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SUMMARY

Worldwide food production is done in different types of agricultural production systems. The main difference is whether it is an intensive or extensive system. The agave production in Mexico has been developed in these two different ways. Firstly, agave for tequila has been produced in intensive capitalist systems with large amount of inputs achieving large production. However, this system has caused important environmental and social problems to the local inhabitants. Secondly, agave for mezcal has been produced in extensive systems within a subsistence peasant culture. The main production system is harvesting wild agave from its natural environment and it achieves very low yields. This system is environmentally compatible and benefits the local inhabitants because it fits into the peasant culture. In this project I compared the sustainability of these systems.

I focused on the mezcal production in some communities of Guerrero. The rural situation in this area, as in most rural regions of Mexico, is very problematic. Agricultural production is not profitable for peasants and there is large unemployment. For these reasons, poverty and migration to urban centres increase, and with this, the peasant subsistence culture is lost. However, peasants in these Guerrero communities who are involved in the mezcal production can support their families by mezcal’s profits and at the same time produce their own food which enables them to preserve their peasant subsistence culture. Nevertheless, since the agave production is very low, few peasants benefit from the mezcal production.

This project aimed to study if the type of agave production system can improve the peasant’s livelihood of the region by achieving a sustainable rural development. In order to do this, the agave production must be increased in a sustainable way and the production system must fits into the peasant subsistence culture.

There are different types of agave production systems. In this study, I characterized the agave production systems in two main categories based in the agave density that each system can reach: low density systems and high density systems. The first ones involve harvesting agave from its natural environment. The yield depends on the agave density in the forest. Nowadays, the density is very low because it has been overharvested in the last decades. However, there are agave planting programmes paid by governmental subsidies to increase the density in the forest. The advantages of these systems are that they preserve the forest and do not involve maintenance labour. This fits into the peasant subsistence culture because peasants have time to produce their own food and use other forest’s resources.

The high density systems achieve very high yields but do not preserve the forest. There are two systems in this category: monocultures and seed spreading system. Monocultures do not fit into the peasant subsistence culture because of several reasons. Profits are earned after the harvest (8-10 years after planting the agave), it requires large investments for the planting, fertilizers, pesticides, risks for pests are very high and large labour maintenance are required. In contrast, the seed spreading system does fit into the peasant subsistence culture. Profits can be earned every year because a small annual harvest is possible, risks of pests are smaller, fewer inputs are required and little maintenance labour is necessary.

The description and comparison of the production systems showed that there are two potential solutions to improve the peasant’s livelihood of the region by achieving a sustainable rural development. Firstly, increase agave in the forest by agave planting programmes. However, governmental subsidies are required. Secondly, change part of the forest into a seed spreading system. The fraction of the forest with a seed spreading system that gives the same profits as all forest planted with agave is 11%. The results of this study give insight about the sustainability and suitability to the peasant subsistence culture of the agave production systems in the region. Nevertheless, since this project was based on a literature research, it is necessary that, for further research, implementation of the acquired knowledge is done in the region.
1. INTRODUCTION

Worldwide food production is done in different types of agricultural production systems. The difference is based on the amount and type of resources that are used and, therefore, on the intensification of each production system. Extensive systems use large amount of land; in contrast, intensive systems use large amount of energy and water. The claim of these resources is causing an enormous environmental impact. For instance, global food production is the major cause of deforestation, desertification and loss of biodiversity (FAO & Bruinsma, 2003).

Throughout time, there has been a transition from extensive to intensive agriculture in order to increase and improve food production in a certain area (Caballero & Popkin, 2002, pag 28; Pimentel & Pimentel, 2008). However, in many regions, especially in developing countries, agriculture is still produced in extensive systems within a peasant subsistence culture. There are large differences between these two systems; not only in the production outcome, but also in the environmental and social consequences.

1.1 Transition from extensive to intensive agricultural systems

Agricultural yields are related to the amount of inputs that are used to produce a certain crop. The inputs in extensive systems usually are low machinery, low fertilizers, low pesticides, low irrigation and high labour with typically low yields (Nonhebel, 2002; Nonhebel & Gerbens-Leenes, 2009; Pimentel & Pimentel, 2008). To intensify the system labour is changed from human power to animal power and eventually to machinery; therefore machinery is increased and human labour is reduced. By doing this, the system becomes labour efficient. Moreover, to increase crop's productivity more fertilisers, pesticides and irrigation are used. This intensive system can achieve higher yields (Pimentel & Pimentel, 2008).

However, the large use of inputs implies higher energy use. The energy use includes the fuel for the machinery and irrigation as well as the large indirect energy use to produce fertilisers and pesticides. Usually in extensive systems the energy efficiency is higher than in intensive systems (Nonhebel & Gerbens-Leenes, 2000). This means that in an extensive system less energy is required to produce a certain amount of yield than in an intensive system. Therefore extensive systems reduce the negative effects per crop of the use of fossil fuels for global warming as well as air, water and soil pollution (Haas, Wetterich, & Kopke, 2001).

In the contrary, extensive systems require more land to produce a certain yield. This means that the efficiency of land use is lower than in intensive systems. Consequently more natural area is converted into agricultural land in an extensive system. A study shows that this loss of ecosystem services is higher in comparison to the benefits of reducing fertilisers and pesticides (Glendining, et al., 2009).

1.2 Subsistence agricultural systems

While in developed countries farmers produce food for the market, in most developing countries peasants produce food for their own consumption and sell the surpluses in the market. This type of production is called subsistence system and is mainly done in low input systems with a variety of crops. The main objective of this system is achieving food self-sufficiency for the peasant’s family; unlike the high input systems which main objective is to raise the profits by increasing the production for the market. Therefore management practices, priorities and rationalities are different for subsistence systems and for high input systems.
Nowadays, subsistence systems have been influenced by technology innovations, market economy and off-farm economic avenues (Singh, Rao, & Saxena, 1997). Moreover, since the Green Revolution in the 60’s, in some cases this subsistence economy has been changing from low input systems with crop diversity to high input monoculture systems. The technology of monocultures is more efficient but also involves higher risks (Koning & van Ittersum, 2009). This has affected the peasant economy in three main ways (Singh, et al., 1997):

1. Increasing the costs of crop production
2. Increasing the risks of pests and diseases by loss of biodiversity
3. Increasing the dependence on external market for basic food through reducing their crop diversity and therefore their subsistence economy

Because of this, and many other reasons, peasants living within a subsistence system are usually poor and sometimes can’t succeed to achieve food self-sufficiency. Therefore it is important to analyze and compare them with high input systems to understand their advantages and disadvantages.

1.3 Agave production in Mexico in intensive and subsistence systems

The agave production in Mexico is a clear example of a crop which in some regions is produced in high input systems and in other areas in low input systems. The main commercial use of agave is the production of alcoholic beverages like tequila and mezcal. The agave for tequila is mainly produced by companies in monocultures with high input systems. The agave for mezcal is generally produced by subsistence peasant farms in low input systems.

The development and consequences of both systems are different. The agave production for tequila increased enormously in the 20th century (CRT, 2009) with big economic benefits for the companies though with large environmental impacts and negative cost for local peasants (Bowen & Valenzuela, 2009; Martínez Rivera, et al., 2007). In a different way, the agave production for mezcal is low with small environmental impacts and the benefits are mainly for local peasants. However the agave production for mezcal is likely to increase in the coming years because the national and international demand for mezcal is increasing (Eguiarte & González González, 2007). For this reason it is important to understand the different agave production systems to assess the consequences of increasing the mezcal production.

1.4 Aim of the project

This project aims to obtain insight in the sustainability of different types of agricultural systems for agave production in Mexico. Both the high input systems for tequila’s agave production and the subsistence peasant systems for mezcal’s agave production. The evaluation includes environmental, economic as well as social analysis. I compare the advantages and disadvantages of each system in order to improve the living conditions of local peasants and contribute to a sustainable rural development.

The evaluation and comparison of the production systems was based on a literature research, email communication and a survey. There is a vast amount of literature about economic, environmental and social consequences of high input systems for agave production for tequila (Bowen & Gerritsen, 2007; Bowen & Valenzuela, 2009; Gobelle, Yavitt, Valenzuela, & Stalcup, 2006; Hernández García, et al., 2005; Martínez Rivera, et al., 2007; Valenzuela Zapata, 2006). However, since there are not many studies about the agave for mezcal I based my analysis on a case study. This case study is an ongoing project of the Mexican NGO “Grupo de Estudios Ambientales AC” (GEA, www.geaac.org). The project is about the agave production for mezcal in some rural communities in Guerrero, Mexico.
For my analysis I used the outcomes of this project which are reports, articles, presentations and a questionnaire (Annex 3) by GEA.

Research Questions

The main research question for this project is:

Which agave production system benefits in to a larger extent the peasant’s living conditions in Mexico in order to contribute to a sustainable rural development?

However, in order to answer this question some other issues have to be addressed. Firstly the rural context of the agave production must be described and understood. Then the different agave production systems must be described and compared analysing the present situation and some possible scenarios. Finally the advantages and disadvantages of each system for local peasants can be discussed.

Subquestions:

- What is the agricultural, rural and agave production situation in Mexico?
- What are the characteristics of the different systems to produce agave?
- What is the present situation of agave production and some possible scenarios?
- Which agave production system fits more to the peasant subsistence culture?

System Boundaries and limitations

In this project, several agave production systems were described and compared. These systems have different advantages depending on which group should be benefit from it. For example, a high input system can benefit the national economy while damaging local peasants. However, the criterion in this project to identify which production system brings more advantages is that the system benefits local peasants. For this reason, in this project, the agave production systems which have more advantages are the ones that fit into the peasant’s culture and promote sustainable rural development.

Furthermore, the main limitation for this project was that it was carried out in the Netherlands, far away from the case study of mezcal’s agave production in Guerrero, Mexico. There is no statistical data about the agave production for this specific region. However this project was developed using the GEA’s outcomes. Since the beginning of this project, I received from them a lot of information that they have gathered and analysed in the last decade. Moreover, during this project I was in communication with them for more discussion. Nevertheless, for further research I would recommend to do a field work study to fill in the knowledge gaps about the agave production in the area.
2. CONTEXT: AGRICULTURE, PEASANTS AND AGAVE PRODUCTION IN MEXICO

In this chapter, I show the results of a literature research in order to learn and understand the situation of agave production in Mexico. Firstly, I describe the agricultural development in Mexico since the 20th century. This analysis shows that there are two different strategies for rural development. These strategies have different characteristics and rationalities.

Then I focus on the agave production in Mexico. I describe the economic, biologic and cultural importance of agave as well as its performance as a crop. Next, I describe the development of the agave production in Mexico for tequila and mezcal since the last century. Finally I focus on the Guerrero communities of the case study. I made a literature research from the reports, articles and presentations by the NGO GEA.

2.1 Agriculture in Mexico since the 20th century

Achieving food self-sufficiency and raising rural living conditions:

After the Mexican Revolution in 1917 and until 1992, the Mexican government distributed 50% of the national territory between communal owners (called ejidatarios in Mexico) and rural communities. Only one third of this area is agricultural land and the rest is forest, grasslands and mounds (Mackinlay, 2008).

An area could be organized under different property rights: private land or communal land. For the latter some of the resources are collective and shared by the ejidatarios, and other resources are used by the individual ejidatarios. From the 30’s to the 60’s Mexico achieved food self-sufficiency and raised rural living conditions. This means that all the food consumed in the country was produced within it. This was accomplished thanks to a good credit system for peasants, technical assistance and improvement of agrochemicals (Barkin, 1990).

Change to export crops by expenses of peasant’s quality of life

In the 1950’s the so called Green Revolution started. This is the term that has been giving to the large increase of worldwide food production in the second half of the 20th century by using “modern” agricultural technology to increase crop’s yield (McKinney, Schoch, & Yonavjak, 2007). Within this context, Mexico accomplished an important increase in its agricultural yields. From the 50’s to the 80’s there was a 7% annual growth in agricultural production (Barkin & King, 1970; Esteva & Barkin, 1980). Then, the national strategy was focused on the production of agroexports and animal feed. However, this lead to a resource disequilibrium because there was a decrease on the production of basic food products (Barkin, 1990).

Also during this period the Mexican government cut the credits for peasants. This forced them to rent their parcels to large producers of agroexports and animal feeds. This caused large unemployment in some rural areas, migration to urban centres and in general impoverishment which increased the inequity of society. Moreover, there was a reduction on the traditional crops production because they were replaced with export crops (Barkin, 1972). It is important to point out that in Mexico, as in most developing countries, peasants depend on subsistence agriculture. This means that they produce (most) of the food that their families consume. Then it is clear that the change from traditional crops to export crops have a direct effect on their subsistence. This was reflected in a slow national growth rate of subsistence agriculture (Barkin & King, 1970).
Agricultural crisis:

In 1980 Mexico has lost its international importance in agriculture (Esteva & Barkin, 1980). Moreover the government switched to a policy of “cheap food” and began to import food mainly from the United States. This made traditional farming even less profitable, so the imports of basic food increased (Mackinlay, 2008). Furthermore, population growth increased food demand. By 1985 Mexican population doubled from its value in the beginning of the 60’s (FAO, 2010). From 1980 to 1983, 35% of maize, which is the basic food product of Mexican feeding, was imported (Barkin, 1990). In 1992, the restrictions on land concentration, which were put in place in 1917, were lowered and ejido land (communal land) was opened for privatization. Therefore the number of small producers (peasants) is reducing (Mackinlay, 2008).

These factors caused the agricultural crisis that is clear nowadays in rural areas in Mexico where there is large poverty and unemployment is rising (or in the worse case there is lack of employment). The productivity of the agricultural fields is decreasing because of poor management practices and the lack of investments for new technologies. For all these reasons migration is increasing to urban centres within the country or else to other countries (Mackinlay, 2008).

Summarizing, the agricultural crisis was caused by the change in policies with different strategies for agricultural development which have different characteristics and rationalities. These approaches do not lead to the same type of rural development. In the beginning of the 20th century the strategy was the assurance of national food security by small producers: the peasants. In this case, the peasants benefit by the credit system and government’s assistance and achieved food self-sufficiency. Then, on the second half of the 20th century, a capitalist strategy for rural development was adopted. In this case the national production increased. However the poverty in rural areas, the dependence on global market’s price and the externalization of environmental problems eventually caused a reduction of agricultural productivity and increased poverty in rural areas. In the following section these two strategies are described in more detail.

2.2 Two strategies of rural development

As mentioned in section 2.1, in the 20th century agriculture was industrialized worldwide thanks to the Green Revolution. It achieved very high outputs though increasing energy and resource inputs, like irrigation, machinery and fertilizers. It was a successful programme which increased the worldwide food production (Barkin, 1972; McKinney, et al., 2007).

Nevertheless in many developing countries, agriculture is still carried out in an extensive way with low inputs and low outputs. In the majority of these cases the primarily objective of agriculture is the family’s subsistence. Peasant families reach food security by producing a diversity of crops for their own consumption. The rest of their income is achieved by selling their agricultural surpluses in the market or by engaging in other economic activities.

These two different agricultural strategies have different characteristics and rationalities. I describe them in the following sections.
Capitalist Development (classical concept of market optimization)

Within this strategy, optimization is reached by achieving the highest possible output by maximizing gain and minimizing costs. The gain is the profit of selling the yield; the costs include the purchase of the inputs (e.g. seeds, fertilizers) and infrastructure (e.g. irrigation, machinery). The environmental and social costs are usually externalized (Friedmann & McNair, 2008). It requires higher investment costs leading to higher yields; however it also increases the risks. For example, the change from a polyculture (planting several types of crops in the same field) to a monoculture system with high inputs increases the yields but also raises the risk of getting crop’s disease and plagues.

The national strategy of many countries to increase agricultural yields has been to enlarge the agricultural area to produce certain export crops (Bryceson, 2000). In that moment the crops that are chosen are the ones that have high economic value; nevertheless the profits of its production depend on international market prices. In general this has lead to national economic development.

In most cases these, or part of these, areas were used previously to produce basic food. Therefore basic food products have to be imported. The consequence is instability of local food prices because, once again, they depend on international market prices (Bryceson, 2000).

In many cases large capitalist and transnational agrifood chains have taken control on the agricultural production leaving small and middle producers (mainly peasants) marginalized. The reason is that the large companies have the means to do large investments and can cope with large risks. In most cases the global production has increased reaching higher economic development. For local peasants it is not economically feasible to compete with these chains, therefore they are cut off from local markets (Friedmann & McNair, 2008).

Peasant Development (subsistence economy)

In a different perspective, the peasant economy is based on subsistence rather than profit. Optimization is reached by a so called “survival algorithm” (Bryceson, 2000) which means achieving maximal profit with minimal risks. To have the minimal risks the following strategies are pursued:

1. Internalize environmental and social costs to guarantee future production.

2. Variety of economic activities and crop biodiversity to assure food sovereignty (Goldman, et al., 1998; Pimentel & Pimentel, 2008)

3. Economy of affection (Bryceson, 2000). There is a strong link between the families in the community. According to Bryceson, their concern is not only their wealth but also their neighbour’s wealth. Therefore, for peasants, their own prosperity as well as the community’s is important. The reason is that this increases their own security: they help when their neighbour needs something and their neighbour will help them when they need something.

In general, agricultural yields are lower than in industrial production leading to slow national economic development. Nevertheless local development is supported and ensured. Another difference with capitalist development, is that in this conception more issues are included in the description of wealth e.g. social labour, ecological processes and cultural worldviews which are externalized in the capitalist conception (Goldman, et al., 1998).

For a peasant economy, according to Veltmeyer (2001), participation is the social empowerment to achieve development. It is more efficient in small communities. That is because the structure of communities already has the basics to achieve participation for example common understanding, mutual
obligations and shared institutional practices. In particular, in indigenous communities, this development is more efficient because their worldview is adequate for management of nature by social organization (Toledo, 1992). This is especially important for Mexico because, by 2005, there were 6 million indigenous people, 6.6% of Mexican population (INEGI, 2009). The majority of these people lived in rural communities within this concept of development.

Veltmeyer also states that decentralization allows a more human and participatory development. In this same notion, sustainable development is accomplished by a creative use of local resources, local participation for planning and implementation as well as reaching food self-sufficiency.

This last issue is very important for peasant economy: food self-sufficiency. This means that peasants produce (most of) the food consumed by their family. This is an enormous advantage in times of economic crisis and high unemployment because they do not need to rely on the market for their own basic needs. Especially when market prices are unstable and food prices can increase to a level hard to afford by peasants. In this case, if they are self-sufficient, the price instability does not affect them very much. Therefore self-sufficiency is a strategy to increase security.

Another important issue for this concept is the internalization of materials and energy cycles on a local scale (Guzmán Casado & González de Molina, 2009). This means that the energy and resources that are used for the agricultural systems should be local. For instance, the fertilizers are produced locally like manure and in organic agriculture these cycles are closed using local resources. This leads to less dependence on market price which reduces risks.

2.3 The agave crop

The plant genus Agave is endemic of America and 75% of its species can be found in Mexico (Eguiarte & Souza, 2007). They grow in many different habitats, from dry areas to oak forests and lowlands (García Mendoza, 2007). Agaves have an optimum development in rocky soils and open areas with a lot of sun. If they grow in poor soil and with little sun, they will be small and will take longer to reach maturity. They are green throughout the year, their leaves are thick and retain a lot of water and have a wax cover which allows them to reduce humidity losses (Illsley, et al., 2005).

The leaves of agave plants are sword shape with a spine at the end. The stem is short and totally covered by the leaves like a rosette, with exception of Agave karwinskii. Agave reaches its maturity around the age of 6 to 14 years. The central leaves become thinner and from the centre of the agave a large inflorescence (popularly called quiote or calehual) of 3 to 6 meters tall blooms just once in its life. The inflorescence grows with the water and nutrients from the leaves and the steam. Flowers bloom in small branches which grow on the inflorescence. Agaves are self-incompatible therefore pollinators are fundamental for the fecundation of the flowers. The main daytime pollinators are bees, wasps, hummingbirds and other insects and birds; and the night pollinators are bats and moths. Bats are the best pollinators. Finally, seeds are produced and the plant dies (Illsley, et al., 2005).

Agaves have high ecologic importance because many of them are key species. They produce large quantities of resources during their reproduction like flowers, pollen and nectar. Many animals depend on these, especially pollinators, which are important for the ecosystem (Eguiarte & Souza, 2007). Moreover, they have high economic and cultural importance in Mexico because they have been used to produce drinks, medicine, food, building material construction and fuel for many centuries (García Mendoza, 2007). Nowadays its main commercial use is the production of different types of distillate alcoholic drinks produced by different agave species. The largest commercial one is tequila. Nevertheless, other types like mezcal and bacanora are popular locally in several regions. In the last years the demand of mezcal is increasing in national and international level (Eguiarte & González González, 2007).
The agaves that are harvested to produce these alcoholic drinks have to be mature and just starting to bloom. The inflorescence must be cut before it starts growing. The plant remains in its place for some months, or even one year. That allows the agave to accumulate sugars and water in the centre of the crop. These sugars come from the leaves and were meant for the growth of flowers and nectar. Then the leaves or stalks are cut and just the “head” is left which looks like a pineapple. For this reason it is called agave head or agave pineapple. This process is done manually. The agave heads are baked, its juice is fermented and then it is distilled (Eguiarte & González González, 2007).

*Traditional mezcal production*

The most common practice for agave production for mezcal is harvesting it from its natural environment. There are other production practices which will be described in the next chapter. The mezcal production is still done in a non industrial way. It is a traditional practice which has been done since many centuries. In this section I give a brief description of the process according to Illsley et al. (2005).

As it was mentioned in previous paragraph, during the agave harvesting the leaves are cut and just the centre of the agave is left for the mezcal production. It has a shape of a pineapple; therefore it is called “pineapple” or head of the agave. The agave heads are cooked in an oven which is a cone shape hole in the ground. The wood is placed in the bottom of the hole. When the wood is on fire some rocks and palm leaves are put on top. Then the agaves are put in pieces to be cooked. Over the agaves another layer of palm leaves with soil is set to isolate the oven and avoid heat looses. By cooking the agave heads, the conversion of sugars into alcohol is easier during the fermentation. Also the smell of smoke gives a special flavour to the mezcal.

Once the agave heads are cooked they are broken down in small pieces by hand or by a mill. Then they are put in one ton wooden barrels for the fermentation process. They are left for two to three days to heat up. After this, water is added so that the mix is 90% water. Once again they are left to rest for two to eight days so the sugars become alcohol. Then, the mix is put on the distillation pot which is heated with wood. This pot is in a fireplace made of rocks and adobe. On top the pot there is a metal coil in which the vapours of the mix condensate. The liquid falls into a 25 litters copper container. Finally, the mezcal is put in glass containers which are buried underground for rest and aging. Traditionally mezcals are spiced with different herbs, fruits, species or insects. Worms are the most popular in the national and international market.

The traditional practices and local customs, like the smoke smell, the spiced as well as the rest and aging, give special inputs to the mezcal. Therefore this can be valued and recognized with a special label like the one they are working on now: “traditional mezcal producers” (GEA, 2005).

**2.4 Development of agave production in Mexico**

*The case of tequila: an example of capitalist development*

According to Bowen & Gerritsen (2007) the first reference of tequila production, which was called “mezcal wine” in that time, was in 1621. The largest tequila companies were founded in the 18th and 19th century and they produced their own agave. After the land redistribution in 1917 the companies depended on the *ejidatarios* for the agave supply. However from 1900 to 1940 there was a large decrease of agave production because peasants and farmers preferred to produce basic grains like maize instead of agave. Even though it was more profitable to grow agave than maize, the agave production required large investment costs for planting and maintaining the crops for the 7-10 years of growth.
Therefore, tequila companies made various types of contractual agreements between the agave producers and them to ensure their agave supply (Bowen & Gerritsen, 2007).

In the 1960’s, with the Green Revolution, tequila production changed from a traditional to an industrialized system for both agave and tequila. In 1977 the D.O. (Designation of Origin) of tequila was declared which increased the national production (this is elaborated in more detail below). In the 1990’s the so called “boom of tequila” took place. This is the term for the large increase of tequila’s national and international demand (CRT, 2009). This lead to a switch from traditional crops production, like maize, green agave and others, to increase the production of blue agave tequilana weber (Bowen & Gerritsen, 2007; Martínez Rivera, et al., 2007). It was around 10% more profitable for peasants to rent their parcels than growing maize (Martínez Rivera, et al., 2007).

From 1995 to 2005 the tequila production doubled by increasing the agave production area and intensifying the production systems. The consequences were an increase of chemical inputs use and intensive agriculture causing a degradation of the environment and an increase of peasants’ economic insecurity. The increased use of chemical, e.g. fertilizers and pesticides, decreased the agave’s ability of plagues resistance. Therefore peasants could not reach their livelihood by agave anymore because of the high risks of losing a harvest because of plagues and diseases and the large investments for chemicals (Bowen & Valenzuela, 2009; Martínez Rivera, et al., 2007).

At the same time, there was a land expansion of agave production from 1999 to 2003 which was commonly done by reverse leasing arrangements (Bowen & Gerritsen, 2007). In these arrangements the land owners rented their parcels to the tequila companies and assured the supply of agave to the companies. According to Martínez Rivera et al. (2007) the peasants rented their parcels for several reasons:

1. The rent was a secure income and it was more profitable than growing maize or other traditional crops
2. They had no experience in growing this type of agave
3. It implied large investment costs.

Nevertheless, environmental costs were externalized and unsustainable management practices were carried out because the production area was rented. This increased erosion which reduces the productivity of the area (Pimentel & Pimentel, 2008). The high use of pesticides increased soil and water pollution and reduced the resistance for diseases (Martínez Rivera, et al., 2007). In summary, the land expansion of agave has worsened power imbalances between peasants and companies as well as increased environmental degradation and low productivity (Bowen & Gerritsen, 2007).

The case of mezcal: an example of peasant development

Since the production of the first distilled “agave liquors” in mid 1500’s (Bowen & Gerritsen, 2007) until nowadays, agave crops to produce mezcal are commonly harvested from their natural environment (Illsley, et al., 2005). They are generally indigenous traditional practices which have been done since many centuries by peasants. Unlike the agave for tequila which since the 18th century has been produced by large companies.

In contrast of tequila production, the mezcal production is generally for local consumption. Therefore the process has not been industrialized and it is still done within the context of a peasant economy. This means that the producers have a variety of other economic activities for their subsistence like creation of handicrafts and production of their food crops. The profit of mezcal production is the extra income for their other expenditures. Most communities produce their own mezcal.
Nevertheless, the popularity of mezcal is increasing in national and international markets (Eguiarte & González González, 2007). Therefore it is likely that the agave production will increase in the coming years.

**Market niches for tequila and mezcal: Designation of Origin**

Tequila and Mezcal have Designation of Origin (D.O.). This is a market advantage for the regions in which they can be produced since they have the exclusivity of producing the agave for these drinks.

The D.O. of tequila started in 1977 and benefited the national production of the drink but failed to benefit small producers. The reasons are that the norms do not specify appropriate agricultural practices to protect the local environment nor value traditional practices to produce the agave and the drink (Bowen & Valenzuela, 2009). Also the norm NOM-006-SCFI-2005 states that tequila can only be produced by the agave specie “blue agave tequilana weber” (CRT, 2009) which cut off many agave producers of other species which had traditionally been used to produce tequila (Illsley, et al., 2005). This reduced biodiversity and increased pest risks.

The norms of the D.O. of mezcal, which started until 1994, have similar characteristics as the ones of tequila. They do not defend traditional practices of the agave and mezcal production. The costs of certification are high for the traditional producers whom in some cases can’t pay this fee and therefore their product is not certified as mezcal. Another similarity to the tequila’s norm is that it does not consider biological diversity, only 5 species of agave are mentioned from more than 20 that are used nowadays (Illsley, et al., 2005). These facts can enhance mezcal production in the future to follow the tequila path production model with the high environmental and social costs that it involves.

### 2.5 Description of the mezcal production region

In Chilapa Guerrero Mexico (Figure 1) some communities have an ongoing project with a peasant’s organisation called “SSS Sanzekan Tinemi” and with the NGO “Grupo de Estudios Ambientales”. The aim of the project is to encourage a sustainable management of agave cupreata in Guerrero. For my research I use this information to develop a study about the sustainability of the agave production in this area.

The population is of Nahua indigenous origin (Annex 3). The region is a clear example of the agricultural crisis described in Chapter 2.2. There is large poverty and marginalization in the region. Most families cannot live from the economic activities of the area. Therefore the migration rate for labour opportunities is as high as 70% of the total population (GEA, 2005). Nevertheless the agave and mezcal are the high economic value resources of the region. The people involved in the mezcal production do not need to migrate searching for other source of income for their subsistence. However, the large migration shows that the agave is only benefiting a small percentage of the population.

The population lives according to the peasant system described in Chapter 2.2. Their economy is based on subsistence and they have a large sense of community. They produce most of their own food and have other economic activities to earn extra money for acquiring other good. These activities include mezcal, palm and handcraft production. According to C. Illsley et. al. (2005) the agave cupreata is a communal resource. It is shared by the ejidatarios. They are in charge of the decision-making for the agave management. The profits of the agave sale are used by the community for social activities, religious and cultural ceremonies as well as the expenses of the authorities. There are also private land owners who produce agave in small areas. The communities produce their own mezcal or otherwise they sell the agave to local producers.
The communities produce their own mezcal branch with the possibility to enter a market niche of fare trade, organic products and traditional Mexican mezcals. Nowadays they are in the process of registering a collective label of “traditional mezcal producers” (GEA, 2005). The mezcal is produced in a “peasant’s economy” way. This means that mezcal producers also have a variety of activities for their subsistence like production of handcrafts as well as production of 70% of their food e.g. maize, beans, cabbage and cattle (Annex 3).

**Figure 1.** Map of Mexico showing the location of Chilapa. The grey area shows Guerrero State. The black area indicates Chilapa which is the mezcal production region that was studied in this project. See text for details. Source: (Chilapa, 2010) with modifications by the author
3. AGAVE PRODUCTION SYSTEMS: DESCRIPTION AND COMPARISON

In this chapter I describe, compare and quantitatively analyze the agave production systems. This allows me to evaluate if these systems fit to the peasant subsistence system. For the description of the production systems I did a literature research. The literature sources are publications and project reports by GEA and experts on the agave production in Mexico, email communication with agave producers as well as with the Mexican regulatory committee of tequila and mezcal. Moreover a questionnaire was developed for GEA about specific data of the production systems in Guerrero (see Annex 3).

Then, I quantitatively compare the different agave production systems according to the agave density that each system can reach. In order to do this I assigned a value to the economic, environmental and social characteristics (see Table 1). The sources and explanation of the data and calculations are described in Annexes 1 and 2.

3.1 Description of the agave production systems

As described in Chapter 2, the agave production in Mexico has developed in two main different ways. It is produced in both monocultures with high input systems to produce tequila within a capitalist system and in extensive systems with low inputs for mezcal production within a subsistence system. In these two production systems the agave has different degrees of domestication.

In general, in Mexico there are three main categories of agave domestication: a) wild, b) semi-domesticated and c) domesticated agaves. The first two are generally within a peasant subsistence system with low inputs and the latter in a capitalist system with high inputs (monocultures). These systems are described in the following paragraphs and Figure 2 shows a comparison of the agave density that each system can reach.

a) Wild agaves (peasant subsistence system)

In this system, wild agaves are grown in natural environments with no assistance for their propagation and no inputs. It is an indigenous traditional management system which has been practiced for many centuries and nowadays it is the most common system to produce agave in the region of Guerrero. The agave density depends on the type of soil, amount of sunlight and type of ecosystem. In forests the density varies between 20 and 1,500 crops/ha and in grasslands between 2,000 and 3,000 crops/ha, see Figure 2 (Illsley, 2008 pag 11). The difference is because in forests case there are large shaded areas which delay the growth and reduce the size of the agaves. Moreover, grasslands have large open areas which are optimum for the agave development. Therefore depending of the ecosystem different yields can be reached.

The density in the forest also depends on the management practices of the community to avoid their depletion. These practices are involved within the peasant culture (Chapter 2.3 and 2.6). They require participation from the community. The decision-making of the management practices are done by the community board which is formed by the ejidatarios (communal land owners). The ejidatarios are the ones who have the rights to use the agave. The norms and agreements for the agave management are defined by them. The main ones are the following (Illsley, et al., 2005):
1. To leave enough crops in the forest as seeders (about 3 crops/ha).
2. The crops that can be harvested are only the mature ones which in average are 10 yr old.
3. In case of a decrease of the agave density, harvest and closed periods are decreed.
4. The inflorescence, which is used as construction material, can be cut only when it has spread the seeds.
5. Protect the agave from cattle by not introducing then into the forest.
6. Prevent and fight fires.
7. Protect pollinators.

Nevertheless in general the agave populations are decreasing because of biological or management reasons (Illsley, 2008). At present in the ejido called Acateyahualco in Guerrero they are harvesting 2,000 crops every 3 years in around 600 ha (Annex 3). Considering that 2% of the total density are mature agaves this means that the density is around 50 crops/ha, see Figure 2. Further information about this calculation is presented in Annex 1.

The advantages of this system is that the ecological services of the forest used by the communities are conserved e.g. preservation of soil and water, wood used as fuel as well as wild animals and vegetation for harvesting and hunting. Moreover the labour time required to produce the agave is small. Since the agave is not assisted during its growth, the labour required is only for the harvest. These two factors enable peasants to preserve their peasant culture. Firstly, they have the ecological services of the forest (wood as fuel, wild animals and plants, water source) which are essential for their subsistence and secondly, since the total labour is small, they have enough time to produce their food. As indicated in Chapter 2.3, this is an enormous advantage for peasants since it enables them to have food security. Especially in times of crises, when food market prices increase, this does not affect them to assure enough food for their family.

Moreover, the agave which is produced is organic since there were no agrochemicals used for its production. This is an advantage because the mezcal produced with this agave can have a “quality brand” which can increase the mezcal price and therefore more families can benefit from it.

Nevertheless the disadvantages are that the yields are very low so very few families benefit from the agave production. Also it requires new areas for cattle because in order to preserve the agave cattle cannot be introduced into the forest.

b) Semidomesticated agaves (peasant subsistence system)

Semidomesticated agaves are grown in areas which have been modified or in natural environments. The agaves are assisted in their propagation like for example by spreading the seeds to assure regeneration in the area (seed spreading system) or growing the tillers in nurseries and then planting them in the forest (agave planting subsidies). With these management practices the agave yields are higher than in wild agaves and the inputs are not as high as in a monoculture. These practices are also done in a subsistence system.

Seed spreading system

The seed spreading system is an agroecologic traditional system which has been practiced for many centuries. As shown in Figure 2, the average densities that can be reached are between 3,000 and 4,000 crops/ha (Illsley, et al., 2005 pag 57). In Guerrero it is not practiced as much as the harvesting of wild agaves and it is commonly done in private properties (Annex 3). The difference with a monoculture is that there are agaves of all ages sharing the space with few trees and herbs. Nevertheless to achieve high densities the area should have low degree of shadows. The area is always covered so there is little soil erosion.
Every year the mature agaves can be harvested instead of waiting for the 10 years that they take to grow like in a traditional monoculture. There is low risk of pests and diseases by being a policulture as well as by the fact that the reproduction is by seeds which gives genetic diversity. This enables peasants to use this system to increase their mezcal production with lower risks than in a monoculture. However the risk is larger than in wild agaves in wooden areas because the density increases.

The area must be fenced to protect the agave from cattle and other predators. Every year the best and strongest mature agaves are selected as seeders - approximately 7 to 8 crops per hectare-. Excluding these seeders, annually all the mature agaves are harvested. When the inflorescence of the seeders blooms it must be cut and put at a lower height like bush’s branches to spread the seeds only within the fenced area and therefore increase the agave density. When young agaves are in unfavourable areas they must be replanted in a different place, this management practice is done once a year (Illsley, et al., 2005 pag 60). Sometimes weed is removed with machetes and if pests appear lime or organic fertilizers are applied (Annex 3).

This shows that the management practices are not as large as in monocultures (see in the following paragraphs) so the labour involved is not much. This allows peasants to have time to produce their own food. As indicated for the wild agaves, this is an enormous advantage for peasants to assure food security.

The advantages of this system are that they achieve very high yields similar as in a monoculture with lower management practices and lower inputs. It gives a sustainable harvest every year unlike in monocultures which give a large harvest every 10. These two issues make this system fit more to the peasant culture than monocultures.

Moreover, as in the wild agaves, the agave is organic because just organic fertilizers are used to avoid pests and diseases. Once again this can benefit peasants by increasing the mezcal price with a “quality branch”. The fact that the reproduction is by seeds gives genetic variability; this makes the agaves stronger for pests and diseases. Therefore the amount of inputs for fertilizers is low.

Nevertheless the ecological services of the forests are not preserved. To achieve high densities there should be few trees and vegetation to have as much sunlight as possible as well as keeping the area for the agave. However erosion is avoided since the land is covered all the time because during the harvest only the mature agaves are removed and also other vegetation covers the area.

Agave planting system

This is a new system which started in 1991 in Guerrero and it is still in an adaptation process. The agave crops are produced in nurseries and planted in native ecosystems where the agave density has decreased or has been totally depleted. The goal is to reach forest’s agave densities from 50 years ago. The production of the plants in the nurseries and the transplanting to the forest is paid by government’s subsidies (Illsley, et al., 2005). The densities by the reforestation of agave in the forest are around 1,100 crops/ha (Annex 3), see Figure 2. The agave is harvested from the forest like in the wild agave system described before.

Between April and May the seeds are collected from the forest. They are used to produce the agave plants in the nurseries. When they are 1,5 to 2 years old they are transplanted in fenced areas in the forest. It is very important that the norms and agreements stated by the community to avoid the agave depletion are performed (Illsley, et al., 2005).

In this region of Guerrero there are 9 communal nurseries which produce around 2 million plants per year (Illsley, 2008 pag 15). The communities which have a Reforestation Committee have planted agaves in forest areas of communal land of about 1 to 50 hectares. Sometimes private landowners also plant agaves in private land with areas of around 1 to 15 hectares (Annex 3).
The advantages of this system are that agave densities which have been decreasing or even depleted in the forest are slowly recovering. The ecological services of the forest used by the peasants are preserved. It also generates large amount of local labour, which is scare in this area, by the nurseries and the reforestation. These two last issues preserve the peasant culture of the people and decreased migration to urban centres.

Nevertheless it depends of the government’s subsidies which can be cancelled when the government changes. Therefore this system can’t be sustained locally without the subsidies. Moreover, the agave density of the area has a limit by the ecosystem so it will not be possible to achieve densities as in a seed spreading system or in a monoculture. Furthermore, only with good management practices the density can be preserved. In addition, peasants say that plants from seed spreading systems are much vigorous and grow faster than the ones planted from nurseries (Illsley, 2008).

c) Domesticated agaves (capitalist system)

Domesticated agaves are generally produced in monocultures with large amount of inputs achieving high yields. Nowadays the agave cupreata is not produced in monocultures. Nevertheless other agave species in Mexico are produced in this type of system (Illsley, et al., 2005). I also study this system to analyze the possible effects for changing the agave cupreata production in Guerrero to monocultures. The most popular agave which is currently produced in monocultures is the blue agave tequilana Weber which is used to produce tequila. The densities are between 2.500 and 3.500 crops/ ha, see Figure 2 (Bejos Camacho, 2009; Mariscal Estrada, 2009; Quijano, 2009).

This system requires more inputs than any other system and the harvest is only done after the growth of the agave which is every 8 to 10 years. The crop is harvested before the inflorescence blooms. Therefore the reproduction is based on clone’s propagation. These clones are obtained from tillers or pieces of tissue from the agaves in the fields. The clones are identical plants with no genetic variability. This causes large problems with pests and diseases which means high investment in agrochemicals. It also reduces its ability to adapt to changing conditions specially by the global climate change phenomena (Illsley, et al., 2005).

Many maintenance activities have to be done. Some of them are manual, mechanical and chemical like weeding, soil tillage, nutrition, pest prevention and control, and pruning (Valenzuela Zapata, 2006). The agave fields are affected by different diseases and insects which could cause large losses or just physiological damages (Hernández García, et al., 2005).

The long cycle of the agave growth allows the soil to be covered and withheld; this favours the rain infiltration and avoids erosion and drought. The erosive rains are tampered by the system of “vegetal coverage” just as long as the fields are aligned counter current and they do not use herbicides (Gobeille, et al., 2006). Nevertheless there are large problems with erosion in agave fields in Mexico because the fields are aligned with the current flow to make the harvest easier. Furthermore, when the agaves are young there are large open areas between them. In the last years the agaves have grown enough to close these open areas. This means that in the early years of each harvest the area is used inefficiently.

The advantage of this system is that it achieves high yields. It also gives large amount of labour for the management practices and the harvest. Nevertheless it requires large investments for the inputs during the whole growing period and the profits are only gain after the harvest which is every 8 to 10 years. Peasants can’t afford the large investment and the long waiting for the profits. Therefore this system can’t be sustained within a subsistence peasant system, just companies with access to credits or else to capital can afford these risks.

The experience in Mexico has shown that agave monocultures cause large environmental problems like loss of ecological services, soil erosion as well as water and soil pollution caused by agrochemi-
To conclude, I classify the agave production systems depending on the agave density that each one can reach. Figure 2 shows a scheme illustrating this categorization. There are two main categories: the low density systems and the high density systems.

The first category, low density systems, includes wild agaves in forests and agave planting systems. Figure 2 shows that the present densities of wild agaves in the forest of Acateyahualco ejido are extremely low. However, with agave planting systems their densities increase. These low density systems are present within a subsistence peasant system.

The second category, high density systems, includes wild agaves in grasslands, monocultures as well as seed spreading system. The seed spreading system is currently used in the Guerrero communities within a subsistence peasant system. It is important to point out that monocultures reach similar densities than this system. However, monocultures usually do not fit to a peasant subsistence system because of several reasons which will be discussed later on this report. Furthermore, wild agaves in grasslands reach similar densities as monocultures and seed spreading systems. However, since the ecosystem of the Guerrero communities is forest, therefore, these agave densities cannot be reached by wild agaves in this region.

3.2 Comparison of the agave production systems

The production systems within each of the two main categories illustrated in Figure 2 have similarities but also could have large differences. In this section I compare the main systems. Table 1 shows a summary of the comparison.
The low density systems cover densities from 20 to 1,500 crops/ha. Figure 2 shows that this includes the wild agaves in forests as well as the agave planting systems. The ecosystems in the region of Guerrero that I use as a case study are oak forest and low land; therefore the densities that can be reached are included in this category. However there is a large difference between the present situation of agave density in the forest (50 crops/ha) and the densities that the agave planting programmes can reach (1,100 crops/ha). Therefore I split the low density systems in these two systems to compare them further on.

The high density systems cover densities between 2,500 to 4,000 crops/ha. Figure 2 illustrates that the monoculture and seed spreading system are the ones that reach these values. Their densities are very similar; however they have large differences which were discussed in Chapter 3.1. Seed spreading systems are usually done within a subsistence peasant family, while monocultures do not fit to the peasant’s system for many reasons. They require large investments for planting and maintaining the field and the profits are until the harvest (7-10 years later). Moreover, monocultures involve higher risks because of the high use of fertilizers and pesticides which reduces the agave’s resistance for pests so agaves become more vulnerable.

There is a large difference in agave yield between the systems. With the present densities of wild agave in the forest, in average just one crop per hectare can be harvested every year, which is very low. With the agave planting systems this can be increased almost 20 times. Furthermore with a high density system the yield can be increased 270 times. These same relations apply to the mezcal production (see Table 1). Higher yields are an advantage to the community because more families benefit from the mezcal production, just as long as the risks don’t increase much (like in monocultures).

As described in Chapter 2.5, the peasant families involved in the mezcal production are the ones that do not need to migrate to urban centres searching for sources of income. However, the change to a high density system increases the risk of pests and diseases. This means that there will be costs for fertilizers and pesticides as well as for other management practices like removing weed. Even thought the costs of monocultures are generally higher than in a seed spreading system and since there is no information about the precise production costs of a seed spreading system; for this calculation their costs are assumed the same.

These costs are considered zero for the low density systems since they do not require any inputs for their growth. The costs of nurseries and planting for the agave planting programmes are indirect cost because they are paid by external governmental subsidies and not by peasants. Moreover the labour costs for these systems are also considered zero because they are not a direct cost since peasants combine these activities with the food production for their subsistence. So it is hard to calculate the representative labour costs because people are not hired to do this job unlike in a monoculture. However a qualitative value, like low or high, can be assigned (Table 1).

It is more interesting to compare the profits by mezcal production (which includes the costs of crop production) than comparing the yield (see Annex 1 for the calculations). Table 1 shows that the profits in a high density system are still 150 times higher than harvesting wild agaves with the present density in the forest; and almost 10 times higher than with the agave planting programmes. This difference is also reflected in the number of families benefited from each system. It is clear that with a high density system more families can live from one hectare of agave production than if the area is used with a low density system.

Nevertheless, in a high density system the ecological services (which are essential for peasant subsistence culture) are not preserved. Therefore the services given by the forest have to be replaced. These services include source of fuel (wood), source of water, wild animals and vegetation as well as the preservation of soil. However, there is a difference between the monoculture and the seed spreading system. In the latter the soils and water is preserved since the area is covered all the time with agaves of different ages and other vegetation. This avoids erosion. Still the forest has a strong cultural impor-
tance to these communities that cannot be replaced with something else. Therefore it is essential for the peasant culture.

It is important to point out that, even thought in some regions the forest is used for harvesting wild agaves as well as to put the cattle, the area should not be shared between them. The reason is that the cattle can deplete the agave by eating it or only destroying it by trampling. Therefore extra land is required for the cattle in low and high density systems.

Table 1. Comparison of low and high density agave production systems.

<table>
<thead>
<tr>
<th></th>
<th>LOW DENSITY SYSTEMS</th>
<th>HIGH DENSITY SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wild agaves with present agave density</td>
<td>Wild agaves after agave planting</td>
</tr>
<tr>
<td>Average agave density</td>
<td>~ 50 crops/ha</td>
<td>~ 1100 crops/ha</td>
</tr>
<tr>
<td>Agave yield</td>
<td>1 crops/ha/yr 30 kg/ha/yr</td>
<td>20 crops/ha/yr 480 kg/ha/yr</td>
</tr>
<tr>
<td>Mezcal production</td>
<td>2.23 l/ha/yr</td>
<td>40 l/ha/yr</td>
</tr>
<tr>
<td>Profits by local mezcal sale</td>
<td>$ 100 /ha/yr</td>
<td>$ 1.900 /ha/yr</td>
</tr>
<tr>
<td>Families benefited</td>
<td>0.04 families / ha</td>
<td>0.63 families / ha</td>
</tr>
<tr>
<td>Ecological services preserved</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Economic activities and resources requiring extra area</td>
<td>cattle</td>
<td>cattle</td>
</tr>
<tr>
<td>Total labour time</td>
<td>low</td>
<td>very high</td>
</tr>
<tr>
<td>Risks for pests and diseases</td>
<td>very low</td>
<td>very low</td>
</tr>
<tr>
<td>Does the system fit to the peasant subsistence system?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*The data sources and the methodology used to calculate these characteristics are described in Annex 1 and 2
** The currency is in Mexican Pesos - $18 ~ €1-.

The total labour time is also different for each system. For wild agaves the harvesting time per crop is very large compared to a high density system because the crops are spread farther from each other and the forest is farther away from the community than in a high density field which can be just next to the peasant’s house. However, harvesting is the only labour required for the agave production, so in total the wild agaves require very little labour time (see Chapter 3.1). In contrast, the agave planting system requires a lot of labour for the tiller’s production in the nurseries and for the agave planting in the forest.

For monocultures a lot of management practices are done during the growing period in order to prevent or cure pests and diseases. Therefore the labour required is very large. Unlike in the seed spreading system which requires low management practices because the agaves have high resistance for pests and diseases (see below).
Finally, another difference between the low and high density systems are the risks involved in the agave production. This is very important for peasants because their subsistence culture is based on reducing risks as much as possible. Table 1 shows that the low density systems have very low risks. This is because the density is very low and the agaves are sharing the space with other vegetation. This reduces the risks of getting pests or diseases; and in case it happens, the spreading of the pest between the agaves is very low. On the contrary, for the high density systems the risks increase to medium risks (in case it is a seed spreading system) or even to very high risks (in case it is a monoculture).

The risks are medium in the seed spreading system (and not high) because the agaves are sharing the space with other vegetation like grasses and some trees. Moreover the reproduction is by seeds which increase the resistance to pests and diseases. However by increasing the density, the spreading of pests and diseases is easier. In contrast, in a monoculture the risks are very high because the agaves are not sharing the space with any other vegetation and the reproduction is by tillers which reduces the resistance for pests and diseases because there is no genetic variability (Chapter 3.1).

To conclude, the low density systems achieve lower yields and, therefore, lower profits than the high density systems. However, the first ones have lower risks of pests, investment costs and maintenance labour; and, for these reasons, they fit to the peasant subsistence system. In addition, the low density systems preserve the forest which is essential to peasants as a source of fuel (wood), water, soil preservation as well as wild animals and vegetation. The present situation of agave density in the forest is very low and, as a result, very few families benefit from the mezcal production. The agave planting programmes (which are also part of the low density systems) increase the density in the forest so more families can benefit from the mezcal production.

In contrast, the high density systems involve higher risks, costs and maintenance labour, but achieve larger yields and, consequently, more families benefit from the mezcal production. Nevertheless, the two systems in this category have differences. The risks, costs and maintenance labour in monocultures are much higher than in the seed spreading system. Besides, the profits of monocultures are gained only 8 to 10 years after planting the agave which is when they are harvested. For these reasons, monocultures do not fit to peasant subsistence systems. On the contrary, seed spreading systems have a harvest every year so families have profits from the mezcal production on a regular base. Also, risks of pest are reduced because the agaves are sharing the space with other vegetation and the reproduction is by seeds. For all these reasons, the seed spreading system fits to the peasant subsistence system and more families benefit from the mezcal production than with the low density systems. Nevertheless, the forest is not preserved so peasants would need to find an alternative for their source of wood, water, wild animals and vegetation.

**Share of production as seeders**

The reproduction in semi-domesticated and wild agave systems is by seeds. While the inflorescence grows the branches are formed from the bottom to the top which will hold the flowers. The flowers open at different times which enable the seed to be produced with pollen from other plants. This assures the combination of genetic information (Illsley, et al., 2005). Therefore, agaves are stronger for pests and diseases.

This process requires that part of the agave production must remain as seeders. However, each system requires a different share of its production as seeders. It is interesting to see the difference which is related to the agave density that can be reached. Figure 3 shows the difference between each system.

According to Chapter 3.1, for wild agaves harvested from the forest and the agave planting in the forest, at least three agaves per hectare must be left as seeders. For the seed spreading system seven agaves must be left as seeders. If the density in the forest is high, this quantity is not very important.
However if the density is very low, as the present situation in Acateyahualco ejido, the share of the seeders is even larger than the yield (see Figure 3). This is a very large disadvantage for peasants because almost 75% of the total production can’t be harvested and has to be left in the forest as seeders.

For monocultures the reproduction is not by seeders but by tillers. This means that no agaves are used as seeders; however the new harvest has no genetic variability. In agave monocultures for tequila production, this has reduced the resistance for pests and diseases causing an increase of pesticides use and therefore increase of pollution and production costs (Valenzuela Zapata, 2006).

In conclusion, the share of agave from the total production that must be left as seeders depends on the agave density in the production area. For high density systems the share is low and by reducing the density can be as large as two thirds of the total production (like in Acateyahualco). Furthermore, for monocultures it is not required to left agaves as seeders.

Figure 3. Share of total production that must be left as seeders in different production systems. The light grey fraction represents the real yield and the dark grey fraction represents the seeders that have to be left in the field. See text for details and data sources.
4. AGAVE PRODUCTION SYSTEMS IN THE STUDY REGION: DO THEY FIT TO THE PEASANT SUBSISTENCE CULTURE?

In Chapter 3 I described and compared the different agave production systems. Now, in this chapter, I apply these systems to the study region and analyse if they fit to the peasant subsistence culture. In order to do this I design four scenarios with different agave production systems. The first two describe the present situation and the other two describe a possible scenario in the future in order to increase the agave production in the region so more families benefit from the mezcal production.

The four scenarios illustrate an average community of the study region in Guerrero. The forest area of wild agave of this standard community is 600 ha; this value is based on the forest of Acateyahualco ejido (Annex 3).

In the first scenario the agave is harvested from the forest with the present agave densities like in Acateyahualco. In the second scenario, the agave is again harvested from the forest but the densities are increased by agave planting programmes. The third scenario describes a possible situation in which the agave density is, once more, as the present situation in Acateyahualco; but, in order that more families benefit from the mezcal production, the profits are increased by raising the mezcal price. Finally the fourth scenario describes the situation in which part of the 600 ha of forest are changed into a high density system. In this scenario I calculate the amount of area with a high density system that gives the same profits as by increasing the agave density in the forest with agave planting programmes. Moreover, I make two distinctions in this scenario; in one case, the area is changed into a monoculture and, in the other case, the area is changed into a high density system.

4.1 Scenario I: Present situation with low wild agave density

In most communities of Guerrero the present situation of wild agave density in the forest is very low. It has been depleted for the last decades by over extraction of agave as well as for deforestation and climate conditions. For this scenario the 600 ha of forest are used for wild agave harvesting like the present situation in Acateyahualco. The agave density in the forest is only 50 crops/ha (Figure 2).

In this scenario, the 600 ha of forest are used to harvest wild agave from its natural environment. Therefore the forest in the whole area is preserved. According to Table 1, the mezcal profits in a low density system with 50 crops/ha are $100/ha/yr. Therefore the annual profits from 600 ha of wild agave with this density are $60.000. Again, Table 1 shows that the number of families that this system can support is 0.04 families/ha/yr. Then, 600 ha of wild agave can support only around 20 families.

These families can preserve their subsistence peasant culture because the agave production does not require a lot of labour time (just for the harvest) so they have enough time to produce their own food crops as well as their other economic and social activities. Also they can use the forest for their subsistence. Moreover this system involves low risks. Therefore it is locally sustainable. Nevertheless the number of families that can be benefit from it is very low.

4.2 Scenario 2: Present situation by increasing agave density in the forest by governmental subsidies

Nowadays, in Guerrero, there is a large programme based on governmental subsidies to increase the agave density in the forest to reach the densities that were present 50 years ago. It benefits the communities by increasing the mezcal production and by giving new sources of employment which are very scarce in the region. Nevertheless not all the communities have these subsidies.
Figure 2 shows that with these programmes the agave density can be increased to 1.100 crops/ha. For this scenario I assume that the 600 ha are planted with agave to increase the density to reach the 1.100 crops/ha. Then the whole area is used to harvest the agave that was planted in the forest.

The 600 ha are planted with agave in the forest and it is used to harvest it from its natural environment. Therefore the ecosystem in the whole area is preserved. According to Table 1, the mezcal profits in a low density system after the agave planting programmes are $1,900/ha/yr. Therefore the annual profits from 600 ha with 1.100 crops/ha are $1,140,000. Again Table 1 shows that the number of families that this system can support is 0.63 families/ha/yr. Then, 600 ha can support around 380 families.

Like in scenario I, these families can preserve their peasant culture because they have the forest for their subsistence. In addition, agaves need little attention during its growth for pest control (just once a month, see Annex 3); so the labour time (once the agave in planted in the forest) is mainly for these activities and for harvesting. This allows them to have enough time to produce their own food and preserve their peasant culture. It is important to point out that the total labour time for the agave planting programmes is very large considering the nurseries labour and the agave planting in the forest. These are full time jobs. However, as I described in section 3.2, these jobs are not considered in the production costs since they are paid by the subsidies. These jobs are not done by the mezcal producers. Actually these are new sources of jobs for young people who otherwise will migrate to urban centres.

An important condition of this scenario is that it requires governmental subsidies for its development. The tillers’ production in the nurseries and the agave planting in the forest require a lot of inputs and labour which is expensive. Therefore a community which does not have access to these subsidies can’t afford this system.

4.3 Scenario 3: Increase of mezcal price by a quality product label

The motivation for designing this scenario is to find a way in which the profits of the mezcal production are increased without governmental subsidies. The goal is that more families benefit from the mezcal production in case there is no governmental support. The starting point is the present situation of agave density in the forest of Scenario 1 (50 crops/ha). For Scenario I calculated the value of the mezcal price in order that the profits of agave production, with this low density, are increased to reach the value that is achieved with the subsidies (Scenario 2).

The mezcal price can be increase with a “quality product label”. Nowadays, the communities of this region of Guerrero are working on certifying their mezcal with a collective label to enter a niche market of high quality (GEA, 2005). The mezcal produced in these communities could be labelled as fair-trade, organic, green as well as a mezcal produced with traditional practices. Therefore this justifies the increase of mezcal price.

The characteristics of this scenario are a mixture of Scenario 1 and 2. The 600 ha of forest are used to harvest wild agave from its natural environment. Therefore the ecosystem in the whole area is preserved. The agave density in the forest is 50 crops/ha. The annual profits (as in Scenario 2) have to be $1,140,000 which benefits 380 families. The families which benefit from the mezcal production can preserve their peasant culture for the reasons given in Scenario 1.

Now, in order to have an annual profits of $1,140,000 with an agave density of only 50 crops/ha I need to calculate the value for the mezcal price. To calculate it Equation 1 was used. For this equation the annual profits that are desired ($1,140,000) are divided by the total mezcal production which is 1,340 l/yr. The latter value was calculated by multiplying the 600 ha of forest by 2.23 l/ha/yr,
which, according to Table 1, is the mezcal production per hectare of the low density agave production system.

\[
\text{Mezcal Price [\$/l]} = \frac{\text{Desired profits [\$/yr]}}{\text{Total mezcal production [l/yr]}} \quad \text{Eq. 1}
\]

The result for this calculation is that the local mezcal price has to be $850 per litre. However, taken into account that the current local mezcal price is only $50 per litre (see Annex 1) this means that the price should increase 17 times. This is the mezcal’s value if there are no governmental subsidies but it is desired to have the same profits as Scenario 2. Nevertheless, this price increase is impossible under current market circumstances. Therefore this scenario is utopic.

**4.4 Scenario 4: Part of the forest is changed into a high density system**

In the same way as in Scenario 3, for Scenario 4 I design a possible situation in which the profits of mezcal production are increased from the present situation (Scenario 1) without governmental subsidies. This time the strategy is to change part of the forest into a high density system, unlike in Scenario 3 which was increasing the local mezcal price. For this reason I calculate the area of high density system which gives the same profits as with the subsidies (Scenario 2). The agave density in these systems is 3,000 crops/ha. In this case, the area of agave production does not preserve the forest; however if this area is not that large, then the rest of the forest can fulfil the needs of the community for their peasant subsistence.

![Figure 4](image)

**Figure 4.** Annual profits by mezcal production with a high density system including crop production costs (Annex 1). The grey line shows the profits of high density system for different amount of area. The black dotted line represent the profits that are desired for this scenario. The intersection of these two lines indicates that 68 ha of high density system give these profits. The currency units are in Mexican Pesos. See text for details. Source: calculations from the author.

Figure 4 shows the profits of mezcal production with a high density system (grey line) in the 600 hectares of forest. They include the costs of crop production described in Table A3 of Annex 1. The black dotted line of the graph indicates the profits of $1,140,000 which is the desired value for this scenario. The intersection of the two lines shows that, in order to have the $1,140,000 profits by mezcal production, the area of high density system must be 68 hectares which represents 11% of the total 600 hectares of forest area.
As a result, for this scenario the area that has to be changed into a high density system is 68 ha which represents 11% of the forest. However, as described in Chapter 3.2, there are two types of high density systems: seed spreading system and monocultures. These systems can reach similar yields; however they have large differences. Then, for this scenario I have to make a distinction whether the 68 ha are changed into a monoculture of into a seed spreading system. These “sub-scenarios” are described below.

**Sub-scenario 4.1: Change 11% of forest into a monoculture**

In this case, from the 600 ha of forest, 11% is changed into a monoculture. Therefore 89% of the ecosystem is preserved. As Figure 4 shows, 68 hectares of a high density system give $1.140.000 of annual profits by mezcal production. However, learning from the experience of tequila production described in Chapter 2.4, agave production in monocultures tends to change from peasant production to a production by large agri-business corporations because they are able to cope with large investments and risks. If this happens, the profits by mezcal production will be transferred from the community to these corporations. Therefore it is uncertain what amount of the profits stay in the community as labour, renting the parcel, etc.

To have an idea of the profits that could remain in the community I carried out the following analysis. First I calculate the production cost. I use Table A5 of Annex 1 which indicates that the production costs represent 40% of the mezcal sell; then the profits (which in this case are $1.140.000) represent 60% of the sell. With this data I can conclude that the production costs for this scenario are $760.000.

Then, Table A3 of Annex 1 shows the agave production costs in a monoculture for tequila production. It determines that the costs of renting the parcel and labour are around half of the production costs. This amount is likely to remain in the community; which in this case is $380.000. Finally I can conclude that if 68 ha are changed into a monoculture the profits remaining in the community will not be $1.140.000 but only $380.000. Therefore, instead of 380 families benefit from the mezcal production, it will only be 126.

In addition, the peasants working in the monoculture field need to spend a lot of time to do the maintenance activities. Then, they will have limited time to produce their food crops. This puts in risk their subsistence culture. However an advantage of this system is that, even though part of the forest is changed into a monoculture by deforesting the forest, still 90% of the 600 ha is preserved. Peasants can use this area for harvesting wood, wild animals and plants as well as a source of water and soil preservation. An advantage to the three previous scenarios is that in this remaining forest peasants can use it also for their cattle since it is not used for agave harvesting.

**Sub-scenario 4.2: Change 11% of forest into a seed spreading system**

As in the previous scenario, from the 600 ha of forest, 11% is changed into a seed spreading system. Therefore 89% of the ecosystem is preserved.

In the same way as for the monoculture, 68 hectares of a high density system give $1.140.000 of annual profits by mezcal production. However, the difference with a monoculture is that the seed spreading systems fits more to the peasant economy. Therefore it is more likely that with this system the production will still be done by the peasants unlike with a monoculture. Then the annual profits by mezcal production will stay in the community.

The reasons why this system fits more to the peasant subsistence system have been mentioned throughout this report. This is a traditional system which has been used by peasants for many centuries. The production field is covered with agaves of all ages and other vegetation. This enables to have
a sustainable harvest every year, instead of a large harvest every 7-10 years like in a monoculture. This is an advantage for the peasants.

Moreover the risks of pests and disease are low for two reasons. Firstly because the reproduction is by seeds which increases genetic variability and increases the agave’s resistance for pests. Secondly because it is a policulture (agave shares the space with other vegetation). These facts also decrease the labour time for maintenance (which in average are required just once a year, Annex 3) and the use of inputs (fertilizers and pesticides). For all these reasons peasants can preserve their subsistence culture because they have enough time to produce their own food and the risks are low. Furthermore, like in Scenario 4.1, the area for the seed spreading system does not preserve the forest. However this area is only 11% and the rest of the forest can still be used by the community for their subsistence.
Table 2. Characteristics of the four scenarios for agave production.
This Table shows a summary of the four Scenarios described in this Chapter. See text for details.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Area of forest</th>
<th>Agave production area</th>
<th>Agave density in production area</th>
<th>Annual profits for peasants</th>
<th>Families benefited</th>
<th>Peasant culture preserved</th>
<th>Labour time for agave production</th>
<th>Inputs required (fertilizer, pesticides)</th>
<th>Area for cattle</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Present situation with low wild agave density</td>
<td>600 ha (100% forest preserved)</td>
<td>Agave production area is the forest</td>
<td>50 crops/ha</td>
<td>$60,000</td>
<td>20 families</td>
<td>Yes</td>
<td>Low (just for the harvest)</td>
<td>Non</td>
<td>Extra area is required</td>
<td>Norms and agreements for agave management MUST be met or else the agave will be depleted</td>
</tr>
<tr>
<td>2. Present situation with govt. subsidies for agave planting</td>
<td>600 ha (100% forest preserved)</td>
<td>Agave production area is the forest</td>
<td>1,100 crops/ha</td>
<td>$1,140,000</td>
<td>380 families</td>
<td>Yes</td>
<td>Low for the agave producers. High for employees of the nurseries</td>
<td>Low</td>
<td>Extra area is required</td>
<td>Governmental subsidies are required for nurseries and agave planting. Also norms MUST be met.</td>
</tr>
<tr>
<td>3. Increase local mezcal price</td>
<td>600 ha (100% forest preserved)</td>
<td>Agave production area is the forest</td>
<td>50 crops/ha</td>
<td>$1,140,000</td>
<td>380 families</td>
<td>Yes</td>
<td>Low (just for the harvest)</td>
<td>Non</td>
<td>Extra area is required</td>
<td>Local mezcal price has to increase from $50/l to $850/lt. This is impossible for the market</td>
</tr>
<tr>
<td>4.1 Change 11% of forest into monoculture</td>
<td>532 ha (89% of original forest)</td>
<td>68 ha (11% of original forest)</td>
<td>3,000 crops/ha</td>
<td>$380,000 (for labour and renting parcels)</td>
<td>126 families</td>
<td>No</td>
<td>Very high (many management practices)</td>
<td>Very high</td>
<td>89% of the forest can be used for cattle</td>
<td>It is likely that agri-business corporations take charge of the agave production deviating profits from the peasants</td>
</tr>
<tr>
<td>4.2 Change 11% of forest into seed spreading system</td>
<td>532 ha (89% of original forest)</td>
<td>68 ha (11% of original forest)</td>
<td>3,000 crops/ha</td>
<td>$1,140,000</td>
<td>380 families</td>
<td>Yes</td>
<td>Low-medium (management practices just once a year)</td>
<td>Low</td>
<td>89% of the forest can be used for cattle</td>
<td>This system fits to the subsistence peasant system. The forest in the production area is not preserved</td>
</tr>
</tbody>
</table>
5. DISCUSSION: CAN THE TYPE OF AGAVE PRODUCTION SYSTEM CONTRIBUTE TO A SUSTAINABLE RURAL DEVELOPMENT?

So far, I have described and compared the different agave production systems in the region and analysed if they fit into the peasant subsistence culture. Now, in this chapter, I make a further assessment between the situation of the communities in the central mountain region of Guerrero and the implications of the type of agave production system in order to contribute to a sustainable rural development. In order to do this, first I discuss the main problematic in the region to link it with the consequences of each agave production system.

5.1 Situation in the region

The main problems in this region are the usual struggles in rural Mexico: poverty, migration to urban centres and environmental problems like deforestation, local climate change (increase of draughts) and soil erosion. These issues are interconnected. For instance, migration is a response to the large poverty and environmental problems. Even though this region has the large advantage to have agave as a high value resource, it hasn’t solved the problem of poverty because of complex issues which are interrelated (Figure 5 summarises some of these issues).

First of all, as I have mentioned throughout the whole report, people in this area live within a subsistence peasant system. The main advantage of this system is that peasants achieve food security by producing their own food and harvesting resources from the natural environment (e.g. wood as fuel). This enables them to be almost self-sufficient within their community and to be independent from food market prices. Furthermore, the agave for mezcal production gives them the extra money for acquiring their extra goods.

However, with population growth, there is not enough land for young people to grow their own crops and agave is not enough to be shared with them. This has lead to two situations. Firstly, young people migrate to urban centres searching for employment. By doing this, they lose their subsistence peasant culture and are dependent on food market prices. Secondly, to preserve their subsistence culture, young peasants make new agricultural area by deforesting the forest. This has increased erosion and change local climate which decreases the productivity in the fields; then the yields are smaller so more land is required.

Moreover, for acquiring their extra money, they harvest more agave than what the forest can sustain; or else, they look for agave in farther areas. This has contributed to the decrease or even depletion of agave in the forest.

The reduction of productivity in the fields and the depletion of agave have reduced food security for peasants and the number of families that can truly benefit from the mezcal production. Therefore these peasants require more money for buying food and their other goods. Since employment opportunities are very low in the region they must migrate to urban centres. If we add the facts that population is increasing, productivity in the fields is decreasing and agave density is also decreasing; then the reasons for migration are higher.

In addition, there is lack of governmental support for technical advice, subsidies, a good credit system for peasants, etc (which was an advantage in the beginning of the 20th century, see Chapter 2.2). This forces peasants to use unsustainable management practices for food production. It reduces the productivity of the fields and increases environmental problems.

Finally, another important issue is the increase of affluent lifestyle. With the influence of western culture by communication media as well as by migration to urban centres, the consumption standards
have increased. For example, the use of “modern” construction materials, electronics, cars, etc. Therefore more income is required to fulfil their needs and, since (once again) employment sources are really low in the region, then people migrate to urban centres.

Figure 5 outlines the factors influencing migration and environmental impact that I just briefly described. This Figure presents the IPAT equation proposed by Ehrlich & Holdren (1971): \( I = P \times A \times T \). This equation states that environmental impact (I) depends on three factors: Population size (P), type of affluence (A) and the efficiency of the Technology (T). For instance, if population increases, even though the other factors remain constant, the impact will be larger. The affluence factor reflects the type and degree of consumption. Usually “western” style (capitalist) implies more consumption than a subsistence lifestyle. Moreover, by increasing wealth, consumption usually raises. Finally, the type of technology also influences the impact. Inefficient technologies cause larger impact. By increasing the efficiency usually the environmental impact is reduced.

In Figure 5 I show that environmental impacts are interrelated to migration and poverty. Then, if one of these problems is desired to be solved, it is essential to consider the other two issues as well.

**Figure 5.** Factors influencing migration, poverty and environmental impact in the central mountain region of Guerrero. All the relations (arrows) between the factors imply a positive influence (an increase) on each other. The bold capital letter on top of some of the factors refers to the issues that integrate the equation \( I = P \times A \times T \). Where \( I = \) environmental Impact; \( P = \) population; \( A = \) affluence; \( T = \) technology. See text for details.
5.2 Comparison of possible agave production system which could contribute to solve regional problems

At the beginning of this chapter, I mentioned that this region has the large advantage of having agave which is a high value resource. However, looking at the present situation of the communities with a 70% migration rate of the total population (GEA, 2005) and large poverty, it is clear that mezcal production hasn’t solved these problems. However, the mezcal production has the potential to support the subsistence peasant culture. I can come to this conclusion because currently, peasants involved in the mezcal production, do not need to migrate searching for new sources of income and they conserve their subsistence culture.

For this reason I state that by increasing the agave production in the area, more subsistence peasant families can benefit, increase their wealth and do not need to migrate to urban centres. By doing this, a sustainable rural development will take place in this region. However, not all agave production systems fit to the peasant subsistence culture. In the following paragraphs I will discuss the consequences of each production systems based on the scenarios developed in Chapter 4.

Scenario 1 describes that currently wild agave density in the forest is very low. Wild agaves are harvested from the forest with no assistance during its growth. To increase the agave production with this system, then peasants must go to new areas for harvesting agave. This will require a lot of labour for the harvest, because these areas are farther, and the benefits are small because the yields are very low. Moreover there is a limit in which they can’t find new harvesting areas for several reasons: they are not allowed to harvest in the new area, there is no agave, etc. Therefore this is not a very potential solution to increase the mezcal production in a sustainable way.

In Scenario 3 I analyzed the option of increasing the mezcal price in order that the profits can benefit more peasant families. However, it shows that in order to achieve the same profits than with increasing wild agave densities, the price is too high and impossible for the market.

Nevertheless, the increase of agave density in the production area is a more efficient strategy. In general there are two ways to do it:

1. Increase wild agave density in the forest
2. Change to a high density system

The first option was described in Scenario 2. Nowadays there are programmes of agave planting in the forest supported by governmental subsidies. This has very large advantages for the communities since it gives large amount of labour because the agave tillers are grown in nurseries and also for the agave planting in the forest. Also, it has increased the mezcal production. Another large advantage is that the forest is preserved which is used for the subsistence peasant culture (see Chapter 3). Moreover, peasants involved in the mezcal production do not require a lot of maintenance labour for the agaves in the forest, just for the harvest. Then they have enough time for their food production which is essential for their subsistence culture.

However, if there are no governmental subsidies this system can’t be sustained. Furthermore, the increase of agave density in the forest has a limit by the ecosystem. According to Figure 2, the forest cannot sustain more than 1.500 crops/ha. In addition, agaves in the forest have higher lost than in a high density system (see Table A5 in Annex 1).

In contrast, the change to a high density system reaches higher agave densities, see Figure 2. Even though it involves higher costs, the profits are higher. Scenario 4a and 4b shows that the area of a high density system that gives the same profits as the agave planting subsidies is only 11% of the forest planted with agave.
Furthermore, by increasing the production area, the high density systems can raise even more the mezcal production than planting agave in the forest. However, by reducing the area of forest, the sustainability for this scenario is reduced. The reason can be understood from Figure 5. By increasing deforestation, the environmental impacts raise decreasing the productivity of the fields. Moreover, the subsistence of peasant is dependent on the resources of the forest (wood, wild animals and plants, water source).

It would be interesting to analyze the maximum area of forest that can be changed to a high density system without having large environmental problems and affecting peasant subsistence. However that is out of the scope for this project. For further research it would be important to study the minimum amount of forest area that can fulfil peasants’ needs and sustain the forest. This can give insights of the maximum amount of mezcal production that can still be done in a sustainable way in the region.

The increase of mezcal production by changing the agave production system into a high density system can be done in two different ways. In one way it can be changed into a monoculture and in the other way it can be changed into a seed spreading system. These two systems can reach very similar densities in the fields (Figure 2) and therefore similar yield. However they have large differences which were mentioned in Scenarios 4a and 4b. The choice for the high density system will have large consequences on peasants.

The agave for mezcal in this region of Guerrero is not produced in monocultures; however learning from the past about tequila production can give insight in the possible scenario of changing agave production for mezcal into monocultures. In Chapter 2.4, I mentioned that agave production for tequila in monocultures has been an example of rural capitalist development in Mexico. In an agave monoculture field all the crops are planted at the same time. The fact that agaves take 7 to 10 years to mature means that large investments have to be done and the profits will be received until 7 to 10 years later. Peasants with no access to a good credit system cannot afford this. For that reason the production can only be sustained by agri-business corporations. As Table 3 shows, if this happens the profits are deviated from the community and only the profits of renting the parcels and the salaries for the management and harvest of the fields are left for the peasants.

Moreover, this has brought large environmental and social consequences to the local communities of agave tequilana production. The main reason is that by renting the parcels the environmental and social costs are externalized so a sustainable management practice is not necessary for the external producers.

Again, from the experience of the agave production for tequila, the change from an extensive and polyculture system (sharing the space with other vegetation) into an intensive monoculture has increased the risks of pest and diseases. It also has increased the costs of crop production which has displaced peasants even more from the agave production. However the large management and harvest activities that it requires have brought labour to rural areas which have large unemployment problems as well as extra money by the renting of their parcels; which has ended up more profitable than producing by themselves any other crop.

To summarize, the experience of agave for tequila shows that agave production in a monoculture do not fit to the subsistence peasant culture. Then, this production system does not have high potential to solve migration, poverty and environmental problems of the region. However by analyzing the characteristics of the seed spreading system throughout this study I can conclude that it has a higher potential to solve these problems. I discuss this in the following paragraphs.

Nowadays in the communities of Guerrero some peasants produce agave in a seed spreading system. The characteristics of this system have enabled the production to be done within a subsistence peasant system. For example, in a seed spreading system there are agaves of all ages sharing the space. Every year the mature agaves can be harvested. Therefore a sustainable harvest can be done every year. Also the fact that it is a polyculture reduces the risks of pests as well as the fact that the reproduction is by
seeds. Then the maintenance costs are lower than in a monoculture. For these reasons, the investment costs are lower and the profits are gain every year.

Furthermore, the reduction of pests and diseases implies lower maintenance activities. This enables peasants to have time for their food production which is the greatest advantage for their subsistence culture. All this issues make this system fit more to the peasant economy.

In conclusion, the increase of mezcal production in this region of Guerrero can reduce the social, economic and environmental problems of the area. There are two potential ways to do it. Firstly, increase the density of wild agave in the forest. By doing this the mezcal production increases and the forest is preserved. However governmental subsidies are required. Secondly, change part of the forest into a seed spreading system. This system achieves high yields as in a monoculture but in a sustainable peasant way.

5.3 Limitation of the methodology

This project was done based on a literature research, email communication with agave producers and a survey. The description of the production systems and its comparison was only supported by articles, reports and questionnaires. However, this can deviate from reality.

For instance, the results of this project show that seed spreading is the agave production system which achieves higher yields and, therefore, increase the profits for the local people and at the same time it fits to the peasant subsistence culture. This production system has been used for many centuries. For these reasons, I would have expected that it is widely used; nevertheless, in these communities of Guerrero is not very common; most of the agave that is used for mezcal production is harvested from the forest which has very low agave density. In order to understand the reasons for this issue it is necessary to go to the area of study to observe the situation as well as talk to local people.

Then, for further research it is necessary to implement the insight acquired in this study about the agave production systems in this area.
6. CONCLUSIONS

In this study, I focused on the agave production for mezcal in some communities of Guerrero, Mexico. In this rural area, as in most rural regions of Mexico, agriculture is not profitable for peasants, there is large problems of unemployment, poverty and migration to urban centres, and with all these issues, peasant subsistence culture is lost. However, peasants involved in the mezcal production in these Guerrero communities can support their families by mezcal’s profits and at the same time produce their own food which enables them to preserve their peasant subsistence culture. Nevertheless, since the agave production is very low, few peasants benefit from the mezcal production.

In order to improve the situation of the region by enhancing peasant’s livelihood and achieving a sustainable rural development, the agave production must be increased in a sustainable way and the production system must fit into the peasant subsistence culture.

There are different agave production systems with different advantages and disadvantages for local peasants. My results showed that there are two potential solutions to increase the agave production in accordance to a peasant subsistence culture. Firstly, increase agave in the forest by agave planting programmes. However, governmental subsidies are required. Secondly, change part of the forest into a seed spreading system. The fraction of the forest with a seed spreading system that gives the same profits as all forest planted with agave is 11%.

Monocultures increase the agave production but do not fit into the peasant subsistence culture because of several reasons. Profits are earned after the harvest (8-10 years after planting the agave), it requires large investments for the planting, fertilizers and pesticides, risks for pests and diseases are very high as well as large labour maintenance are required. For these reasons, this production system does not achieve a sustainable rural development in the region.

The results of this study give insight about the sustainability and suitability to the peasant subsistence culture of the agave production systems in the region. Nevertheless, since this project was based on a literature research it is necessary that, for further research, implementation of the acquired knowledge is done in the region.
7. REFERENCES


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ANNEX 1: DATA SOURCES FOR THE AGAVE PRODUCTION SYSTEMS

In this Annex, I describe the sources from where I obtained the data for the description of the agave production systems in Chapter 3. Table A1 shows the principal characteristics of the agave cupreata performance as a crop. Moreover, Table A5 summarises the different characteristics of each production system.

Year for agave cupreata to mature

According to GEA (see Annex 3) and Cohetero Villegas (2009) from COMERCAM A.C.,(2009) the agave cupreata takes 10 years in average to mature. After this period it can be harvested to produce mezcal.

Average crop size

As reported by GEA (Annex 3) and according to Cohetero Villegas (2009), the average weight of an agave cupreata crop is 25 kg.

Performance of agave for mezcal production

As Cohetero Villegas also stated, the amount of agave required to produce one litre of mezcal depends on two factors. First, on the type of agave that is used because the sugar concentration is different. Second, on the mezcal production process that is used. However, in average to produce one litre of mezcal (with 45% of alcohol volume) 11 kg to 14 kg of agave cupreata are needed.

Local price of mezcal

In a marketing report about mezcal production by agave cupreata in the region of Chilapa Guerrero, GEA (2002) states that the mezcal production from February to May 2002 was sold locally in $50/lt. The report declares that the local price varies from $25/l to $90/l. It is important to point out that this mezcal is sold in bulk; therefore the price is largely increased when it is sold in the regional and national market packed in bottle with a brand. For the calculations I use the $50/l because I do not include the process of packaging and selling to external markets. The currency is in Mexican Pesos ($20 ~ €1).

Agave density

The ecosystems of the regions studied in Guerrero are oak forest and lowland. According to Illsley et al.(2008 pag 11), the wild agave density that can be reached in a wooden area is between 20 to 1.500 agaves /ha. However it is important to point out that the present agave density in most communities in

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1 The COMERCAM is a nonprofit organization called Mexican Regulation Committee of the Mezcal Quality. More information about this organization at: www.comercam.org
Guerrero is very low. For example in Acateyahualco the average value is 50 crops/ha (Annex 3). Nevertheless with agave planting programmes and good harvest management practices the density can be increased (see Figure 2). The current agave planting programmes are reaching 1.100 crops/ha in the forest (Annex 3). However, only with good practices and the agave planting programmes this density can be sustained.

The density value that was chosen for the high density system is 3.000 agaves/ha. This is the average density of an agave tequilana Weber monoculture which is used to produce tequila, see Table A2 and Figure 2. This specie of agave was chosen to represent the value of an agave cupreata monoculture because it has been produced in monocultures since the second half of the 20th century. Therefore it shows a possible situation in which the agave cupreata would perform if it is produced in monocultures. According to Figure 2, the seed spreading system can also reach 3.000 agaves/ha and even higher densities (Illsley, et al., 2007 pag 333).

### Average loss of production in relation of agaves that are planted

At this moment there is a study in progress on measuring and analyzing the agave population of the Acateyahualco ejido from 2007-2009 (Annex 3). Preliminary results show that not all young crops reach maturity in the forest. The reason is that the natural conditions are not as ideas as in a controlled environment like a closed field or a nursery. In the forest there are predators (native animals and cattle) which eat or affect the agaves.

The results of the first sampling of the study illustrate that only 1%-3% are mature crops (GEA, 2008). These are the agaves that are around 10 years old and can be harvested. This means that in average only 2% of the total density are mature agaves which can be harvested. In theory, if there would be no lost of agave during its growth, then the mature agaves would be 10% of the total density (because they take 10 years to grow). Therefore the lost of agave harvested from its natural environment is 80% (because the mature agaves are only 2% instead of 10%).

For the high density system, the crops are assisted during the whole growth period. Then, the conditions in the fields are more controlled than in the forest. This enables them to have less loss than wild agaves. According to Mariscal Estrada (2009) “only” 10% of the total agaves that are planted in a monoculture are lost for the harvest.

### Costs of crop production

In the high density systems, the crops are assisted from the planting stage until the harvest. By raising the density the risk of plagues and diseases increases; therefore fertilizers and fungicides must be applied.

These two factors increase the costs of crop production. Nevertheless the costs of a monoculture are larger than the costs of a seed spreading system. The reason is that in the latter the risks of pests are reduced by having other vegetation between the agaves and by the fact that the reproduc-
tion is by seeds and not by tillers. Further details of these characteristics are described in Chapter 3.2.

According to Velasco (2009) the average production cost of an agave tequilana weber grown in a monoculture is $1,50 / kg, see Table A3. There is no information about the precise production costs of a seed spreading system. Therefore the value given by Velasco is also considered for the seed spreading system keeping in mind that in practice it could be lower because in this system fewer inputs are used.

The low density systems do not require any assistance during the agave growth as well as no inputs are used. Therefore the production costs are zero. However in the low density systems a lot of labour is required. Then, for the low density systems the labour costs are not included because it is not a direct cost since peasants combine these activities with the food production for their subsistence. So it is hard to calculate the representative labour costs because people are not hired to do this job unlike in a monoculture.

Moreover in the agave planting programmes people are hired to work in the nurseries and for the agave planting in the forest (Chapter 3.2). These labour costs are also not included because they are not direct costs for the agave and mezcal producers since they are paid by the governmental subsidies.

Cost of crop production in relation to local price of mezcal

As I mentioned in the previous paragraph, the cost of agave production in a high density system is $18,75 / l. Considering that the local price of mezcal sale is $50 / l it implies that the agave production cost represents 38% of the total mezcal price. As I do not consider production costs for the mound system the agave production costs in relation to the mezcal price is 0%. However, as I mentioned in the previews section, the labour time for the mound systems is not included but must be kept in mind for further discussion.

Amount of mezcal production that benefit one family

The marketing report by GEA (2002) states that the fixed people involved in the mezcal production of the community “La Esperanza” in Guerrero are 83, see Table A4. Each person can support his/her family; therefore this Table shows the number of families that benefit from the mezcal production are 83. This report also says that the average amount of mezcal production by this community is 5,000 l/yr. As was mentioned before, the average local price of mezcal sale is $50 / l. Table A4 shows that with these values it can be estimated that 60 litres per year are required to support one family with an annual profit of $3,000. The amount of litres to support a family was calculated by dividing the total mezcal production (5,000 litres) by the total families involved in its production. The annual profits for each family were calculated by multiplying the litres to support a family (60 l) by the local mezcal price.

To put the annual profits into perspective I compare them with the minimum salary defined by the Mexican government. According to SAT 2, the minimum salary in this region of Guerrero is $51.95 per day. Therefore the annual salary would be $16,208. This means that the profits from the mezcal production are only one fifth of the minimum salary. This value is very low; however the fact that they produce most of their own food implies that they have low expenses in food.

The 60 litres to support a family does not include crop production costs; therefore the amount of mezcal to support a family in a high density system is higher. To calculate it the following formula was used:

\[ \text{Number of families} = \frac{\text{Total mezcal production}}{\text{Average amount of mezcal production per family}} \]

\[ \text{Annual profits per family} = \text{ litres to support a family} \times \text{ local mezcal price} \]

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2 SAT is the Tax Administration Service office from the Mexican government. Every year they define the minimum salary for 3 different regions in the country. For more information visit: www.sat.gob.mx
Litres to support one family = 83 l/family/yr = 60 l/family/yr * (1 + $18.75 / l )
in a high density system

Where the 60 l/family/yr is the amount of mezcal that supports one family with no costs of crop production; $50 / l is the local mezcal price and $18.75 / l is the cost of crop production.

Table A4. Fixed people involved in the mezcal production and the annual production in La Esperanza community. Source: GEA (2002 pag 15-17)

<table>
<thead>
<tr>
<th>FIXED PEOPLE INVOLVED</th>
<th>FAMILIES SUPPORTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Labradores” (people who cut the agave leaves)</td>
<td>47 families</td>
</tr>
<tr>
<td>Owners of factories</td>
<td>3 families</td>
</tr>
<tr>
<td>Mezcal producers</td>
<td>29 families</td>
</tr>
<tr>
<td>Mezcal resellers</td>
<td>4 families</td>
</tr>
<tr>
<td>TOTAL</td>
<td>83 families</td>
</tr>
</tbody>
</table>

| Litres to support one family on average | 60 l/family/yr [1] |
| Profit of agave production with a local price of $50 / l | $ 3,000 /family/yr [2] |

[1] This value is calculated by dividing the annual mezcal production of the community (5,000 l/yr) by the total families supported by the fixed people involved in the mezcal production (83 families)
[2] Currency in Mexican Pesos: $20 ~ €1

Table A5. Characteristics of the different agave production systems depending on its agave density

<table>
<thead>
<tr>
<th>LOW DENSITY SYSTEMS</th>
<th>HIGH DENSITY SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild agaves with present agave density</td>
<td>Wild agaves after agave planting programmes</td>
</tr>
<tr>
<td>Costs of crop production</td>
<td>$ 0</td>
</tr>
<tr>
<td>Costs of crop production in relation to local mezcal price</td>
<td>0%</td>
</tr>
</tbody>
</table>

[6] Calculated by multiplying the crop production cost -$1,50/kg- by the mezcal production -12,5 kg/l-;
[7] Table 5; [8] Equation A1; NOTE: Currency in Mexican Pesos: $20 ~ €1
ANNEX 2: CALCULATIONS FOR THE DESCRIPTION OF THE AGAVE PRODUCTION SYSTEMS

In this Annex I describe the methodology for the calculations of the different production systems’ characteristics. The results are shown in Table 1 in Chapter 3.3.

**Agave yield**

For the low density systems, the yield is calculated considering that every year 2% of the total density is harvested (Annex 1). Then from this value 3 crops must be left as seeders (Chapter 3.2 and 3.3)

Low density system yield [crops/ha/yr] = (density in the forest [crops/ha]) * 0.02 – 3 crops/ha  Eq. A2

For the high density system, the yield is calculated by considering that every ten years the total density is harvested minus the loss which is 10% (Table A5 in Annex 1). For this system no crops are left as seeders. This is the situation of a monoculture. In the seed spreading system, 7 crops/ha must be left as seeders. As this number is not very large compared to the total density (see Figure 3 in Chapter 3) the difference of being a monoculture or a seed spreading system doesn’t make much difference for this calculation.

High density system [crops/ha/yr] = (3,000 crops/ha) * 0.9  Eq. A3

To calculate the yield in weight [kg/ha/yr] the result of Equation A2 and A3 is multiplied by the average weight of an agave cupreata crop which is 25 kg/crop (see Cohetero Villegas (2009) and Annex 3).

**Mezcal production**

To find the annual mezcal production, the yield in kilograms is divided by the average performance of agave cupreata to produce mezcal which is 12.5 kg/l (Cohetero Villegas, 2009).

**Profits by local mezcal sale**

The total profit of the mezcal sale was calculated by multiplying the total mezcal production by the local mezcal price minus the production costs:

Profits by local mezcal sale = (total mezcal production)* (local mezcal price – production costs)  
[$/ha/yr] *[l/ha/yr] *[$/l]  Eq. A4

**Families benefited**

Here I calculate the number of families that each system can support in one hectare. Therefore, the annual mezcal production per hectare for each system is divided by the amount of litres that one family requires (see Table A4 and A5 for the data).

Families benefited per hectare = Annual mezcal production per hectare / Volume of Mezcal to support one family  Eq. A5
Ecological services preserved

For this criterion I determine whether the production system preserves or not the ecosystem. Therefore the ecological services will be preserved or not.

Economic activities requiring extra area apart from the forest

For this criterion I determine which economic activities can NOT be done in the area of the agave production system.

Risks

For this criterion I determine whether the system has low or high risks for pests and diseases, as well as for lost of large investments caused by weather problems.

Labour time

Since there is no precise value for the labour hours involved in the low density systems this is a qualitative value indicating whether the system requires low or high labour time.
ANNEX 3: QUESTIONNAIRE ABOUT THE SUSTAINABLE MANAGEMENT OF AGAVE CUPREATA IN GUERRERO

Answered by: Grupo de Estudios Ambientales A.C. (GEA)
It was answered in Spanish and I translated it into English

1. Information about the communities

1.1.- Has the population indigenous origin? Some of them have Nahua origin, and others are “mestizos”.

1.2.- How many members does an average family has? 5

1.3.- Apart of the agave and mezcal production, What are the other economic activities of a mezcal producer family? The sons of the mezcal producers migrate to other regions to work.

1.4.- What are the monetary incomes of these activities? Between 150 and 200 pesos daily, but depends on the activity that they do.

1.5.- In average, how many persons of a mezcal producer family migrate searching for job opportunities? 2

1.6.- What percentage of their income represents the remittances? 20%

1.7.- What type of food does the mezcal producer family grow for their subsistence? Maize, beans and cabbage.

1.8.- What percentage of their food do they need to buy? 30%

1.9.- How long do they take to produce the mezcal once they have the agave heads? 10 days

2. Mound management system

In the presentation of GEA “Manejo Campesino de Maguey Papalote del Ejido de Acateyahualco, municipio de Ahuacuotzingo, Guerrero” in November 2008 a large study of the agave density of the municipality is shown.

2.1.- Where can I find this study? It has not been published jet, they are still working on the data (they are doing a monitory of the agave population from 2007-2009)

2.2.- Is this area communal or private? It is an “ejido” (communal land), the area which has been studied is of communal use and has an area of 594 ha of forest where the agave is harvested.

Agave harvesting

2.3.- Between how many people the agave is shared? Between the “ejidatarios” which are 74.

2.4.- How many agave is harvested per year in this area? Approximately 2000 heads of agave are harvested in the 594 ha, nevertheless they don’t finish harvesting this area every year. Usually they finish harvesting in 3 years. The agave is shared between the 74 “ejidatarios”. After this time they decide if they harvest again or they wait for the agave population to recover.
Cut of the agave

2.5.- At what stage of the agave growth can it be harvested? **At velillas and capons**

2.6.- How old are the agaves when they are harvested? **Approximately 10 years.**

2.7.- In average, how far is the mound for the peasants? **One hour and a half**

2.8.- In average, how many donkeys does each person take to carry the agave heads? **2 donkeys**

2.9.- How many agave heads can each donkey carry? **If the heads are small they can carry 5, if the heads are big they can carry 4 halves (2 heads)**

2.10.- Once the peasant is in the mound, How long does he takes to find the agave, cut the leaves and put it on the donkey? **It takes 3 days in average for each “Labrador” to cut the 30 heads that are meant for him.**

2.11.- In average how much a head weights? **The weight depends of the size, it could be between 10 to 40 kg**

Fenced area

2.12.- What is the fenced area to protect the agave from the cattle? **In the particular case of Acateyahuacalco there are 2 fenced reforested areas of 25 ha each.**

3. Agroecologic management system: seed spreading system

Agave harvesting

3.1.- How many agaves are harvested per hectare per year?

3.2.- How many times per year do they harvest? **The harvest is done once a year, it means that in a particular area or spot all the velillas or capons are harvested. If they need more agave they look for another place.**

3.3.- How long do they take to harvest? **From 3 to 5 days**

3.4.- How many people is needed for a harvest? **At least 3 persons, first they “labran” (take off the leaves and cut the head of the agave) and the same persons or others take them to the factory.**

3.5.- How far is the place where they take the agave heads? **Around one hour if the place is in the lands of the mezcal producer, but often they cut agaves from other communities.**

Seeders management

3.6.- How long does it takes to cut the seeders and put them in the lower branches of the trees? **1 day**
3.7.- How many people is required? 1

Management of the agave cultivation

3.8.- How are herbs controlled in the fenced area? Sometimes they are manually removed with machetes.

3.9.- How are pests and diseases controlled? When the agaves are very close to each other or their leaves are touching each other’s and they could spread the disease; they are removed to other place with lower agave density. If there are pests lime is added.

3.10.- How frequently are these activities done? Maybe once a year

3.11.- How many people is needed? 2 to 3 persons

Fenced area

3.12.- What is the fenced area for the production of agave by seed spreading? There are areas of 1 ha to 13 ha

3.13.- What is the average agave density of the fenced area?

3.14.- Is the fenced area communal or private? Usually the people who have a seed spread management system they have private properties

4. Agroecologic management system: nurseries and reforestation subsystem

Agave harvesting

4.1.- How many agaves are harvested per hectare per year? The reforested agave takes more time to grow because of the change in conditions to the once it was used in the nursery. It also doesn’t grow and develop at the same time, therefore the 1100 plants/ha are not harvested at the same time

4.2.- How many times per year do they harvest? Once a year

4.3.- How long does they take to harvest? 3 days

4.4.- How many people is needed for a harvest? 3 people

4.5.- How far is the place where they take the agave heads? From 1 to 3 hours

Seed collection

4.6.- The seeds are collected from the mound between April and May, how many days do they have to go to the mound to collect enough seeds? One week

4.7.- Do you collect seeds from the fenced area? Yes

Nursery work
4.8.- How many people work in the nursery? In average 5 people

4.9.- How many hours per week do they work in the nursery? They work 8 hours per day from Monday to Saturday

4.10.- How are herbs controlled in the fenced area? They are manually removed.

4.11.- How are pests and diseases controlled? With organic insecticides and lime

4.12.- How frequently are these activities done? Once a month

4.13.- How many people is needed? 5 persons

Fenced area

4.14.- What is the fenced area for the production of agave by seed spreading? It depends on who asks for the plant, they could be “ejidatarios” or communities where the area varies from 1 ha to 50 ha and/or also the land owners reforest areas from 1 ha to 15 ha.

4.15.- What is the average agave density of the fenced area? 1100 agave plants per hectare are reforested

4.16.- Is the fenced area communal or private? Both