aztec had rights to land. Also the rights of possession were clearly identified and well enforced (Tannenbaum, 1968, 3).

The aggregate of land surrounding an Aztec village and belonging to the community was known as altepetlalli. The whole land was distributed among the calpulli (clans) composing the village. The untilled portion of the altepetlalli, belonging to a certain clan, could be used only by the member of that kinship group. The cultivable portion, on the other hand, was divided in smaller plots called tiatmilli and assigned to the head of families in the calpulli (Simpson, 1937, 4). There was also a public land designated to the temples and the priests (teocalli).

The allotments of land parcels to the household heads were made by one of the elders named pariente mayor. He kept a picture map of all lands of the clan, indicating their boundaries, the quality of the land, the name of the occupant and the various crops under cultivation. He usually kept up-to-date the map frequently, indicating new assignments and changes. (Wetten, 1948, 77).

The landmarks were marked off by stone walls, rows of trees (maguey), irrigation ditches or paths. The clan protected their boundaries jealously, inflicting often severe punishments to the intruders, reserving them even the death penalty for the removal of a benchmark (Whetten, 1984, 78). There was no written title to the individual lots, and the families owned only the usufruct which was also transferable from father to son. However, the families could lose the privilege to the land if (1) they did not cultivate the land for two consecutive years or (2) moved away from the village or become extinct.

This patriarchal communism went under an extensive modification which destroyed gradually whatever equally was formerly existed creating a form of tenure that resembled the individual holding of post conquest days.

First the parent mayor become gradually considered as a different member of the clan and received special lands (pillali) for his support. These lands were larger than the other individual lots, cultivated by serfs and regarded as personal properties of the pariente mayor family: they were indeed transferable by hereditary rights.

Second, some nobles named teules received land as a reward for their courage showed in the battle field or for other notable services to the community. This possession could be transferred to the heirs upon inheritance. In addition, the temple land, increased in size and was tilled no longer by the people of the village, but by the serfs to support the considerable sacerdotal class.

At the time of the Spanish conquest, nobles, overlords, chiefs, priests and other privileged individuals were a large growing group and landless peasants (known as tialmatil) were definitely a social class. The large Aztec estates resulting by these changes, can be considered as the great-grandfather of the modern Mexican hacienda (Simpson 1937, 5).

2.3 THE SPANISH CONQUEST

When the Spaniards arrived in Mexico, two forms of landholding were developed by the indigenous population: village landholding and individual held estates. The conquerors were familiar with both the land tenure system, and measures were taken to protect and foster them. The Spanish Crown, indeed, established legislation to ensure sufficient land to the new and old Indians for their adequate support. The fundo legal (town site) measuring 600 varas (about 500 meters) from the church to all directions was instituted. The land outside the village was called ejido and it was used as agriculture, wood and pasture land for the village. The land, however, was owned by the Crown and plots were awarded to individuals.

In spite of the regulations, designed to protect the landholding village, other forms of land tenure were developed to detriment of the community. These new forms bore out as a Crown's reward for the colonization. The most effective of these was known as repartimientos or encomiendas (Wetten, 1948, 81). These consisted of allotments, protected by the law, of certain number of villages and carried with the rights to collect tribute from the population that lived in the district. The pre-existing land tenures of the Aztec private estates was a favorable environment for the establishment of such a feudalistic type economy so familiar to the Spaniards. In fact, they simply took the place of the defeated Indian chieftains, and continued to collect tribute and services from the Indians.

However, at first the encomiendas were regarded as temporary arrangements

but successively a series of decrees extended the term from one to at least five generations. Soon, in spite of royal orders, the system gradually developed into e feudalistic pattern of land tenure, where the district assigned to the encomendero was seen as his personal property and the Indians living within as his serfs (Wetten, 1948, 81). Other forms of land ownership were established such as (1) the peonia and (2) the caballeria. The size of these land holdings were much inferior to the encomiendas, however they frequently served as a nucleus around which to accumulate larger holdings. This aggrandizement took place through different ways such as (2) the confiscation of Indian holdings, (2) the marriage of an Indian woman who owned lands or (3) the occupation of unclaimed lands (McBride, 1923, 51-52). It is believed that many haciendas (the future large estates) are born by this process of gradual annexion and consequence confirmation of title (Watten, 1948, 92-93).

Moreover, the Church, which considered itself the protector of Indian, during the colonial regime, gradually acquired very large holdings. The clergy had been, since the beginning, an economically privileged class (Whetten, 1948, 94). Their members received grants of land from the King of Spain, and built monasteries, churches and residences thanks to the financial efforts of the crown itself and the Spanish population. The native population instead furnished the unpaid labor. This was also the time when several religious orders arose, among them the Jesuits.

In addition, the Church had an advantage in respect to layman encomenderos, that is, they did not need any type of income source to build their own houses as did the encomenderos (Whetten, 1948, 94). Furthermore, the Church held these lands perpetually and, as result, the clergy was one of the most powerful landholder of the New Spain by the end of the sixteenth century. The amount of land held by the Church is unknown: estimates have varied between one-half and three-fourths of the total area of the Republic (Tannenbaum, 1929, 7). From this immense prestige, it is not surprising that the Church dominated the colonial era economically and politically (Wetten, 1948, 94).

The Spanish colonial legislation attempted to protect the Indian, and as result many of these native groups succeeded in preserving their freedom. However, those were the ones living in the mountainous sections of Mexico. The best land was on the plains, it was subdivided in large estates and the Indian inhabitant became serfs of the conquerors and their descendants. The general trend of the colonial history is, therefore, the accumulation of land in few hands (Tannenbaum, 1929, 7).

In the later years of the colonial period the Crown took steps towards the breaking up of those vast accumulations of land. The most significant was the abolition of encomiendas and the confiscation of the property of the Jesuit order. The excessive inequality of land distribution had affected the agricultural production of the country, and an alarming decline was observed in both the mother-country and in the colonies (the encomiendas already existed in Spain since the period of the conquest). The abolition of encomiendas was a slow and gradual process born with the intent to dismember these large holdings. From this time, a movement toward the division of the land and the creation of small holdings started to take a precise form in Mexico (McBride, 1971, 60-61)

One of the most recognized events toward the division of land in Mexico was the confiscation of the property of the Jesuit order during the eighteen century. By the year 1767, this order held a large of number of haciendas in Mexico whose the majority was of great size and located in the most productive part of the country (McBride, 1971, 62).

2.4 THE WAR FOR INDEPENDENCE IN MEXICO

Since the arrival of the Spaniard in New Spain, the Indian were gradually deprived of their holdings or allowed to remain as serfs. The unequal distribution of land and other minor factors were responsible for the War of Independence in Mexico during the nineteen century (1810-1821). The war, indeed, was largely motivated by the agrarian ambitions of the Indians (Tannenbaum, 1968, 8). The end of the war, however, did not extirpate the evil from the system abated. The accumulation of land in few hands was maintained much as in colonial times, many of these estates passed from Spaniards to Mestizos (mixed Indian-Spanish born Mexicans) or to Creoles (Spanish born Mexicans) (McBride, 1968, 66).

Never less, the war did lay the basis for three elements that contributed to the attempted break-up of the large estates in Mexico. It led to (1) the abolition of legal inferiority of Indians, (2) abolition of entailment of large holdings and (3) ultimate confiscation of church lands, which was completed at the end of the Three Years War (1857-1859) (Tannenbaum, 1968, 8-9). As result of these acts, some of those large properties resulted divided, but many others passed unbroken (Whetten, 1948, 98). In addition, this Reform, contrary to its original intent, caused the attack of the communal land of the

Indians that protected by the Spanish Crown, survived throughout the colonial period (Tennenbaum, 1968, 10).

2.5 THE DIAZ REGIME

Porfirio Diaz was the most remarkable ruler during the post-colonial period of Mexico (Tennenbaum, 1968, 138). He took office in 1876 keeping his power until 1911, except for the presidential period of 1880-1884. His rule was considered the most constructive in hundreds of years of the Republic. The Diaz administration was centered toward a rapid industrialization of the country by developing railroads, public utilities and stimulating the mining industry. These changes increased the flow of foreign investment in Mexico and as a consequence it led to a rapid rise in land value, but land speculation also. From here on, the Mexican government developed a land policy that was deleterious for the country (Tennenbaum, 1968, 138).

The attempt to destroy the feudal character of the Mexican land system was also defeated by the Diaz regime. The confusion already existing in the Mexican land system, which derived due to imperfect title, was enhanced by the land policy of Diaz. In 1883, in order to develop colonies in some of the most remote region of the Republic, a law was amended through which private companies (companias deslindadores) were empowered to carry out the survey of the land. In return, those companies received a third of the land surveyed as compensation of the work done and in addition they could buy the remained two-thirds at special rates (Simpson, 1937, 27).

This system of distribution of public land set up a period of land grabbing and speculation that brought one-fifth of the entire geographical area of Mexico in the hands of 29 private companies (SImpson, 1937, 28). During this time, every owner became subject to the manipulation of the surveying companies whose purpose was correcting and revising their titles. Many titles of small dimension properties were declared defective and denounced. Since the titling interpretation was subject to officials who were persuaded monetarily, land monopolization increased as never during the colonial times. The Indians who were less prepared and unable to protect their untitled land from the rich grabbers, were pushed off from their lands. The Diaz regime saw rapid economic growth and industrialization, but landholding became more concentrated (Tannenbaum, 1968, 14).

In addition to land issues, the Diaz administration failed in regard to the racial problems existing in Mexico. Indeed, it showed continuously an aversion toward the Indian population and their institution. The destruction of the Indian communal institutions was believed to be the hope for the Mexican economy and the Diaz Policy was toward a replacement of the Indian population with foreign immigration (Tannenbaum, 1968, 14-15).

2.6 THE REVOLUTION AND THE REFORM

The policy of the Diaz regime had brought rapid economic growth and a pronounced concentration of wealth in the hands of few individuals. However as a counter effect, the peasant villages lost most of their land, while inflation exceeded the increase of agricultural wages, and the standard of life for the masses in Mexico was lowered. These elements combined with other economical and industrial factors weakened the power of the central government creating the premises for the Mexican Revolution (Tannenbaum, 1968, 155).

The revolution broke up in 1910 and ended seven years later with the overthrow of Porfirio Diaz. The new nationalist and populist government was committed to the peasant class, and particularly during the presidency of Lazaro Cardenas (1934-1940) a redistribution of land was proceeded throughout Mexico on the basis of the constitutional principles established in 1917 (Article 27) (Rello, 1986, 1). The agrarian legislation created a central organism, the National Agrarian Commission (NAC), that carried out the restitution or the donation of the lands to the villages. It was a very powerful agency whose dictates could fulfill or deny the aspiration of thousands of Indian villages. The commission was composed of nine members and acted as final decision maker in the process of turning lands over to villages. The NAC received the records from the local agrarian commissions and could approve or disapprove the decision taken by the state authorities, modify, enlarge, reduce the area provisionally allowed in possession. Its final judgment was than passed back to the local authorities for execution (Tannenbaum, 1968, 224-226).

The agrarian land reform (embodied in the article 27 of 1917) of the post-revolution period was, therefore, carried with the intent to redistribute the land among the peasant communities which were deprived unjustly of their rights to land during the nineteenth century. As a consequence, the expropriated owner did not receive any compensation for the dispossession, and the reform beneficiary was not required to pay for the land granted (Eckstein, 1978, 18).

Land distribution occurred gradually over decades, and the process in Mexico differed substantially from other Latin America countries, that is the state generally was the initiator for the titling operation. However, the peasant communities had to submit an initial petition and the process between the submittion and the provisional grant was completed in about five years. In addition, for the ejido to gain the definitive title, it was required a further grace period of seven years. Until the 1930s, only few modernized estates were expropriated representing 6% of the country land (Eckstein, 1978, 18). After that, the process accelerated and by 1940, 22% of the farmland was redistributed among more than 50% of the agricultural population. After 1940 the redistribution slowed down again until 1960 when peasant pressure produced an increase of re-allotment. The last major expropriation took place in 1975 and since then reallotment was almost null mostly because there was no more available land (Dale, 1988, 35).

The large farms were divided essentially into ejidos, the communal land for the indigenous communities and settlements. Within the ejido individual lots were assigned individually to the ejidatarios. Furthermore, some ejidos were tilled in cooperative as corporations (known as collective ejidos), others were farmed individually (individual ejidos) or were mixed. The ownership in the individual ejidos was vested by the community and for this reason it could not be sold, rented, mortgaged or given away, but it could be inherited. In addition, an ejidatario could lose its right to land if he abandoned it. However, this problem could be solved by bribing local officials who could arrange the abandoned land to another ejidatario or to a private outsider. These subterfuges made de facto the communal land and the individual plots to be conveyed as private properties (Dale, 1988, 35). Also there was the tendency to split the original groups in smaller ones, and by 1960 the number of Mexican ejidos dropped about one half of the original number (Eckstein, 1978, 20).

3. CONTEMPORARY LAND TENURE IN MEXICO

The Agrarian Reform imposed a maximum legal limit on privately owned land (pequeña propiedad) to avoid land-feudalism. However, since the 1940s a small group of agricultural entrepreneurs (the new agrarian bourgeoisie) who operating with modern technology and mechanization contributed to the greater part of the agricultural production, started to monopolize the highest productive regions. This land-grabbing was possible through false titles that generated neo-latifundio whose size and resources exceeded the best ejido parcel (Rello, 1986, 3).

In this new capitalistic vision the ejidos represented an obstacle for various reason, among them an excess of bureaucracy and corruption. As result, renting ejidos parcels became a widespread practice in contrast to the agrarian legislation that forbidden such transactions. However, the agrarian bourgeoisie could evade the anti-latifundia laws, nominally dividing their estates into separate entitlement held officially by others acting as a front. These illegal operations were possible because they had the support of the political party (Simpson C, 1994, 3). As result, the most productive (and irrigated) district fell into the hands of private individuals who built large land holdings without formally owning the land (Rello, 1986 , 3) . Chiapas was an example of corruption of state officials, protecting large landowners and cattle ranchers, who monopolized two million hectares that represented one half of the entire state's land (Carrigan, 1 995, 77).

In addition to political favors, they had also links to the country's financial and commercial elite. Consequently, credit, technical assistance was concentrated in these large productive estates. Also, as in many states, the economic and political powers were themselves large landowners or cattleman. Thus, the lack of the rule of law had permitted the erosion of the ejido land, the growth of a labor surplus and the maintenance of low rural wages.

Actually in Mexico two agricultural systems exist: (1) a small minority number of powerful, well capitalized enterprises holding the best land, controlling the country's agricultural economy and export market and (2) a vast majority of impoverished small holdings (Burbach, 1994, 2). In contrast to the large rich estates, these minuscule ejidos are characterized by absence of technology, financial resources, credit, access to markets, information and training. Often these holdings provide less than the necessary income to sustain the peasant family. These farmers, even though beneficiaries of the agrarian reform, have been squeezed in poor or medium quality lands. About 80% of the peasants in Mexico lived under these conditions accounting for no more than 25-30% of the total agricultural production (Rello, 1986, 2).

In 1991 President Salinas modified the agrarian legislation (article 27) by making possible the sale, leasing and investing of individual plots. With this new law Salinas hoped that the redistribution program was officially ended and a modern agriculture system commenced. However, many peasant groups such as the State Council of Indigenous and Campesino Organization (CIOAC by its initials in Spanish) of the State of Chiapas believed that more illegal farms needed to be redistributed. This process could contribute to the fragmentation of the ejidos with deleterious consequences on indigenous customs and autonomy. The Salinas' administration hoped that the land would, instead, fall into the hands of productive farmers and corporate investors. However, since the minuscule private ejido parcels were still without technological training and access to credit, the agrarian situation in Mexico is still unchanged, with most of the land in the hands of few (Johnson, 1995, 25). The Salinas reform did transform land tenancy in the outskirts of urban centers. And allowed the formal expansion of cities into ejido lands..

Never less, some economic and agricultural analysts believe that the Salinas' effort was leading to the right direction. They are of the opinion that communities need and are able to make their own decisions regarding land matters. The problem was that the community did not have the technology and the financial power necessary to support the program (Johnson, 1995, 25).

4. PRESENT SITUATION

In 1995 despite, economic troubles, Mexico initiated a program called National Cadastre Modernization Program (NCMP) sponsored by Mexico's National Secretariat of Social Development (SEDESOL). The program had the objective of implementing a Geographic Information System to manage land records in Mexico. The Mexican Government hoped that the improvement of property record management would stimulate and benefit the country's economic development. In order to nationally promote the program, SEDESOL organized a conference in their office in Mexico City attracting more than 300 local, state/national officials, and private companies. SEDESOL encouraged the implementation of a geographic information system supporting the following expected benefits from a GIS:

-increasing revenues from first-time taxation of previous unrecorded properties

-attracting of foreign investment

-improvement of problem resolution

Two cities, Tijuana and Ensenada, are implementing GIS under a program called Cadastral Application for Tijuana and Ensenada program (CATE). The cities are shearing the costs for developing a database management system capable to handle all data maintenance, reporting and valuation needs as well as interfacing with the graphic portion of GIS. The program is close to completion, however, as of April 1997, I lacked further information about the success or failure of the CATE program. However, promoters hope that the program will be easy to use and the lower price can give incentive to other municipalities to follow the path undertaken by the cities of Tijuana and Ensenada (Klein, 1995, 64).

5. CONCLUSION

Mexican agriculture has been the most studied agrarian system in the world (Burbach, 1994, 20), and it is agreed that Mexican agricultural is in crisis. Grain production, that mostly comes from the ejidos, represents the great plague of Mexican economy (Burbach, 1994, 20) due to its decrease in price at the world level (Bellon, 1996, 380).

With this perspective, President Salinas introduced the Procampo program, a government system of subsidies. Under this program farmers can receive funds and are able to shift gradually from deficient grain production to more profitable areas of productions such as fruits and vegetables.

Such result is, however, unlikely. Under the Procampo project, the producer will receive about $ 100 per hectare per year. This amount is not enough to carry out a change over process for new crops, indeed, for strawberry production $ 10,000 per ha. Is necessary, while $ 2,300 is the minimum subsidy for broccoli production (Burbach, 1994, 20).

The inability of Mexico to feed its own people is rooted in the poverty of the rural class that constitutes, as we have seen, the majority of the Mexican population. Some analysts advocate the elimination of the ejidos and the marginal agricultural producers because they can not compete in the present market place. They argue that the interventions sponsored by the Mexican government to assist the ejidos have failed in the past, leaving the agricultural sector uncompetitive, undercapitalized and under productive (Burbach, 1994, 20).

This failure however does not depend on the primitive character of the ejidos system nor due to the lack of initiative of the peasantry. As David Barkin argues in Distorted Development, a prejudice conception was created around the poor farmers. This situation favored the urban industrial economy at expense of the agricultural sector (Burbach, 1994, 22). In addition, as in many cases, the ejidos are relocated in the marginal areas scarcely fertile, and essentially are cut off from market access.

Mexico needs real land reform that takes into consideration the ability of the Indian population to participate fully in the modernization of rural Mexico. The ejidos and agrarian communities have to be given the resources they need, and empowered with their own decision making. To succeed, the peasant population of the small ejidos need political freedom, that must be combined with the access to credit, technical and commercial support services. From a more technical point of view, a modern cadastral system is not a priority in resolving the land tenure system in Mexico. A modern cadastral system is already existing in Mexico City and more cities are experiencing the implementation of a geographic information system. Thus a legal infrastructure and a credit reform must come first.

6. BIBLIOGRAPHY

Barkin, D. 1990, Distorted Development: Mexico in the World Economy, Westview press, Boulder, Colorado.

Bellon, M. 1996, Landholding fragmentation: are folk sol taxonomy and equality important? A case study from Mexico. Human Ecology Journal, v24, n3, p373(21).

Braasch, H. W. 1975. "Land Information System in Developing Countries." Land Information System, Symposium of International Surveyors Federation, FIG, Technical University of Darmstadt, Germany, 631-39.

Burbach, R. And Rosset, P. 1994. Chiapas and the crisis of Mexican agriculture. Institute for Food and Development Policy.

Carrigan, A. 1995. Chiapas: the first post-modern revolution. Fletcher ForumWorld Affairs 19(1): 71-98.

Dale, P. And Mc Laughlin, J. 1988. Land information management: an introduction with special reference to cadastral problem in the third world countries. Oxford: Clarendon Press.

Dobner, H.K. 1983. Mexico City's new integral cadastral information system. FIG. Sofia, Bulgaria: FIG.

Eckstein, S., et al. 1978. Land Reform in Latin America: Bolivia, Chile, Mexico, Peru and Venezuela. The World Bank.

Harvey, H., R. 1991. Land and Politics in the Valley of Mexico. Albuquerque, University of New Mexico Press.

Johnson, N. 1995. Rural Reform fail to take root. Bus-Mex 5(3): 24-26

Klein, D., H. 1995. Mexico Implements National Cadaster Modernization Program. GIS World 8(6): 62.

Mc Bridge and McCutchen, G. 1971. The land systems of Mexico. New York, Octagon Books.

Ollson, Sr., C. 1958. Land reform and democracy. Gainesville, University of Florida Press.

Powelson J., P. (1988) The story of land: a world history of land tenure and agrarian reform. Lincoln institute of land policy: Cambridge.

Randall, L. 1996. Reforming Mexico's agrarian reform. Colombia University seminar ser.

Rello, F. 1986. Bourgeoisie, peasants, and the state in Mexico: the agrarian conflict of 1976. Geneva: United Nation Research Institute for Social Development.

Simpson, E., S. 1937. The Ejido: Mexico's way out. Chapel Hill: The University of North Carolina Press.

Simpson, C, R. and Rapone, A. 1994. Why did Chiapas revolt? Commonwealth, v121, n 11, p 16(4).

Tannenbaum, F. 1929/1968. The Mexican agrarian revolution. Archon Books.

Whetten and Laselle, N. 1948. Rural Mexico. University of Chicago Press