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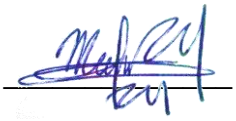
Unterschrift / *Firma*: 

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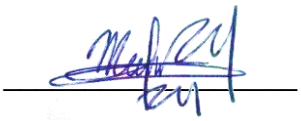
Unterschrift / Firma: 

CONTENTS

TABLES INDEX 3

FIGURES INDEX 4

ABBREVIATIONS 5

ACKNOWLEDGMENTS 6

RESUMEN 8

ABSTRACT 9

I. INTRODUCTION 10

I.1 PROBLEM STATEMENT 12

I.2 RESEARCH QUESTIONS 13

I.3 OBJECTIVE 13

I.4 STUDY SITE LOCATION AND GENERALITIES 14

II. THEORETICAL FRAMEWORK 16

II.1 Sustainability assessment 16

II.2 Agroecology 21

II.3 Sustainability indicators in agroecosystems 22

III. METHODOLOGY 26

IV. THE CONTEXT OF MEZCAL PRODUCTION 29

IV.1 Mezcal origin and types 29

IV.2 Maguey (*Agave* spp.) in Mexico 29

IV.2.1 Maguey in Oaxaca 33

IV.3 Mezcal production 34

IV.3.1 Artisanal mezcal production 35

IV.3.2 Mezcal production background in Santiago Matatlán, Oaxaca 36

IV.4 Denomination of origin 38
IV.5 Mezcal normative 40
IV.6 Mezcal Regulatory Council 41
IV.7 Mezcal commercialization 41
V. CHARACTERIZATION OF THE CASE STUDY 43
VI. STUDY CASE SUSTAINABILITY ASSESSMENT FRAMEWORK 57
VI.1 Sustainability conceptualization and objectives 57
VI.2 Study case sustainability attributes 59
VI.3 Study case sustainability indicators 62
VII. DISCUSSION 70
VIII. CONCLUSIONS 74
Annexes 76
Annex 1. Matrix for the analysis of field work information 76
REFERENCES 85

TABLES INDEX

Table 1. Sustainability Assessment Frameworks characteristics (SAF). Design by the author based on Galvan (2008). 19
Table 2. In-depth interviews topics. Design by the author. 27
Table 3.Maguey uses. Design by the author based on Vela (2014) 30
Table 3. Material and energy uses, fluxes and transformations through the artisanal mezcal process. Design by the author based on Sanchez López (2005) and the field work. 47
Table 4. To maintain and problematic aspects on artisanal mezcal production in Santiago Matatlán. 58
Table 5. Social-cultural dimension indicators 63

Table 6. Institutional-Political 64

Table 7. Economic dimension indicators..... 66

Table 8. Environmental dimension indcators 68

FIGURES INDEX

Figure 1. Santiago Matatlán, Oaxaca, location. 11

Figure 2. Oaxaca eigth regions map.(Gobierno del estado de Oaxaca 2010-2016)..... 14

Figure 3. Critic steps to develop a Sustainability Assessment Framework. 21

Figure 4. Research methodology. 26

Figure 5. Design features of theresearch according Sandoval (2002). 26

Figure 6. Mezcal maguey production process in Oaxaca. Based on Sanchez López (2005). 33

Figure 7. Santiago Matatlán subsystem. 43

Figure 8. Artisanal mezcal production steps. Design by the author based on Sanchez López (2005) and the field work. 45

ABBREVIATIONS

CRM	Mezcal Regulatory Council
DO	Designation / Denomination of Origin
DOM	Mezcal Designation / Denomination of Origin
NOM	Official Mexican Norm NOM-070-SCFI-1994, Alcoholic beverages- Mezcal Specifications
SAF	Sustainability Assessment Frameworks

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RESUMEN

La aplicación del concepto de sustentabilidad mediante marcos de evaluación integrados por indicadores permite reconocer tendencias y cambios en los agroecosistemas e identificar tanto potencialidades como problemáticas. Estos marcos son estructurados de forma jerárquica: primero se caracteriza el sistema en estudio, posteriormente se definen atributos deseables y finalmente son establecidos indicadores caso-específicos (Astier & González, 2008).

El presente estudio busca proponer un marco de evaluación de sustentabilidad (MES) para el caso de la producción de mezcal artesanal en el municipio de Santiago Matatlán, Oaxaca. Para esto, la investigación fue desarrollada en tres etapas: revisión documental, investigación de campo y análisis de la información para formular indicadores.

La caracterización de la producción de mezcal artesanal en Santiago Matatlán mediante las dimensiones de la sustentabilidad, permitió la identificación de interrelaciones, aspectos valiosos que deben ser mantenidos, así como problemáticas sobre las cuales trabajar. Estos resultados, en conjunto con la consideración de acuerdos existentes sobre las implicaciones de la sustentabilidad en el marco de la agroecología, permitieron la definición de atributos de sustentabilidad que dieron pie a la formulación de indicadores, que en su mayoría han sido planteados para su aplicación a nivel de palenque.

Para el análisis de los indicadores es recomendado un análisis multicriterio que permita reconocer aspectos que se quedan rezagados, así como la identificación de las condiciones de los indicadores señalados como críticos, de manera que sea posible priorizar la toma de decisiones.

El marco de evaluación de la sustentabilidad resultado de esta investigación, es el primer paso para lograr la evaluación de la sustentabilidad de la producción de mezcal en Santiago Matatlán. En trabajos posteriores deberá de trabajarse en la elaboración de las herramientas que permitan aplicar la evaluación.

ABSTRACT

Applying the concept of sustainability through assessment frameworks integrated by indicators allows to recognize trends and changes in agro-ecosystems, and to identify potential problems. These frameworks are structured hierarchically, first the system under study is characterized, later desirable attributes are defined and finally case-specific indicators (Astier & Gonzalez, 2008).

This study aims to propose a framework for sustainability assessment (SAF) for the case of the artisanal mezcal production in the municipality of Santiago Matatlán, Oaxaca. For this, the research was developed in three stages: document review, field research, analysis of information for the formulation of indicators.

The characterization of artisanal mezcal production in Santiago Matatlán by the dimensions of sustainability allowed the identification of relationships and of valuable aspects that must be maintained, as well as issues which need a change. These results together with consideration of the sustainability concept in the framework of agroecology, allowed the definition of sustainability attributes that led to the formulation of indicators, most of which have been raised for it application at small factories level.

For the analysis of the indicators a multi-criterial analysis is recommended to recognize aspects that are neglected, and the identification of the conditions of the indicators identified as critical, so it is possible to prioritize decision making.

The SAF result of this research is the first step to achieve a sustainability assessment of artisanal mezcal production in Santiago Matatlán. Subsequently, work should be done on developing the tools necessary to implement the evaluation and, at last, the application in decision-making.

FORMULATION OF A SYSTEM FOR ASSESSING THE SUSTAINABILITY OF THE ARTISANAL PRODUCTION OF MEZCAL: THE CASE OF SANTIAGO MATATLÁN, OAXACA

I. INTRODUCTION

In Latin America and around the world, agricultural production problems are understood not only as a technical issue, but as a matter of "social, economic, political, cultural and environmental" dimensions. Therefore the approach for the solutions to these problems could be taken from the "sustainability of agriculture" framework (Altieri & Nicholls, 2000).

Sustainability, understood as a feature that varies according to crops and geographic areas (Altieri & Nicholls, 2000), is a concept built according to the society and its needs (Wu, 2012). It refers to the agroecosystem ability to " ... maintain production through time, in the presence of repeated ecological and socio-economic pressure restrictions" so it is possible to obtain a sustained yield (Altieri & Nicholls, 2000).

Sustainability can be analyzed through three classical dimensions: social, economic and environmental (Wu, 2012). However, Altieri and Nicholls' (2000) proposal considers the holistic understanding of agriculture situation through an agroecology framework, which includes five dimensions: the three classical plus political and cultural. From agroecology, the units of analysis are the agricultural ecosystems (or agroecosystems) and within them energy movements and transformations, socioeconomic relations, nutrient cycles and biological process (Altieri & Nicholls, 2000).

In seeking to properly apply the concept of sustainability in agriculture according to Altieri and Nicholls (2000), an analysis of the correlation between growth models or development and conservation of natural resources is necessary at different scales. To do this, it is suggested to carry out an interdisciplinary assessment that uses indicators of socio-economic and agro-ecological performance so it is possible to know the conditions of adaptability, stability and equity in the agricultural ecosystem.

Sustainability assessment is a process that allows trends and changes recognition in systems, while making possible to identify both potential and current limitations of strategies or activities developed, enabling learning and decision making (Rodríguez Sosa & Zeballos, 2007).

To perform such evaluation, a wide variety of Sustainability Assessment Frameworks (SAF) have been developed, seeking to make understandable in day to day basis the reality sustainability concept. These frameworks represent a "... link between the theoretical development of the concept and its practical application." Generally, these frameworks are structured hierarchically, so first there are defined principles and later desirable attributes and indicators (Astier, Masera, & Galvan-Miyoshi, 2008).

Astier et al. (2008) reports the recognition of fundamental systemic attributes or characteristics, as interactions, use of materials, values and dynamics, as a critical aspect of SAF. In addition, the same authors report the need to develop case-specific indicators, defined both in terms of the particular context and according to the principles or attributes of sustainability.

In this sense, the present study seeks to propose a Sustainability Assessment Framework, comprising indicators in the particular context of artisanal mezcal production in the municipality of Santiago Matatlán, situated in Oaxaca (Figure 1) known as the "world capital of mezcal" due to the large amounts of production of this spirit.

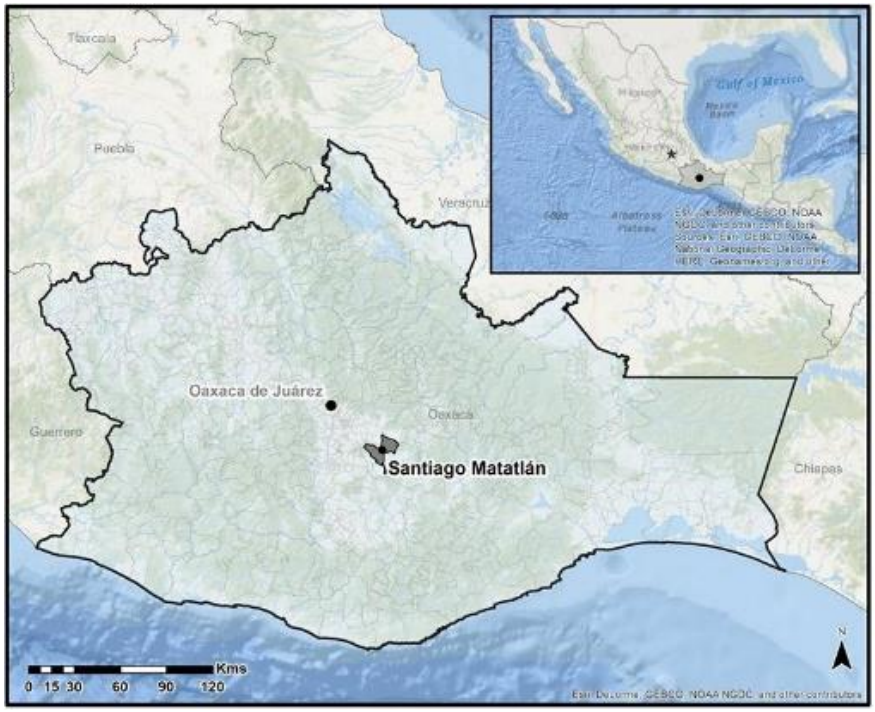

Figure 1. Santiago Matatlán, Oaxaca, location.

Mezcal is a Mexican alcoholic beverage made from maguey or agave (SCFI, 1997) which artisanal production is characterized by the use of traditional techniques and tools such as ovens dug in the ground, sugar mills, wood or ceramic containers and animal skins, among others (SCFI, 2016).

In recent years there has been an increased appreciation and consumption of mezcal in Mexico and around the world. Between 2011 and 2014 its production increased by 147 % (CRM, 2016) and it is estimated that this trend will continue due to the growing demand for this drink at national and international level (Bowen, 2015). This situation is part of a cultural and historical context that gives mezcal its own identity: complex socioeconomic relations between maguey and mezcal producers, traders, authorities and consumers as well as environmental aspects associated with periods of scarcity or abundance of maguey plants, soil pollution and deforestation, among others.

The development of this study considers the characterization of the agroecosystem in which the production of artisanal mezcal is involved, specifically in the case of Santiago Matatlán, to further define the meaning of sustainability for this case through the identification of aspects to maintain and change, allowing the definition of sustainability attributes and indicators.

It is expected that the resulting SAF of this research provide a useful outline to develop, in further studies, the tools that allow to apply a sustainability assessment and decision-making, it is not the intention of this research to develop the assessment.

I.1 PROBLEM STATEMENT

Due to the ambiguity in the general concept of sustainability and the extended discussion on its implications, several attempts have been done to make sustainability applicable to day-to-day situations. One of these attempts consists on sustainability assessment through indicators systems (Sarandón & Flores, 2009).

The current growth on mezcal demand in the market (Bautista & Terán M., 2008; Bowen, 2015), has allowed maguey and mezcal production to reach an important place on Santiago Matatlán economic activities (H. Ayuntamiento Constitucional Santiago Matatlán, 2014) . However, mezcal growth implies much more than economic aspect: richness of culture, social relations and perceptions, environmental factors, regulations as well as political decisions is involved.

Sustainability seems to be an integrative point of reference to guide the present and future of mezcal if its implications are clearly settled. In addition, several authors have mentioned the importance of sustainability understanding according to specific areas and contexts.

The problem that guided this research is related with sustainability understanding and the definition of its attributes according to maguey and mezcal situation in Santiago Matatlán and its consequently indicators which allow sustainability recognition and determination.

Another associated problem is the systematic characterization of the maguey and mezcal situation in Santiago Matatlán, which must include information from previous studies as well as from official entities and stakeholder's interests, problematic perception and desires about future. This characterization set the base to define sustainability implications in the study case.

I.2 RESEARCH QUESTIONS

According to problem definition, the following research questions are proposed:

- Which are the most relevant characteristics, problematics and values of Santiago Matatlán artisanal mezcal production?
- How to conceptualize sustainability for the study case?
- What it is desirable to maintain and what needs to be changed or developed?
- Which are the indicators that will allow sustainability conditions recognition for the study case?

I.3 OBJECTIVE

The aim of this research is to develop a sustainability assessment framework composed by indicators for the artisanal mezcal production in Santiago Matatlán, Oaxaca.

The steps proposed to achieve this goal are:

- Characterize the agroecosystem in which artisanal production of mezcal is immersed.
- Conceptualize sustainability for the case study.
- Define the attributes of sustainability for the case study.
- Define the corresponding sustainability indicators.

I.4 STUDY SITE LOCATION AND GENERALITIES

The municipality of Santiago Matatlán where this research was made, self-named as the world capital of Mezcal, is located within the district area of Tlacolula, Central Valleys, 56 km SE away from Oaxaca city, in the state of Oaxaca, Mexico; its climate is mild with small variations of temperatures along the year and winds from the north (Álvarez, 2003; INAFED, 2010).

Oaxaca's free and sovereign state is situated in the southeast part of the country and belongs to the Mexican south pacific economic area. Its geography makes it the main transit route for a great variety of human groups with their own traditions, influences and cultural concepts (Álvarez, 2003).

The state has an area of 95,365 km^2, which represents 4.85 % of the Mexican territory making it the 5^{th} biggest state in the country. The state land is divided into 30 different political districts and these into 570 municipalities. In addition, there is another land division which classifies the state into regions; such regions meet the "ethnographic and folklore" interests of the people as well as some biotic, economic and geographic aspects. This division evolved from 1930 until 1970 when the following regions were established (Álvarez, 2003):

- Cañada
- Costa
- Istmo
- Mixteca
- Papaloapan
- Sierra Norte
- Sierra Sur
- Valles Centrales

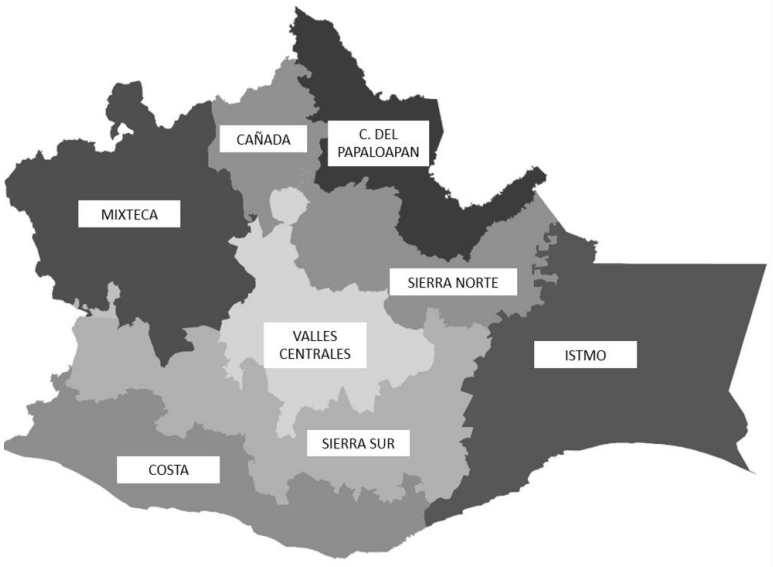

Figure 2. Oaxaca eigth regions map.(Gobierno del estado de Oaxaca 2010-2016)

The Central Valleys region is made up of the valleys in the east basin of *Rio Verde* (green river), also known as "*Atoyac*", between 1,150 and 1,850 m of altitude. Even though the local ecosystems are similar, there are some differences in their microclimate, vegetation, hydrology, land and topography. This area is of average productivity; the land used to be thickly covered with vegetation and organic matter, however nowadays it is worn away due to the significant agricultural activity that has been taking place during the last 4,000 years (Álvarez, 2003).

The Central Valleys have the state's largest population, consisting of mestizo (mixed races) groups, people from different ethnic groups that have migrated to the area, and Zapoteca group, which is predominant. This area is currently of great importance both socially and economically due to the population's high density; it is the seat of central political powers and has major commercial activity (Álvarez, 2003).

II. THEORETICAL FRAMEWORK

II.1 Sustainability assessment.

Since 1987, when sustainability or sustainable development concept emerged, different actors in the public and private sectors have applied these terms, even without consensus on its meaning and implications. After nearly three decades, it is possible to say that there are basic criteria to sustainability understanding, although its conceptualization is still under construction (Sarandón, 2002).

This research uses sustainability and sustainable development as synonyms, even though there is a discussion on a different meaning between them. It is not the intention of this work to perform an analysis of the different positions concerning sustainability concepts. Some general characteristics and conclusions, in which there is now some degree of consensus, are used.

Sustainability, a complex and multidimensional concept (Galvan-Miyoshi, Masera & López Ridaura, 2008), seeks to meet several goals simultaneously, which involve "productive, ecological or environmental, social, cultural, economic and temporal dimensions" (Sarandón, 2002). The aspects to maintain as well as those that need to change are a common point of debate. Determination of what is sustainable should be conceptualized according to different contexts, geographical areas or even specific crops, in order to define relevant sustainability principles and objectives (Altieri & Nicholls, 2000; Bond *et al.,* 2012; Medellín-Milán *et al.,* 2011).

At Rio conference in 1992, the need to design strategies to achieve sustainability objectives, was detected (Bond et al., 2012). The planning of these strategies requires transforming the abstract concept of sustainability in to an operating term (Sarandón, 2002) so it is possible to monitor the performance of the strategies through sustainability assessment systems that facilitate decision making (what must be approved and under what conditions) (Bond *et al.,* 2012).

Proper sustainability objectives, characteristics and attributes definition, are the base for an assessment framework which allows recognition of systems tendencies and change, identification of potentialities and limits as well as continue evaluation of applied strategies. This will allow the identification of impacts and learning of what is done, to plan improvement and mitigation schemes, adjust objectives and take decisions that lead to guarantee progress towards sustainability in each case (Gibson, 2006; Rodríguez Sosa & Zeballos, 2007).

Sustainability assessment is in an early stage of development; sustainability so far has been evaluated in cases such as mining, agriculture or industries and universities; however, there are still a variety of contexts and approaches where designs that fit reality are necessary to ensure progress towards sustainability in each case (Bond *et al.,* 2012).

Sustainability assessment works, commonly refer at least three pillars or dimensions of sustainability, or even five: social, cultural, institutional, economic and environmental. The definition of these is a matter of focus. What really matters, is to understand the relations and interdependence between them; therefore, it is only possible to approach sustainability from a holistic and systemic approach (Gibson, 2006).

The environmental conditions of an agroecosystem are strongly influenced by the economic activities performed in a place. At the same time cultural and political aspects determine the dynamics that these economic activities follow; the condition of one dimension could have an impact on the fluxes, dynamics, interactions and conditions that take place in the others.

It has been identified that sustainability goals, such as access and preservation of livelihoods, security, health, intra-generational and intergenerational equity, participatory communities, democracy, new opportunities generation, productivity, efficiency, self-management, biodiversity conservation, among others, are related to more than one pillar, so is important to pay attention on what is required to achieve objectives from a "multidimensional" approach (Gibson, 2006) (Galvan-Miyoshi, Masera, & López Ridaura, 2008).

A wide variety of sustainability characterization and assessment frameworks have been done, with focus from the global to the national, regional and local scale. Some of the most relevant and useful are (Parris & Kates, 2003):

- A suite of 58 indicators for social, environmental, economic and institutional dimensions, proposed by the United Nations Commission on Sustainable Development.
- A “Dashboard of Sustainability” composed of 46 indicators that cover environment, economy, institutions and society, was proposed by the Consultative Group on Sustainable Development Indicators.
- The World Conservation Union has developed the Wellbeing Index composed of 88 indicators which are divided into two sub indexes: human wellbeing (health and

population, wealth, knowledge and culture, community and equity) and ecosystems wellbeing (wide, water, air, species and genes and resources use).

- Environmental Sustainability Index is composed of 68 indicators which are meant to cover environmental systems, environmental stresses, human vulnerability, social and institutional capacity as well as global stewardships.
- A set of 65 indicators, proposed by the Global Scenario Group, describe aspects of international equity, national equity, hunger, energy use, water use, deforestation, carbon emissions, sulfur emissions and toxic wastes.
- Ecological Footprint, which is one of the most spread, consists in a comparison between the use of croplands, grazing lands, forests, fisheries, infrastructure and fossil fuels, and the global capacity to provide each aspect and renew it self.
- Costa Rica's System of Indicators for Sustainable Development is a national proposal composed of 255 statistical tables divided into three categories: social, economic and environment. This system has different scale indicators, from house to national series.
- Boston Indicators Project, which is an example of a community based effort, is composed of 159 indicators organized in 10 subjects: culture, civic health, environment, economy, education, safety, health, housing, transportation and technology. This model can be applied by neighborhood.

Lack of a specific time setting for the assessment, not clear sustainability implications and poor involvement of all stakeholders (top down approach), are some weaknesses from many of these frameworks (Parris & Kates, 2003), which can be originated due to the diversity of interests behind their creation, for example in many cases indices and indicators are developed in ways to protect or justify political agendas or particular interests (Parris & Kates, 2003).

The diversity of developed methodologies for sustainability assessment, have been classified by Galvan-Miyoshi *et. al.,* (2008) into three groups:

- Lists of sustainability indicators which are shaped primarily by environmental and economic indicators; some include social indicators as well as institutional. The weakness of these lists is that indicators results are not always integrated, sustainability objectives sometimes are not clear, so that strategic planning is difficult.

- Indices of sustainability. This form of assessment summarizes the evaluation of indicators in a single numerical value, the disadvantage of this method is that it is difficult to identify strengths and weaknesses if the analytical framework is not presented, it may be an unwise interpretation of results.
- Sustainability assessment frameworks (SAF). This methodology is based on the definition of sustainability principles, objectives or attributes, which serve as a basis for further define criteria and indicators, which are defined as both context situations and defined attributes.

The last type, constitute the chosen approach for the present research. SAF characteristics are presented in Table 1:

Table 1. Sustainability Assessment Frameworks characteristics (SAF). Design by the author based on Galvan (2008).

Characteristics	**Description**
Approach	SAF could have an orientation through objectives or systemic views. • Objective orientation considers management desires, aspirations or expectations. Usually Brundtland and Agenda 21 objectives are used as a reference. • Systemic orientation, make emphasis on functional and behavioral attributes as well as in reciprocity relations.
Assessment areas emphasis	Objectives and attributes can be classified by areas, social, environmental and economic, at least. Tensions between areas, movements and changes are recognized as inevitable conditions; it is considered that sustainability is strongly related with autoregulation and adaptation system capacities.
Assessment type	• "*Ex-post*" is the done evaluation when specific strategies have been applied. • "*Ex-ante*" is the evaluation used to compere potentialities between alternatives, could be understand as a planning tool.
Assessment scales	Scales can be related with spatial, organizational and time dimensions. • Spatial dimension, consider physical space where sustainability applies, is composed of two variables extension and resolution. • Organizational dimension, refer basic unit's relations that control system dynamics, for example institutions or families. • Time dimension, is refer to observation duration and also has extension and resolution variables.
Indicators development	• Top-down, indicators are obtained from expert's consultancy on relevant problematics or objectives. • Bottom-up, indicators are obtained from systems characterization and analysis which allow the identification of sustainability weakness and strengths.

Table 1. Sustainability Assessment Frameworks characteristics (SAF). Design by the author based on Galvan (2008).	
Characteristics	**Description**
	• Mix focus, in this case indicators definition consider both, what experts said and is relevant according to the context characterization.
Indicators integration	There are three common approaches for indicators analysis. • Indices, which are used to globally rate a system through integrated indicators. By this methodology results are simplified, but detail of useful information is lost. • Graphical representations, by this methodologies information of each indicator is showed with the purpose of make an integrated analysis, this type of indicators integration allow to analyze sustainability conditions in each dimension and between them. • Models, which are used to study systems dynamics, help to assess different sustainability strategies consequences. A weakness of this methodology is that results does not show reality complexity.
Participation	Inclusion of stakeholders is important to guarantee the applicability and flexibility of the assessment framework. Participation guarantees relevance, credibility and legitimacy of the evaluation.
Application experience	SAF application depends on it characteristics of adaptation and flexibility. Depending on the focus and objectives, a SAF could be applied to very specific systems or more general ones.

Is important to consider that sustainability assessment must be applied to identify needs as well as to prioritize action areas, to allow sustainability strategies design; these strategies must be monitored in order to know if they are working as planned or if is necessary to make adjustments; that is the reason why assessment should be done "*ex-post*" as well as "*ex-ante",* if possible, as a cycle which continuously enhanced sustainability (Galván-Miyoshi *et.al.,* 2008).

Sustainability assessment must consider all scale dimensions mentioned by Galván (2008) to have an integral view, to better understand fluxes and dynamics. This will allow the identification of relevant characteristics which permit the definition of useful and well planned indicators. Talking about the time scale, there is not an official time to assess the sustainability of a system, some have said that a time reference that include present and future generations could be 25 years (S. J. Sarandón & Flores, 2009).

According to information presented by different authors as Galvan-Miyoshi *et. al.* (2008), Sarandon (2009), the process to develop a sustainability assessment framework, consist in the following critic steps (Figure 3).÷

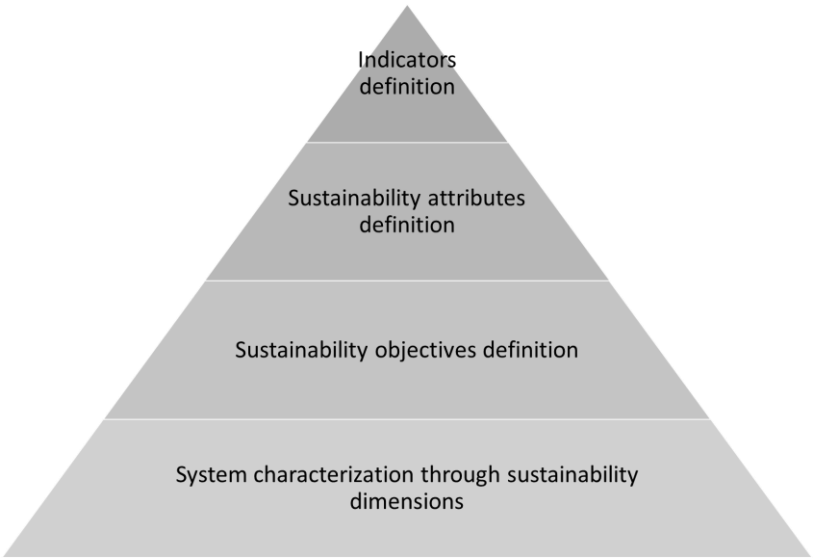

Figure 3. Critic steps to develop a Sustainability Assessment Framework.

Before indicators definition, is important to identify the fundamental characteristics of the study system according to chosen sustainability dimensions; definition of sustainability attributes is the next step, which will set the base (Galván-Miyoshi *et al.,* 2008). This logic process permits the creation of a SAF in which indicator values could have a proper interpretation that lead to decision making.

II.2 Agroecology

The search of agricultural production improvement, has led to a deeper understanding of agroecosystems and it functions. In this context agroecology emerged as a discipline that provides ecological principles to study and manage agroecosystems, in order to conserve it natural base and enhance it productivity, through an environmental, economic, social, political and cultural perspectives (Altieri, 2002; Castillo, 2002).

Agroecosystems can be understanding as plant and animal communities that interact in a physical environment which has been modified by humans in order to obtain products for their consumption as food, fuel, fibers, among others. Agroecosystems and it natural and human elements, dynamics, functions, interrelations and processes. are studied by agroecology (Altieri, 2002; Altieri & Nicholls, 2000).

The aim of agroecology is the integral understanding of agroecosystems in order to propose alternative approaches of relations and consequently agricultural production models (different to

the industrial ones). Alternatives are based in local and traditional knowledge related with the efficient use of locally available resources and even applying proper technologies. Agroecology permit the integration of traditional and modern knowledge to reach production methods that allow the conservation of healthy ecosystems and the equitable access to livelihoods to the society. Many times the problem with technologies, is that most of the times they are no affordable or appropriate to the local conditions (Altieri, 2002; Castillo, 2002).

Farming systems can be the unit of agroecology study, in this framework, it sustainability is related with the natural base conservation and the satisfaction of the producer needs, the lack of any of this conditions will impact significantly on the farming system sustainability (Altieri, 2002).

The application of agroecology framework in the reality, needs a deep knowledge in the local agroecosystems as well as creativity and preparation not only in natural sciences, but also in social and politics, to apply agroecology concept to particular cases, contrary to conventional systems that are more homogeneous and do not need specialized knowledge (Altieri, 2002).

In this research, agroecology constitutes the framework for artisanal mezcal production sustainability conceptualization. The context where mezcal is produced is very influenced by environmental and natural conditions, traditional ways of production, agricultural practices, politic and social dynamics. Although mezcal is not a direct agricultural product, the context of it production have a lot of things in common agricultural ones.

II.3 Sustainability indicators in agroecosystems

An indicator is a sign or signal that gives information of a condition of interest, and it changes through the time; indicators are variables used to represent qualities, characteristics or properties of system attributes (Wu, 2012), that would be difficult to recognize by simple observation or analysis (Sarandón & Flores, 2009). Sustainability indicators show how reality behaves in comparison to the concept of sustainability and it attributes.

Indicators are a central point in the decision making process, that is why they are important but also dangerous if they are not properly defined. Decisions are made according to a current state or condition, in order to achieve a desire state, actions are defined depending on the difference between the reality and the wanted condition (Meadows, 1998).

According to the information that indicators give, they could be classified in qualitative, quantitative or composed indices (Astier & González, 2008). Qualitative indicators are used to know properties

that usually have a subjective nature, while quantitative indicators allow to know properties that are possible to measure and have a numeric interpretation (Astier & González, 2008).

Sustainability indicators, are strongly related with the system characteristics that seek to assess, the problem focus, the scales of analysis, the analyzed crop and processes as well as the sustainability concept and attributes. In this way the indicators could be very specific and relevant according to local situations, that is why there could not exist a universal system of sustainability assessment (Altieri, 2002; Astier & González, 2008; Fraser *et.al.*, 2006; Sarandón & Flores, 2009).

Due to the wide variety of sustainability concepts and it dependence on the interest of whom is proposing them, sustainability indicators could be different in each case of assessment, making difficult the comparison of the sustainability between cases or systems. For the case of agroecosystems, Altieri (2002) indicates that there two common characteristics that distinguish sustainability: conservation of the natural base and satisfaction of the manager of the system (the manager could be the farmer).

Indicators design or selection, is related with scale which is referred to observation units (regions, communities, farms, families, etc.), scale selection should be guided by the possibility of change, the choose of a unit where change in direction to sustainability can be done (Parris & Kates, 2003; Sarandón & Flores, 2009).

During the process of design or select an indicator, one problem is to identify the useful indicators that provide sufficient, not repeated, relevant and easy to interpret information; to many indicators could create confusion. One solution is the creation of indices which is a group of indicators (Wu, 2012). There is a discussion on the difference between indices and indicators, though it is not an objective of this research.

Due to review of experiences on the formulation and application of indicators to assess sustainability in agroecosystems, it has been identified that some relevant features that indicators must have are (Astier & González, 2008; Sarandón, 2002):

- Be related to sustainability attributes. It is important to understand the relevance and the meaning of an indicator, this is possible to achieve if the indicators have as a base clear sustainability requirements or attributes, for the different dimensions.

- Be sensitive to change. This characteristic refer to the indicator ability to change through the time, the indicator must be able to reflect changes in the desire time reference.
- Present poor natural variability. This characteristic is related with the previous one, if the indicator uses a variable that naturally is changing, it will not be an adequate indicator.
- Have predictive ability. Indicators must be able to present tendencies.
- Easy collection and use. Information availability could be related with it reliability, is important to maintain reliability even if the difficulty on information gathering present an increase.
- Be independent from the observer. The indicator value should not depend on the appreciation of the evaluator.
- Be integrative. The performance of an indicator must have the capacity to collect and synthesize relevant information from several variables.
- Be easy to communicate. The units of the value of an indicator or it condition, should be easy to understand mainly by the people who is supposed to use the indicators.

Indicators need a reference, like a benchmark, target, threshold, goal or desire behavior, to be useful (Astier & González, 2008; Wu, 2012). This references can be determined according to relevant knowledge of the system of study or shared understanding of the desirable conditions by involved community (Wu, 2012).

Some indicators references, are easy to determine, for example the case of organic matter in drinking water; nevertheless, there are cases where referent levels are difficult to define, in this case is important to specify the preference on the change direction of the indicator, for example when talking about satisfaction.

Common problems when defining indicators according to Meadows (1998) are:

- Over aggregation, it happens when too many things are combined and the interpretation is difficult.
- Measure what is possible to measure rather than the important, for example when the covered area by a forest is measure rather than the diversity or health of the forest.

- Dependence on a false model, it happens when the perception of what is necessary to know do not match with the information gather by the indicators.
- Deliberate falsification, when an index carries bad news, information can be altered or delayed; also terms or definitions can be changed in order to reduce the bad results.
- Diverting attention from direct experience, the measure of a bad planed indicators can blind people with numbers and make difficult the interpretation of the situation in the reality.
- Overconfidence, indicators may lead people to think they are understanding the full reality, even when them could be faulty.
- Incompleteness, indicators should be understanding into a system to a correct interpretation of the measure. The measure by itself lose the detail of the studied phenomena.

Indicators definition, is a continuous process, it relevance and suitability must be proved through the time, in order to adjust and decide if a change is needed.

III. METHODOLOGY

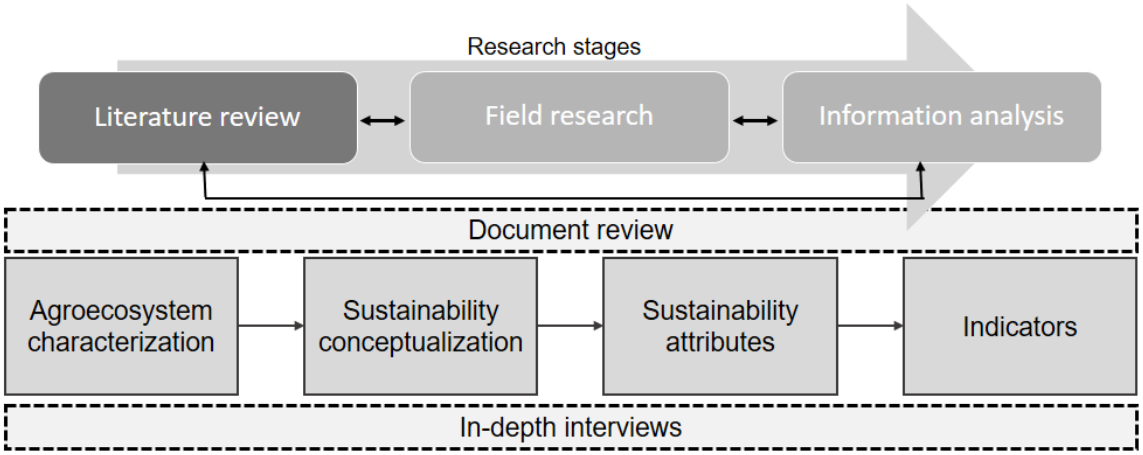

Figure 4. Research methodology.

In the previous diagram (Figure 4) we can see the three different stages in which the research was carried out, the steps to make a sustainability assessment framework of artisanal mezcal production and the used methodology tools. In each stage it was possible to obtain certain elements, which allowed the development of each step.

The research was carried out in an open, flexible and multi-cyclic process (Sandoval Casilimas, 1996) meaning:

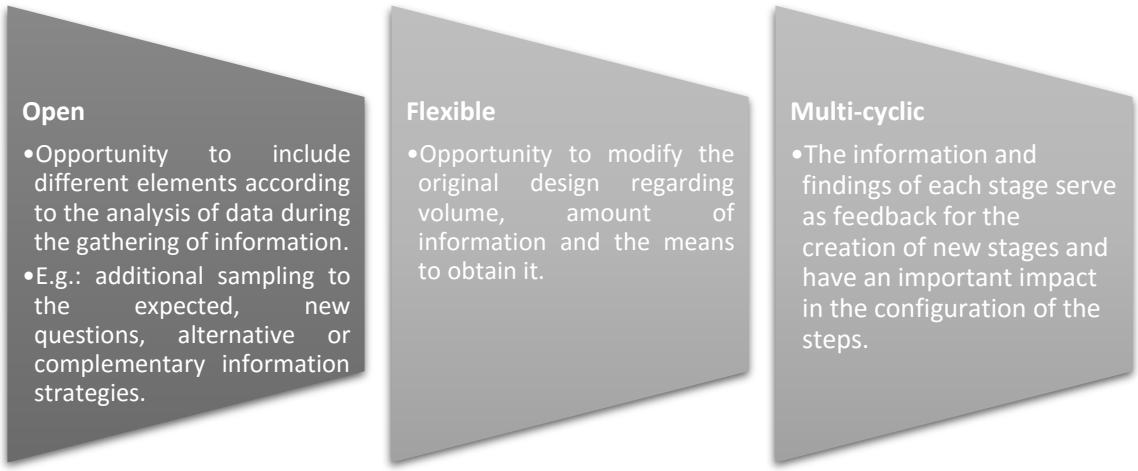

Figure 5. Design features of the research according Sandoval (2002).

The first stage consisted of conceptual research by documentary analysis sustainability assessment and indicators. The description of mezcal's background and context was done simultaneously. This

stage considered the review of literature as journal papers, thesis, specialize books in the topic, reports and federal regulation papers.

Field research was carried out from April to June 2016 mainly in the municipality of Santiago Matatlán but also in the municipalities of Santa Catarina Minas, San Dionisio Ocotepec and Oaxaca City. This stage consisted of a series of semi structured thorough interviews with specific topics for gathering information. General topics were stated and the development of the interview was determined by the answers of the interviewee (Malhotra, 2004).

Such specific topics are mentioned in Table 3:

Table 2. In-depth interviews topics.
Historical and cultural mezcal production background
Mezcal production process • Raw material • Production steps • Working tools • Workers • Costs • Wastes • Times
Product commercialization • Clients • Prices • Brands • Certification
Social, political, economic and environmental mezcal industry status quo
Municipal mezcal worker's organizations
Actual problems, possible solutions and future of the industry

The interviews were carried out to relevant stakeholders[1] that could provide thorough and detailed information on the subject (Martínez-Salgado, 2012). The interviewees were selected while doing the research (theoretical sampling) according to the results of previous interviews (Sandoval, 1996).

At the end of the field research period, fifteen interviews were applied to:

- Nine mezcal producers
- Two mezcal retailers

[1] Some criteria to select relevant actors are: belonging to a pole of typological exposition, living crucial conflicts, leaders, key personalities (with a strategic social position), dilemma personalities (multiple communications) (Serbia, 2007)

- A researcher on agave and mezcal subjects
- An accountant specialist in tax issues related to alcoholic beverages
- A writer and owner of a tour agency who seeks to spread the culture of mezcal
- The director of the Mezcal Regulatory Council

During the interviews the interviewed were informed about the objectives of the research, anonymity conditions, use of information, people with access to information and audio recording of the interviews in order to maintain an ethical environment and comfort for the participants (Malhotra, 2004).

The interviews were carried out until the saturation of information; that is until listening repeatedly to certain ideas and being able to draw some important conclusions about the subject of the interview so that further interviews would not disclose any additional information (Martínez-Salgado, 2012).

The information gathered during field research was analyzed by means of comparative analysis. The answers were compared according to the established topics and relevant data or tendencies were identified (Sandoval, 1996)

The matrix for the analysis is presented in the Annex 1.

The results obtained after the next two stages, allowed the beginning of the analysis of information in which the gathered documental information was used to include the background and theoretical framework of the research. These elements, together with the information gathered during fieldwork, were analyzed in order to find connections, differences and interrelations and then explain sustainability implications in the production of artisanal mezcal and a way to recognized them (Sandoval, 1996).

In order to determine the indicators, the following steps were carried out: first the contextualization of maguey and mezcal production was done; then the study case characterization using the agro ecosystems and sustainability dimensions (socio-cultural, institutional-political, economic and environmental) as a guide. Such characterization allowed the identification of key aspects to maintain and to change. Sustainability attributes for each dimension and the indicators were defined considering the agroecology sustainability objectives and conceptualization.

IV. THE CONTEXT OF MEZCAL PRODUCTION

IV.1 Mezcal origin and types

The word "mezcal" comes from *náhualt* word *mexcalli*, from *metl* (maguey) and *ixcalli* (cooked) terms (Aguirre Rivera *et.al.*, 2001; SAGARPA, 2006), and it refers to cooked agave plant (originally it was consumed by chewing), which juices are extracted, fermented and distilled to obtain an alcoholic beverage (Sánchez López, 2005). There is currently an important discussion about the origin of mezcal as there are authors who say their production dates back to the days before the European conquest (Zizumbo-Villareal & Colunga-García Marín, 2007), while others report that with the arrival of the Spaniards the distillation process was introduced and until then was it possible to obtain this drink (Serra Puche & Lazcano Arce, 2015)

Currently two types of mezcal are recognized, type I corresponds to mezcal made with 10~~0%~~ agave distillate, meanwhile type II is the one that contains up to 20 % of other sugars. Both types can be classified as young, rested or aged and macerated (addition of natural products, flavoring or coloring) (SCFI, 1997).

According to experience, it is said that the flavor and aroma (organoleptic characteristics) of this drink, take special notes according to the maguey specie, soil type and topography of the site where it grew, climate, vegetation, water, materials employed in the process of preparation, the experience of the producer, the use yeasts, the alcohol content, among other factors (Gutiérrez González, 2015; SCFI, 2016)

It is possible to consider, a great part of the produced artisanal mezcal in the country as organic, as many of it is produced from wild maguey, and in the case of cultivated, never or in rare occasions are applied agrochemicals. However, it notes that only some producers are certified organic products, as it is not very accessible from an economic perspective (Carrillo, 2007).

IV.2 Maguey (*Agave* spp.) in Mexico

In the present study, the words "maguey" with Hispanic roots, or "*Agave*" a term defined by Linneo, are used interchangeably to refer to different plants of the agave species.

Maguey are rosette-like plants, the growth of the leaves is around a stem, with very short internodes, where the leaves are arranged close together in helical form around the germinal bud, which gives the plant an appearance of a rose (Bravo, 1937; Font Quer, 1953). Its leaves are

succulent, parallel veins (Bianco *et al.,* 2004), composed of spongy parenchyma to retain water, a generous system of vascular bundles, waxy epidermis and in most species, spines on the margins (called teeth) and an apical spine, properly known as thorn or puja (Gentry, 1982). New leaves are generated from the center of the plant, from a cone which is the apical bud, considerably developed (Font Quer, 1953), the cone is colloquially known as bud or *cogollo* in Spanish. Once mature leaves, buds emerge from leaving their teeth marked on the youngest leaf (Gentry, 1982).

Agave genus is endemic from the south of North America and its extension through Central America to northern South America and the Caribbean islands; of all existing species in Mexico is possible to find 75 %, about 150 species (69 % of them are endemic) (Garcia Mendoza, 2007).

Maguey is adapted to dry environments, so their presence in the Mexican territory is important because humans have learned to obtain many different benefits from it. Maguey has been used to satisfy a several number of human necessities, from basics, as food and clothing, to the spiritual ones. The knowledge about it different uses was acquired by the observation and the experimentation with each of the plant parts. Maguey can be use, as a hole or by parts, for food, drinks, construction, adornment, domestic tools, textiles and agricultural objectives (Garcia Mendoza, 2007; Sánchez López, 2005; Vela, 2014). A detailed description of the possible uses is presented in the Table 4.

Table 3.Maguey uses. Design by the author based on Vela (2014)

Part of the plant	**Classification of use**	**Uses**
Flowers	Food	• *Flower stew*
Seeds	Adornment	• *Corporal adornment* • *Toys* • *Rattle*
Quiote	Food and drinks	• *Sweet juice* • *Tortillas* • *Desserts*
	Construction	• *Rain water collecting canals* • *Beams* • *Bridge construction*
	Domestic tools	• *Arrow quivers*
	Adornment	• *Women hair styling*
Maguey spine / spike	Domestic tools	• *Sharp needles* • *Cloves*
Stalk	Agricultural objectives	• *Compost* • *Cattle feed*
	Construction	• *Mixture additive* • *Mixture rafts*

Table 3.Maguey uses. Design by the author based on Vela (2014)		
Part of the plant	**Classification of use**	**Uses**
		• *Roofs*
	Textiles	• *Threads* • *Ropes* • *Fabrics*
	Food and drinks	• *Sweets* • *Barbecue cooking* • *White worms*
	Domestic tools	• *Fuel* • *Food recipients* • *Natural scouring sponges* • *Cradles* • *Paper*
	Adornment	• *Base for feather and gold adornment* • *Fiber for flower arches*
Heart / Head	Food and drinks	• *Tamales* and bread flavoring • Fructose • Warm salt • Mezcal • Tequila • Aguamiel • Dessert

From the pre-Hispanic period, the colonial, to the present time, in Mexico, maguey has been used, grown, harvested to be today an agribusiness (Valenzuela Zapata, 2006), which has been made possible by observation and study of the characteristics and forms of reproduction of the plant.

Maguey reproduce sexually and asexually. Sexual reproduction occurs through pollination by bats, insects and birds, usually after breeding plants die. Seed production becomes up to 65 000 per plant, when they reach maturity, are dispersed by wind (Garcia Mendoza, 2007).

The most common reproduction form is through clones (asexual reproduction or vegetative propagation) surrounding the rosette or born in the inflorescence (Garcia Mendoza, 2007). Clones are also called *hijuelos* (sapling agave plant), begin to be born around the plant from the second or third year after planting. Bulbils or clones also come to grow in the inflorescence (Garcia Mendoza, 2007).

Sanchez López (2005) classified used maguey to mezcal production in cultivated and wild, however the processes to obtain maguey are more complex than that. Maguey could be cultivated in modern and intensive plantations, as the case of *A. angustifolia,* also could be highly manage in wild areas

as the case of *A. salmiana* in San Luis Potosí, or the case of *A. potatorum* or *A. karwinskii* in Oaxaca, in these cases some plantations are started to take place. There are also low manage wild maguey, which are not harvested, but gathered. Originally all maguey was gathered in wild areas, however humans have selected some variants to plant due to their qualities, as sugar concentration, maturity time, among other (Sánchez López, 2005).

The most common crop technique is called "cultivation by *desahije*", this is to remove sapling agave plant or *hijuelos* (*desahije*), which once separated, are exposed to the sun to heal their roots and then planted (Sánchez López, 2005).

Another technique that has become important, is the use of growth bulbils in the inflorescence. Once the maguey has developed inflorescence or escaped floral, flower formation is expected, before the petals open, them are cut to the base of the flowers, over time, in the places where flowers were cut small agaves are born, when them reach 3 to 5 cm, they are detached from the escape and become planted in seedbeds and then be transplanted into the fields. With this technique, is possible to obtain 2,500 to 3,500 bulbils per plant (Sanchez Lopez, 2005).

Laboratory techniques have been also developed to reproduce maguey, in this case genetic plant material is used to achieve reproduction and obtain thousands of plants that retain the characteristics of the plant of origin (Sanchez Lopez, 2005).

The process of mezcal agave obtaining goes from the land preparation, to agave planting, land and planting management and agave cropping, at the end it is possible to obtain maguey hearts or heads which are used to mezcal production, however there are secondary products that can also be obtained as maguey *hijuelos* and maguey leafs. Maturity is reach between four to five years, after it is planted, in the case of small plants and 10 to 25 years in the case of bigger plants, for example *A. angustifolia* reach maturity around seven years after it plantation (Garcia Mendoza, 2007; Sánchez López, 2005).

A general overview on intense and semi-intense cultivated maguey obtaining steps, in the case of Oaxaca, are described in Figure 6.

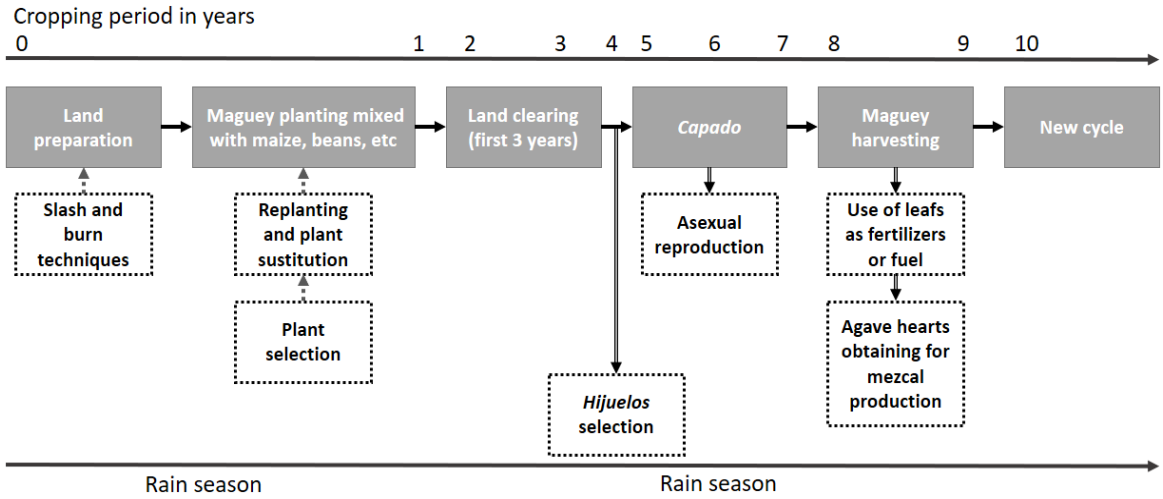

Figure 6. Mezcal maguey production process in Oaxaca. Based on Sánchez López (2005).

Some of the most common and severe diseases in mezcal maguey, are caused by the fungi genera: *Alternaria*, *Aspergillus*, *Colletotrichum*, *Fusarium*, *Phytophthora* and *Pythium* among others; so it has been recorded that the *Erwinia* bacteria causes damage to the plant. Insect pests cause most damage are *picudo* (*Scyphophorus interstitialis*), the belatobe or belato (*Hypopta agavis*) and scale insects (*Aonidiella* sp. and *Aspidiotus* sp.) (Sanchez Lopez, 2005).

Beyond technical issues, social and environmental situations involved maguey production. The need of more cropping lands is leading to a deforestation process which is accompanied with erosion problems and forest destruction in some areas. In addition, the land preparation method "*roza, tumba y quema*" (slash and burn), in the long term lead to soil nutrients loss impacting on soil fertility. In the social part there is a complex situation related with market competition for maguey, specially between mezcal and tequila producers which is going to be explained later in this document (Sánchez López, 2005).

IV.2.1 Maguey in Oaxaca

Talking about biological richness, in Mexico the most important states, due to the quantity of species that have, are: Oaxaca wit 37 species, Puebla with 31, Sonora with 30, Durango with 26 and Querétaro with 24 (Garcia Mendoza, 2007).

The importance of agave in Oaxaca is manifested by the wide geographical area covering 146 municipalities, located in nine districts in the state. In 60 % of these localities, the activities derived from its cultivation and use are the main economic support (Sánchez López, 2005).

In this 60 % of localities, the use of maguey is a fundamental component of the rural economy (Huerta Rosas & Luna Zamora, 2015), in this state the main species of agave used to mezcal production are: *A. angustifolia*, *A. americana*, *A. potatorum*, *A. rhodacantha*, *A. marmorata* and *A. karwinskii*; of these species are grown mainly two: *A. angustifolia* and *A. karwinskii* (Larson & Aguirre, 2015). Also exist other species such as *A. seemaniana* and *A. convallis* (Espinosa Paz *et. al.*, 2002)

IV.3 Mezcal production

Mezcal production have been consolidated in two general forms, in one had is the domestic production where families work together, the product is used for own consumption, local and regional consumption, obtaining quality spirit through the use of simple copper stills, superimposed pots or intermediate solutions. The increasingly using wage labor and production for the market, with copper stills, obtaining regular quality mezcal because sometimes the fermentation process "is accelerated by the use of chemicals" products. (Sanchez Lopez, 2005)

According to Sánchez López (2005) and Carrillo (2007) the mezcal production consists of the following steps:

1. Mezcal maguey selection, which will vary depending on the place, it could come from a plantation or the wild environment. The best is to choose mature *capon* or *sazón* agave due to the sugar concentration, this is the maguey which floral scape has been cut (capado) and is harvested some month or a year after that, the time varies from maguey specie (Aguirre Rivera et al., 2001; Carrillo, 2007). Maguey used to mezcal production, are graded in decreasing order in relation to its quality (sugar concentration) as follows: maguey castrated and flavor of plain*, desquiotado* maguey, *quiotillo* and finally the immature or green maguey that despite its size needs more than a year to produce the quiote (Aguirre Rivera et al., 2001).
2. Maguey harvesting, the part used to mezcal production is the stem, named head or heart, which is obtained by the cut of the leafs, then the stem is being transported to the *palenque* or mezcal production center by beasts, carts and trucks.
3. Maguey cooking, once the maguey hearts arrived to the factory, these are cut and put in an oven for it cooking. The oven can take at least three different forms: conical or natural, masonry and autoclave.

4. Maguey grinding, cooked hearts are ground either by wooden sticks or in the stone mill (*tahona*) that can be carried by an animal, a tractor or by a mechanical system, there are cases where electromechanical mills, also known as wrenching machines, are used. After milling is obtained must and bagasse.
5. Fermentation, products from grinding are fermented in containers of different types, from animal skins, metal jars, plastic recipients or wooden cubes, to transform sugar on alcohol. Fermentation can occur using natural "spontaneous" yeasts or by adding legume, cultivated yeasts or ammonium sulfate. The time that fermentation needs vary according to the weather temperature of the place.
6. Distillation, once the sugars were converted to alcohols double distillation takes place by using clay pots, copper stills or modern continuous distillation equipment; at the end of this process mezcal is obtained.

There are producers who later adds a worm, scorpion, spices, aromatic herbs or fruits like plum, pineapple, apricot, apple and pear or who distilled mezcal for the third time, in this process include a chicken or turkey breast or meat from other animals, with the purpose of enriching the flavors. It is also possible to produce mezcal *reposado* or aged using oak barrels, glass carboys or clay containers (Carrillo, 2007).

Talking about the process efficiency (kg / L), Aguirre (2001) mention that the determining steps are cooking and fermentation. Excessive heat during the cooking causes the caramelization of hydrolysate sugar, reducing the amount of fermentable sugars and consequently the amount of alcohol that can be obtained, also is produced furfural, an inhibitor of fermentation. Furthermore, the lack of cooking reduces the conversion of polysaccharides to fermentable sugars (Aguirre et al., 2001).

IV.3.1 Artisanal mezcal production

The artisanal mezcal is a drink made 100% of agave, produced with techniques that are considered ancestral or traditional, which is made without adding chemical substances that accelerate fermentation or distillation, some said that the alcohol content is close to 60 ° GL (Serra Puche & Lazcano Arce, 2015).

A weakness on artisanal mezcal production, is that the different stages of the process are not standardized, control is performed based on the judgment and experience of the producer, in

addition the equipment and process do not have control instruments, so in many cases the quality control is low leading the breaching of the NOM requirements (Aguirre Rivera et al., 2001).

Currently, it is in approval process the actualization of the applicable NOM, the project of the updated NOM includes the implication of artisanal process, which difference is mainly on the used materials and techniques:

"5.3.2. Artisanal Mezcal: it production must meet at least the following four stages and equipment:

5.3.2.1. Cooking: cooking maguey heads in earth ovens or high masonry well.

5.3.2.2. Milling: with deck, bakery, Chilean mill (*tahona*) or Egyptian, *trapiche* or wrenching.

5.3.2.3. Fermentation: in stone hollows, soil or trunk ones, masonry pools, containers of wood or clay, animal skins, which process may include maguey fiber (bagasse).

5.3.2.4. Distillation: with direct fire stills in copper boiler or clay pot and *montera* of clay, wood, copper or stainless steel; which process may include maguey fiber (bagasse)" (SCFI, 2016)

Normally artisanal mezcal definitions consider it composition, materials and equipment used on it production; the produced volume and the limits to adopt technologies are not clearly settle.

It is mentioned that artisanal mezcal is produced by traditional techniques. In the case of this research, tradition is understanding as the selection of knowledge that is transmitted from generation to generation; is the experience of the past that is used in the present which is in a continuous process of transformation. Tradition do not imply always accurate reproduction, is continually recreated and assuming new roles.

Tradition do not have to be the opposite to innovation, both categories are strongly related, any tradition change is produced on a continuity framework, while any permanence include variations according to the context, tradition is dynamic, changing and adaptive. Tradition is strongly related with the identity of social groups.

IV.3.2 Mezcal production background in Santiago Matatlán, Oaxaca

Currently, Oaxaca has more than 97 % of national production and 95.2 % of the exported mezcal comes from this area; it has 84 % of the packaging for the export market and 81.3 % for domestic market (the packaging can be done outside the origin area). Based on this information, it can be concluded that Oaxaca holds the most important place of the mezcal industry (CRM, 2016b).

In Oaxaca, mezcal production began in the area known as "mezcal region" which is composed of seven districts, prominent among which Tlacolula, a region where climate conditions are favorable for agave cropping. The municipality of Santiago Matatlán in this district is known as "the world capital of mezcal" because it produces 70% of national production of this drink (Bautista, Ramírez Juárez, & Smit, 2015)

In 1940, when he formally mezcal production began in Santiago Matatlán were mainly used wild maguey, over time, growing production lead to a shortage on wild species, so that plantations started (Bautista & Smit, 2012).

In Oaxaca, the maguey with better characteristics for the production of mezcal is *A. angustifolia* Haw. also known as *espadín*, which is from the 40s decade , the most commonly used for the production of mezcal in Santiago Matatlán (Bautista et al., 2015)

Maguey *espadin (A. angustifolia*) is used to produce 85 % of certified mezcal (CRM, 2016). This is because this specie is the only one obtained by intensive cropping; it have a high sugar concentration, short maturation time (5-8 years) and it have a relatively easy *hijuelos* propagation system (Bautista *et al.,* 2015; Conabio, 2006)

Between 1960 and 1970, there was a heyday of mezcal in the municipality, it is estimated that there were 250 *palenques* (mezcal factories), which generates large amount of direct and indirect jobs, activity in other local and regional economic sectors, as well as a steady stream of income (Bautista *et al.,* 2015).

The development that took place in Matatlán and around in this time, was achieved thanks to the "use of human, material and economic resources that existed at local and regional level" (Bautista et al., 2015). However, in the 1980s, half of the *palenques* in Santiago Matatlán had to close, due to the introduction of Tequila producers in Oaxaca, who took maguey used to mezcal production due to a shortage of blue agave caused by phytosanitary problems and the increase in Tequila demand (Bautista *et al.,* 2015).

This phenomenon caused lack of employment not only for mezcal producers but also in all the economic activities related to it, carpenters, artisans, drivers and other input suppliers suffer the impact, the consequence was an important increase of migration to the United States as an alternative of income source(Bautista *et al.,* 2015).

Mezcal producers who remained in the municipality, faced a shortage in their essential raw material, the maguey, the costs of the artisanal mezcal was 200 5 higher in comparison to the industrialized one, so the profitability of artisanal mezcal production decrease, situation that lead to mezcal adulteration with alcohol obtained from other sugars. The appreciation of the spirit in the market was negatively impacted.

In the 1990´s, several actions were implemented to promote mezcal quality and change it reputation as the creation of the NOM, the establishment of the Mezcal Regulation Council and the implementation of development programs for maguey and mezcal producers by the government (Bautista *et al.,* 2015).

Mezcal production started to recover not only in the municipality but also in mezcal region, until 2000, when tequila producers entered again, which lead to an important increase in maguey prices, leaving again in disadvantage to mezcal producers who use traditional technology. From that time to the present, it is estimated that less than 10 % of *palenques* are operating, compared with the heyday times (Bautista et al., 2015), even it is said that mezcal is recovering again it position and value in the market (Bowen, 2015).

IV.4 Denomination of origin

The nomination or designation of food products according to the place of its production, is an ancient practice that takes place during the distribution and sale of such products, this nomination gives them a special value to be recognized the connection between the natural environment and man, as the origin of characteristics and product quality (Carrillo, 2007).

Thus it began in France (Bowen, 2015) the "designation of origin", defined as "... one that uses the name of a region or geographic location of a country to designate a product whose quality or characteristics are exclusively from the geographical environment resulting from natural and human factors" (Carrillo, 2007).

Mexico signed the Lisbon agreement, international treaty on designations of origin, in 1964 and was in 1973 that the country protocol for defining designation of origin (DO), which considered environmental factors, human as well as cultural. Unlike other countries, in Mexico the designation of origin only defines a geographic area where it can be produced a given product, quality standards are regulated separately through official standards (Bowen, 2015).

Another difference is that in Mexico the owner of the DO is the government, not the producers. Mexican government owns designations of origin and authorizes to the producers it uses, if they comply with the regulations; thus it is supposed that the country seeks to protect its heritage while producers gain market recognition. In addition, the designation of origin seeks to maintain the essence and quality of products, by protecting manufacturing techniques and / or culture that may have an ancestral origin (Carrillo, 2007).

The first denomination of origin (DO) in Mexico was granted to tequila in 1978, to date 14 products made in the country have designation of origin, including mezcal which is currently regulated by NOM-070-SCFI 1994 (Carrillo, 2007). The designation of origin for mezcal, was defined in 1994, with the aim of restoring prestige to this drink, promote traditional processes and protect producers (Bowen, 2015). Although there exist maguey from southern United States to Colombia and Venezuela (Aguirre *et al.,* 2001) according to this DO only Mexico can produce spirits with the name of mezcal (Huerta Rosas & Luna Zamora, 2015).

A peculiarity of the designation of origin for mezcal, is it reference to a drink and not to a specific geographical area, although it is said that the intention is to be recognized as a drink from Mexico. However, while it is estimated that the mezcal can be produced in 24 states (Bowen, 2015), not all were recognized, not all species that can produce mezcal; therefore, producers have produced mezcal generations cannot use the name, calling their drinks as "distilled agave" (Larson & Aguirre, 2015).

The production of mezcal is a cultural and economic activity extended around all the country, distillation of agave receive different names: Oaxaca, Guerrero, Durango, Zacatecas, San Luis Potosí, Guanajuato (mezcal and tequila), Jalisco (tequila, raicilla and mezcal), Michoacán (mezcal and tequila), Estado de México, Morelos, Chihuahua, Sonora (bacanora), Tamaulipas (mezcal y tequila), Nuevo León, Sinaloa, Nayarit (mezcal and tequila), Baja California, Colima (tuxca), Chiapas (comiteco), Coahuila and Querétaro. Mezcal production can be found in 28 states and even in other countries (Illsley Granich *et al.,* 2005).

On emission of the declaration of the mezcal designation of origin in 1994, only a few number of states were considered: Guerrero, Oaxaca, Durango, San Luis Potosi and Zacatecas. Since then, several states have been included in this declaration, in 2001 and 2015 two municipalities in the state of Guanajuato, in 2003 were included 10 from the state of Tamaulipas, later in 2012 added 29

municipalities from the state of Michoacán and finally in 2015 were considered 115 municipalities from the state of Puebla (IMPI, 2015).

IV.5 Mezcal normative

With the emergence of the denomination of origin mezcal was necessary to establish a regulatory standard, as indicated in the point four of the declaration (SCFI, 1997). At present, the most important tool that regulate mezcal production, is the "Official Mexican Standard NOM-070-SCFI-1994, Alcoholic Beverages-Mezcal-Specifications" whose latest version was posted on June 12, 1997 (Aguirre Rivera *et al.,* 2001).

The standard establishes the characteristics and specifications to be met by persons authorized to produce and / or commercialize mezcal. This is applicable for alcoholic beverages produced in areas which establishes the DOM and which are obtained from the following species of agave:

Agave angustifolia Haw.

Agave aspérrima Jacobi

Agave weberi Cels ex Poisson

Agave potatorum Zucc.

Agave salmiana Otto ex Salm-Dyck ssp crassispina (Trel) Gentry

The standard includes other species of agave, as long as they are not used as raw material for other drinks with designations of origin within the same State.

It is worth to mention that some agave species in the NOM are not properly written or they are not use commonly for mezcal production (Aguirre Rivera et al., 2001; Carrillo, 2007).

The NOM also specifies the mezcal types based on its content of distilled agave, categories of mezcal, the percentages of minimum and maximum alcohol that may contain, labeling and sampling and the tests techniques to determine the mezcal composition.

The NOM basically describes the limitations of commercialization for an agroindustry of high volumes based on the market demand and do not consider the communities originals ways of production, giving an advantage to the outsiders who start to produce mezcal in high volumes (Bowen & Valenzuela Zapata, 2009; Carrillo, 2007). This situation put in danger the traditions and diversity of the mezcal industry, taking away the strongest characteristics of the distillate.

It should be noted that currently the NOM-070-SCFI-1994 is in a process of actualization, it is expected that the most up-to-date standard will be published in 2016

IV.6 Mezcal Regulatory Council

With the creation and establishment of the Mezcal Designation of Origin and the NOM-070-SCFI-1994, the creation of a regulatory body, to monitor the NOM compliance and perform mezcal certification process, was required (Bowen, 2015; Carrillo, 2007). In 1997 the Mezcal Regulatory Council (CRM), a non-governmental and non-profit organization was created. In 2003, the CRM was certified as an entity capable of providing certifications to mezcal producers that met the standard (Bowen, 2015).

The CRM is responsible to conserve mezcal authenticity and quality of mezcal into the market. To meet this objective CRM certifies different parts of the mezcal production process: takes records of agave plantations to ensure the DOM, certifies produced mezcal to ensure that the mezcal has not been adulterated and has chemicals contents that guarantee safety. Finally certifies the packaging process with the same objective. As indicated by the standard, since 2005, when the first certification took place, mezcal without the verification of the CRM should not be commercialized (CRM, 2015).

Certification is strongly related with economic and social issues, costs of mezcal certification have a high price to the small producers, this lead the clandestinely, illegality, corruption and the abuse of intermediaries by the creation of mezcal manufacture without the possibility of added value of production and commercialization for the local producers (Carrillo, 2007).

Even the economic obstacles and complex social relations, between 2007 and 2014 there has been a significant increase in the number of certified mezcal (Bowen, 2015), however, the certification task is not easy, as the area OD is very large and continues growing (Larson & Aguirre, 2015), so for a large number of producers it is very difficult or slow to acquire certification, due to the lack of resources and capacity of the CRM.

IV.7 Mezcal commercialization

It is estimated that mezcal exist, as beverage, since the 1500s, when the Spaniards introduce distillation process. Mezcal was first refer in occidental literacy in 1621 by Domingo Lazaro Arregui who describes an alcoholic beverage with the characteristics of the mezcal (Luna Zamora, 1991;

McEvoy, 2014; Sánchez López, 2005). Since then, artisanal mezcal have being produced in the same way only with small changes.

Nowadays, mezcal market is part of the alcoholic beverage at national and international scale. In Mexico, the alcoholic beverages market is led by beer category with 94 % of the market; just follow by the spiritual drinks category, mezcal is part of it, with 4 % of the market. The most important market in a national scale is concentrated in Mexico Valley region with 47.15 % of the total consumption (CRM, 2016).

Talking about international markets, CRM register a growth in mezcal exportations during the last years; currently mezcal is exported to 48 countries (CRM, 2016).This statistics are more precise for the case of international market, in the national level there are mezcal which is commercialized without certification, so is impossible to the CRM to have an exact data in this scale.

Mezcal is a product with demonstrated potential and growth. The recent expansion in production and distribution in Mexico and different countries around the world, make this product a motor of economic development, especially in rural areas of Mexico with high and very high marginality index, like Santiago Matatlán municipality (SEDESOL, 2014). It is estimated that this activity generates about 30,000 jobs, that is why this industry have a high value in Mexico (SAGARPA, 2011).

The use of agaves and the process of distillation is presenting changes from artisanal to industrial processes due to the increase of the demand and the business opportunity that represent to some investors. The distillation obtain in an industrial way have less quality and diversity compare to artisanal ones (A. Valenzuela Zapata, Regalado Pinedo, & Mizoguchi, 2008). One of the main differentiators of mezcal is the origins of the raw material, the quality and singularity of the productions methods and the used tools material, which gives to mezcal high organoleptic richness, making possible to this spirit to be part of premium markets so achieve better prices in the international market (Sánchez López, 2005).

V. CHARACTERIZATION OF THE CASE STUDY

Sustainability varies according to crops and specific geographical characteristics (Altieri & Nicholls, 2000; Medellín-Milán et al., 2011); a proper sustainability assessment, requires as a first step, the characterization of the system of study (Galván-Miyoshi et al., 2008). It is this chapter intention, to present a holistic analysis of the mezcal production characteristics and conditions in Santiago Matatlán. To achieve this, the first part of the characterization is based on the agroecosystem framework, afterwards it is presented the most relevant relations and condition according to four sustainability dimensions: social-cultural, institutional-political, economic and environmental.

The present research is focus on the agroecosystem where artisanal mezcal is produced. The use of agroecosystem framework has the objective of present a scientific approximation on the organization, function, in puts, out puts, flows, stakeholders and associated relations with mezcal production (Altieri & Nicholls, 2000).

Mezcal production could be considered as subsystem since it is embedded in bigger systems (Sánchez López, 2005), as shown in figure 7. The artisanal mezcal production of Santiago Matatlán, is part of the production in the central valley region, which at the same time is part of the total mezcal production in Oaxaca. Oaxaca mezcal production is part of the DOM as well as Mexico's agave production and it derivatives.

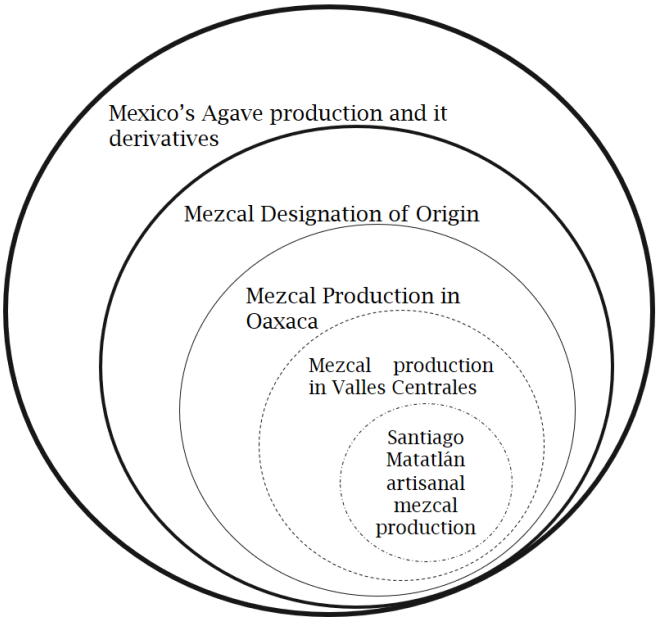

Figure 7. Santiago Matatlán subsystem.

The systems considered inside Santiago Matatlán artisanal mezcal production are maguey production and mezcal production. In this research, artisanal mezcal production has been divided on 16 steps, this division considered that Sanchez López (2005) stablished that the subsystem "agave-mezcal" goes from the maguey cultivation to the mezcal distribution for it consumption, and the results obtained from the field work.

The first four steps are related with the maguey production or gathering, the steps five to thirteen are related with the activities that take place in the "mezcal factory" also called "Palenque". The sell can be directly to the consumer by the mezcal producer or to retailers who bottle the mezcal. The proposed steps are showed in the following figure:

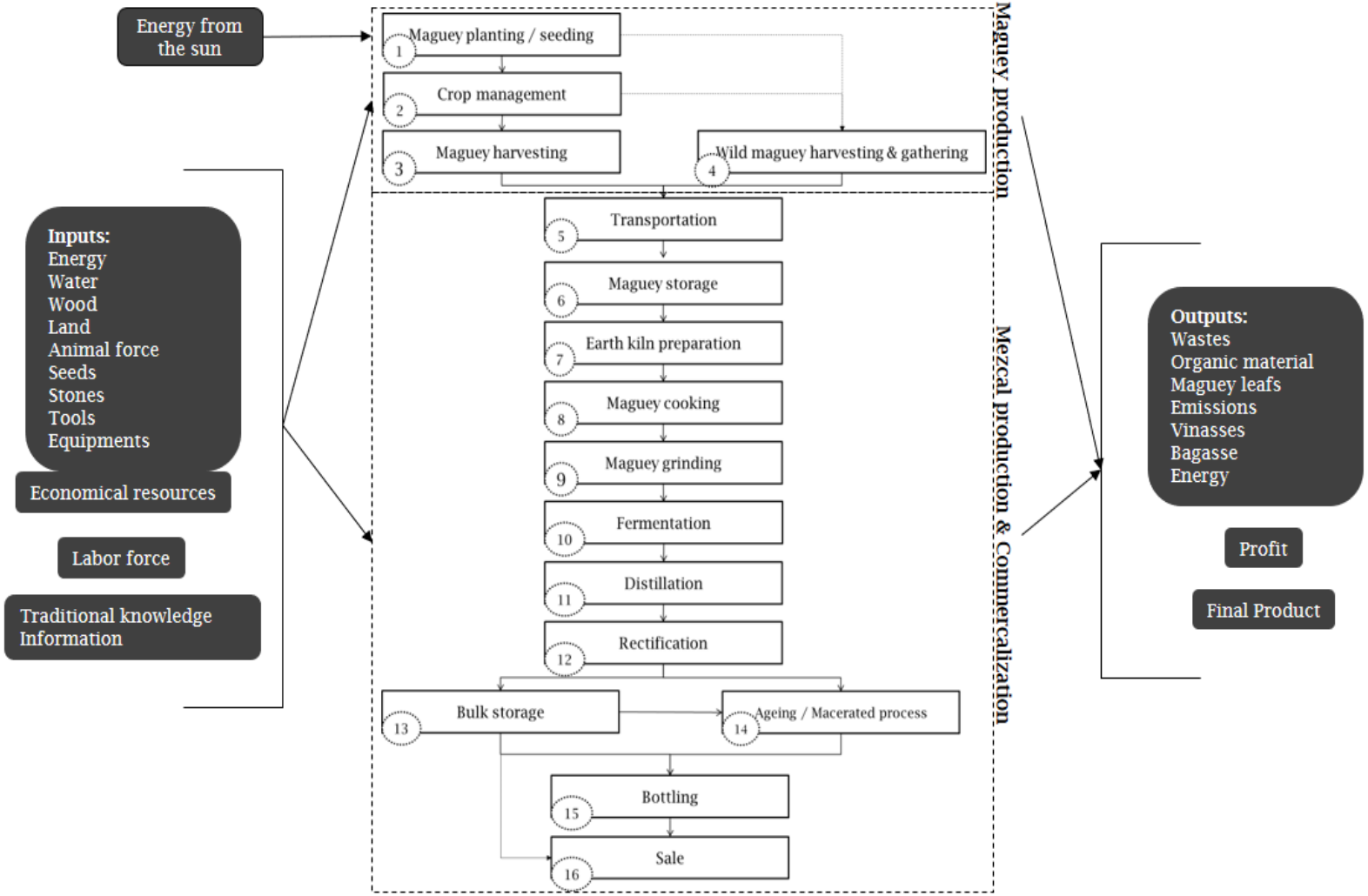

Figure 8. Artisanal mezcal production steps. Design by the author based on Sanchez López (2005) and the field work.

Artisanal mezcal production needs natural and handmade materials, energy, labor force and economical resources. Production knowhow is defined by the traditional knowledge as well as by the available information on technologies and production practices. The process produces not only mezcal at the end, also there is released energy, wastes, residual organic material as well as profits.

The detail of the material / energy uses, flow and transformations is presented, in the table 3, according to the fieldwork and literature information, key stakeholders are also presented for each defined step. The last column shows maguey transformation through the process, from the plant growth to the mezcal production.

Wood is commonly used as fuel during distillation, however some producers use, or want to use, gas due to the temperature better control they can have, the shortage of wood in the region and the space demand for the big volumes that storage requires.

Energy can also be used as electricity to light up the working areas, in many cases distillation is done during the evenings or nights; there are some producers who use solar energy for this purpose or for the water pumping; it is worth to mention, that the selection of solar energy does not have as a base an environmental reason, it is more related with accessibility and cheaper costs.

Table 4. Material and energy uses, fluxes and transformations through the artisanal mezcal process. Design by the author based on Sanchez López (2005) and the field work.

Production Steps		Inputs	Energy use & transformation	Outputs	Stakeholders	Maguey transformation
1	Maguey plating /seeding	Seeds Hijuelos Land Water Tools Tractor/Yoke	-	Organic material	Nursery man Farmer	Plant growth
2	Crop management	Tools	-	Organic material	Farmer	
3	Maguey harvesting	Tools Animal force	-	Maguey Leafs		Maguey's hearts gathering
4	Wild maguey harvesting & gathering	Tools Animal force	-	Maguey Leafs Organic material	Farmer / Gatherer	
5	Trasportation	Motor Vehicle	Gasoline is transform on motive power	Emissions		Maguey's hearts pieces
6	Maguey storage	Maguey hearts	-	-	Mezcal producer	
7	Earth klin preparation	Stones Wood Tools	Wood used as fuel is transformed on heat	Emissions		
8	Maguey cooking	Maguey hearts in pieces	-	-		
9	Maguey grinding	Animal force Tahona Mill	-	Organic material		Bagasse
10	Fermentation	Water	-	-		

Table 4. Material and energy uses, fluxes and transformations through the artisanal mezcal process. Design by the author based on Sanchez López (2005) and the field work.

Production Steps		Inputs	Energy use & transformation	Outputs	Stakeholders	Maguey transformation
		Wood vats				Mosto
		Plastic vats				
		Tools				
		Cupper still	Wood/ Gas used as fuel is transformed in heat	Emissions		Mezcal
		Clay still		Bagasse		
11 & 12	Distillation & Rectification	Water				
		Wood		Vinasses		
		Water pump	Electricity is transform on motive power			
		Gas				
13	Bulk storage	Plastic / Steel containers	-	Used containers		
14	Ageing / Macerated process	Wood Barrels	-	Used barrels		
		Glass conteiners		Glass		
15	Bottling	Water	Semiauthomatic equipment use electricity	Wastes (plastic, paper, cardboard)	Mezcal producer	
		Bottles				
		Labels			Retailer	
		Plugs				
		Tools				
		Equipment				
16	Sell	Mezcal (bulk / bottles)	-	Profit	Mezcal producer	
					Mezcal consumers	
					Retailer	

Sometimes mezcal producer also produces maguey, so play the role of nurseryman and farmer too, in this cases there is more control on raw material quality and the prices variability have a lower impact to them, allowing more stable production and economic conditions.

There are more stakeholders involved in mezcal than the ones that appear in the table 3; as other industries that use agave as a raw material, especially the case of tequila industry; suppliers of services (accountant), tools, equipment, wood and materials (bottles, labels or plugs), are also involved in the process, and are part of other systems, for example the CRM (which is part of the system that encompass mezcal DO) or governmental institutions, whom have also an important influence in mezcal dynamics.

Involved stakeholders belong to urban and rural contexts, a strong relation between both exist, is difficult to conceive them as separate environments; globalization, market as well as modernization tendencies introduced in rural areas, impact on traditional agricultural techniques and mezcal processes as well as in agave and mezcal cultural and economic value (Bautista & Terán M., 2008).

Mezcal production is more than a technical issue, as an activity that takes place in an agroecosystem, where nature and socioeconomic elements have integrated-dynamic relations, there are social, institutional-political, economic and environmental issues that influence all the production steps, on temporal and spatial scales, and should be analyzed (Altieri & Nicholls, 2000).

Obtained information during fieldwork and interviews is used to present a detailed analysis on the dynamics that take place on selected sustainability dimensions for this study.

SOCIAL-CULTURAL

Interviews revealed that Santiago Matatlán mezcal importance is related to the historical background, high volume production, product quality and location near Oaxaca city. Bautista *et. al.* (2015) and the municipality development plan (2014) agree, that these reasons made mezcal production one of the main economic activities in the municipality and region.

Interviewed consider mezcal production as a cultural heritage as well as a family tradition, transmitted knowledge from generation to generation lead to the artisanal mezcal knowhow production nowadays. As Bowen (2015) and Serra Puche & Lazcano (2006) as well as the interviewed, consider that mezcal is artisanal due to traditional techniques use and the type of used materials. Some producers and key stakeholders comment that volume of production should be a variable to distinguish artisanal production from industrial one, but this is not considered in the

regulations. It was mentioned that the reasons to continue the artisanal mezcal production are also related with mezcal quality and it organoleptic richness.

A recurrent topic during the interviews were growth of mezcal industrialization impacts over the traditional knowledge, traditional crops production, as well as the identity that characterize mezcal, taking away mezcal real values. Producers said that artisanal mezcal is still produced due to it quality appreciation (smoky and gritty flavor, spiciness, alcohol concentration) and Bowen (2015), Valenzuela Zapata (2008) and Sánchez López (2005) mentioned the growing market preference on handmade, organic, artisanal products, as an other relevant reason.

Literature, CRM (2015) and Sarah Bowen (2015) and interviews agree on actual growth in mezcal consumption and appreciation. Though, some social sectors have a lack of appreciation of artisanal mezcal real value, the amount that some consumers and retailers are willing to pay does not cover all the costs and does not reflect the value of the traditional techniques. According to the interviews, producers, retailers as well as other interested people, develop mezcal education activities in order to create a better consumer's perception.

Producers recognized that benefits related with mezcal production growth are not only economic, there are families have better education opportunities besides services availability, infrastructure has improved and touristic activities grow in the region. Nevertheless, it was observed that benefits do not have an equal impact in the community, not every mezcal producer family improve it condition.

Bautista *et.al.* (2015) social networks are reinforced by mezcal producers, since they contribute to conserve traditions, support community activities and festivities, as it was said in the interviews; this should be conserved as the mezcal industry social responsibility with the community. This situation is not favored by the introduction of external actors in the industry who threaten community cooperation.

As a result, from the interviews, it is possible to say that there are social problematics related with mezcal, as the case of disadvantageous situation of small producers, which can be decreased by the reduction of intermediaries, this could be achieved by producers' organization, however there is a historical distrust due the organization leaders' corruption incidence.

Lack on balance between production quantity and quality as well as mezcal social, environmental, economic and political problematics, are enhanced by limited formal information and lack in

scientific research of these topics. Moreover, the few done researches are not available or the language is not easy to understand by people who can take advantage of it.

INSTITUTIONAL - POLITICAL

Some interviewed stakeholders perceived mezcal regulations as necessary to guarantee the quality of the product, however there is also a negative perception by others, because it limits the small producers' possibility to develop and grow. Even they understand that certification give the opportunity to sell mezcal nationally and internationally, it is difficult to some producers to legalize their production since their lack of resources, preparation, legal and financial knowledge.

The CRM, centralized institute that still growing and adapting to the mezcal industry growth, recognized during the interviews it lack of capacity to certified new producers and brands as well as to analyze all the production. This constitute another obstacle, even when the producer or retailer want to have the certification, they do not have access to it, this is a problem, as Bowen (2015) said, around 80 - 90 % are uncertified.

It is worth to mention that some of the interviewed producers that already have the regulatory certifications, still looking for other volunteer certifications as the organic, ecological or kosher ones. Interviewed, who do not have a brand, expressed their interest in brand registration and mezcal certification, even the perceived obstacles. Some small producers certified part of their production to bulk sale, others produce to specific retailers and some associate with them, in this cases commercialization benefits are not for the producers but for intermediaries, bottlers, retailers or exporters.

During the interviews it was mentioned tax registration and payment difficulty, due to the no tax payment culture, education and infrastructure, which represent another obstacle to mezcal producers' legalization. Another recurrent tax problem is imposed taxation in the same way to traditional and industrial producers, this is perceived as a disadvantageous situation because of small traditional producer's production higher costs compared with the high volume production ones. In response to this, interviews refer the need to adjust the taxing regulations as it has been done with other artisanal products in Mexico.

Certified mezcal taxation is incredibly high. As a high-proof alcoholic beverage in Mexico, mezcal have a special tax on Production and Services of 53 % and a 16 % of value added. The taxes paid for exported mezcal can vary by destination country. As mentioned by Bowen (2015) and the CRM

interview, there is a propose on lowering the tax rate for artisanal mezcal producers form 53 % to 10.07 %. This would help the small producers to get certified.

It was recurrently mentioned, during the interviews, that another regulatory need is related with the creation of norms to prevent the shortage and extinction of wild agaves due to its intensive use, shortage of water and local disposal of wastes regulations.

As Bowen (2015) and Bautista *et. al.* (2007) indicate, the political influence in mezcal system, is not only through regulations, government spread and support the use of modern technologies and specific agave species crops for the promotion of agro industrial growth. The threat in this cases, is the traditional production systems marginalization and the loss of agave and mezcal organoleptic characteristics diversity.

Many times, government applied strategies are perceived by the interviewed as unplanned, unequal and ineffective, the equipment is not appropriate to local mezcal production, the benefits are only for some and there is the perception of conditioned support during election periods. According to Bautista & Terán (2008), the uses and costumes system (Santiago Matalan's type of government) have been affected by political actors who use mezcal topics to their own interest and generate conflicts between the community inhabitants. This could be related with to the distrust on organizations, expressed by interviewed producers.

The DO is a continuously criticized topic by the academy, Aguirre *et. al.* (2001), Torrentera (2001), Bowen (2015), Larson & Aguirre (2015), and the interviewed mezcal stakeholders; because only certain regions that produce distilled agave are favored by the DO, these rules do not reflect the Mexicans mezcal tradition, as the benefits of the designation of origin exclude many regions and most of the states which produce excellent quality maguey distillates.

During the interviews, it was also mentioned the need of re-frame mezcal regulations according to regions and traditional techniques, as in the case of the DO´s around the world, in order to recognize the diversity of techniques and agaves, promoting the conservation of the cultural heritage.

Another discussion topic in literature, Bowen & Dany (2014), and during the interviews, is related with the DO property in Mexico which put the real mezcal owners and experts aside, giving the power to the state to transform and regulate the production processes and product characteristics in order to meet economic and political goals. As said before, this situation should be analyzed and

take the example of other DO where decision makers are the traditional producers, wine and cheese examples could be taken.

Finally, but not less important, is the corruption perception in the CRM, public and private institutions that are perceived and sometimes proved in the mezcal industrial sector, as mentioned by interviewed and stated in the interviews made by Bowen (2015), examples of this are the capture of founds from the Secretary of Agriculture that are transferred fraudulently and unequally between the industrial mezcal elite and the small mezcal producers, making their situation even more unequal.

ECONOMIC

Interviewed producers said that they performed complementary activities to mezcal production, as other crops cultivation, other jobs or commercial activities performance, Bautista & Smith (2012) and Sanchez Lopez (2005), studied this phenomena and mention that this situation give small producers a larger range of economic stability and livelihood options.

The artisanal mezcal producers recognized socio-economic relationships that generates direct and indirect employment in the municipality and region. Them and their families get employment benefits, as well as suppliers and employees. This local and regional employment is related with production of distillation and fermentation equipment's, and purchase of stones, wood and even the raw materials.

During the interviews it was said that labor can be hire formally to work full time or to work in specifics tasks. The availability of jobs has reduced the migration while migrants have the opportunity to return to their homeland, helping to reduce the traditional knowledge loss.

Even the producers consideration of costs from agave, wood, bottles, labels or certification, there are many items that are not considered, as their own or their family labor, services cost (electricity), water cost, tools and equipment depreciation or merchandising cost; due to a lack of business knowledge and financial preparation, usually small producers have never done a proper costs calculation, the result is that the mezcal price does not cover the real costs of the production therefore there are not real profits for the producers.

Some producers have the perception of get a profit out of mezcal sells, but the determined mezcal sell price barely covers the direct costs, while the indirect costs are paid by the supposed profit, this lead to difficulties to improve their facilities, their production capacity and to reach other markets.

The improper costs calculations and considerations, are also link to the use and commercial value that the producers give to their products. As Bonfin Batalla (1995) explains in his research, the capitalist way of production is not fully integrated and implemented to their business or culture, they give a selling price based on raw material costs but not to their work and expertise. This left them in a disadvantaged situation during the negotiation of their product price.

This situation gets worse when there is no association with the retailers, this originated bigger disadvantages for the producers who receive less benefits, sometimes the paid price is less than the (not properly) determined by the producer, while the retailers get the bigger profits. According to Bautista *et al.* (2015), there are cases where the retailer obtains more than 100 % of the paid price, this situation takes place due to the lack of financial and commercialization preparation.

On the other hand, during the field work it was also observed some business models where the retailer makes agreements with mezcal producers, oral or written, in order to stablish more equal relations, where the producer can cover it material production costs and obtain some profit, in some cases also a part of the profit obtained from the retailer sale, impact on the producer.

A common idea about the future between producers and key actors is the continued growth of mezcal industry with adaptations and artisanal technification, if protected and value properly. As mentioned by Bowen (2015) and Bautista & Terán (2008), the market tendencies on the artisanal products will permit the tradition valorization that distinguish mezcal as a premium product. This is an important market opportunity, that the industry has to valorized and develop to get all the benefits out of it, with equity and improvement for all the value chain stakeholders.

ENVIRONMENTAL

Producers said during the interviews, that mezcal can be obtained from cultivated or gathered maguey. As other producers in Oaxaca, Matatlán producers who were interviewed said that the most used is *A. angustifolia* Haw, it could be cultivated in the producer's land, borrow or rented one, in this cases the agreements can be written or oral as used to be traditionally. There have been cases where agreements are not respected, due to the demand of agave from Tequila industries, especially when oral agreements are done.

As mentioned before and reinforced in the interviews, agave could be cultivated or gathered from wild environment. *A. angustifolia* Haw is the most used maguey for mezcal production and it could be cultivated in the producer’s land, borrow or rented one, in this cases the agreements can be

written or oral as used to be traditionally. Eguiarte & Gonzáles (2007) explains that agave *espadín* (*A. angustifolia* Haw) dominates because it fits into the industrial model that values efficiency and profitability, but the implications of monoculture intensive cultivation of genetically uniform, can bring phytosanitary problems, biodiversity and genetic variety lost.

As seen during the fieldwork, some of traditional agave growers made a semi-intensive cropping which has 1,500 agaves per Ha approximately, mix with other crops. Producers explains that they practice agave reproduction methods by *hijuelos*, *quiote* treatment or seeds. None of the interviewed recognized the use of chemical fertilizers or herbicides, it was mentioned the use of agave fibers (bagasse), agave leafs and other organic wastes to improve the soil characteristics, however Bautista & Smit (2012) mention that there are some small producers in the municipality who use chemicals to weed control. It was said that the plagues and diseases are not common in the region nevertheless sometimes the presence of picudo (S*cyphophorus acupunctatus*) is known.

Interviewed producers said wild agave is not commonly gather from the municipality, as an official authorization is needed, that is why wild agaves are taken from outside. Species gather, by mezcal producers themselves or wild agave gatherers, are: *A. potatorum* (Tobalá), *A. rhodacantha* (Quixe), *A. karwiinski* (Madrecuixe), *A. marmorata* (Tepeztate) and *A. americana* var. oaxacensis (Arroqueño). The intensive use of them impact reproduction cycles and led to a shortage.

As seen in distilleries visits, some producers are carrying out conservation activities as in vitro reproduction, seeds gather, nursery, growing and transplantation on their own or in wild lands; because of the wild agave shortage.

Producers state that when the plants are bought, the price can be negotiated or not, depending on agave market demand. The bought maguey can be selected or not by mezcal producer, this impact on final product quality, almost every producer selects *capón* / *sazón* agave which have the best quality, but it was recognized that sometimes, they have to use “mature” agave which actually does not have the proper maturity (sugar concentration) or green agave.

The local producers appreciate artisanal mezcal production as a not significant environmental impact activity, due to the organic and traditional nature of the production. However according to the literature, Bautista & Smit (2012) and the interviews information, there are recognized problems as deforestation by wood use as well as for agave planting, water misuse and pollution, wild agave

shortage and the most harmful impact perceived, the vinasses generation which are disposed without treatment in soil or rivers.

As mentioned by Bautista, et al. (2015), Sanchez López (2005) and the interviewed, agave shortage is enhanced by other industries competition for this resource, for example the food or pharmacy industry and most importantly the mezcal agave extraction by the tequila industry, phenomena that impact not only the plant availability, but also the prices, economic activity, employment, culture conservation, etc.

There are issues that could be classify in more than one dimension and that are influenced by "higher" or different subsystems; for example, the common disadvantageous situation between small producers and retailers impact on the economic dimension as a result of a social dynamics that take place in Santiago Matatlán subsystem, but are strongly influenced by phenomena that occurs in Mezcal DO subsystem and in Mexico's agave production system.

Another example is the situation of the maguey shortage, which is not only an environmental topic, the situation produces an effect on the economic dimension, in addition part of it cause is related with the competence and relation with Tequila industry (Mexico's Agave production system), which is a social and political issue.

One more example is the local situation of the certification, which is strongly related with decisions that are taken beyond the subsystem of study and have a local impact on economical topics as well as on traditional ways of production. Is important to mention that the presented description and it classification, is a proposal that can be improved or modified through other researcher's criteria and focus.

VI. STUDY CASE SUSTAINABILITY ASSESSMENT FRAMEWORK

VI.1 Sustainability conceptualization and objectives

Sustainability conceptualization and objectives guide the definition of attributes for the case study (Galván-Miyoshi et al., 2008; Sarandón, 2002). General agreements on sustainability, from the framework of agroecology, are taken as reference that guide the identification of problematics as well as aspects to conserve:

> Sustainability must focus on: preservation, maintenance and management of the ecologic base to allow agricultural production through the time, increase social and ecological capacity to cope with change (adaptation capacity) and to preserve and expand available options to confront natural and social transformations (Altieri & Nicholls, 2000; Bautista & Smit, 2012; Gallopin, 2006).

Sustainability definition discussion, is not the purpose of the present research. The premise set above, is a useful reference for the study case, but it cannot be taken as a complete or unique concept.

Chosen sustainability definition, is complemented by agroecology objectives, in order to better understand the implications and direction of sustainability. This research, took as reference the sustainability long term objectives that Altieri and Nicholls (2000) proposed:

- "Maintain natural resources and agricultural production;
- Minimize impacts on the environment;
- Adapt economic gains (feasibility and efficiency);
- Meeting human needs and income;
- Respond to the social needs of families and rural communities (Public health, education, etc.)."

By the holistic understanding of the study case context, dynamics and stakeholder's relations, through sustainability concept, objectives and dimensions, is possible to define what should be conserved, the most important problematics and the probable limits that the mezcal system has, and take that as a base to define the sustainability attributes for the case study (Bond et al., 2012).

To maintain and problematic aspects on the case of Santiago Matatlán artisanal mezcal production, are classified by sustainability dimensions as presented in table 4.

Table 5. To maintain and problematic aspects on artisanal mezcal production in Santiago Matatlán.

	Dimensions attributes			
	Social -Cultural	Institutional - Political	Economic	Environmental
Aspects to maintain	Traditional production knowledge	Regulations to guarantee product quality	Mezcal demand	Complementary crops
	Traditional production materials use		Touristic activities	Traditional crop management
	Community traditions		Local employment	
	Factories infrastructure improvement and technologies adaptation	Added value through volunteer certifications	Regional employment	Uncommon use of chemical fertilizers and herbicides
	Reinforcement of social networks		Complementary jobs/commercial activities	
	Education access improvement	Interest on mezcal certification	Migration reduction	Use of organic material to improve soils
	Mezcal education activities			
	Mezcal quality	Permission need to gather wild agave	Market tendencies on artisanal valorization	Wild agave conservation activities
	Growth in mezcal consumption			
Aspects to change	Traditional knowledge displacement by industrialization	CRM lack on certification capacity	Price that consumers / retailers are willing to pay	Agave diversity loss
	Mezcal value and identity loss	Small producers lack on tax payment	Economic difficulties to production legalization	Local agave displacement by political strategies
	Appreciation lack on artisanal value	Unequal taxation rate	Unequal distribution of commercialization benefits	Occasional use of chemical to weed control
	Benefits unequal impact	Lack on wild agave use regulations	Unpaid family labor	Wild agave shortage
	Industry threat to community cooperation	Non planned, ineffective and unequal government strategies	Lack on small producer's costs calculation	Use of immature agave
	Distrust on organization	Unequal & conditioned governmental support	Uncovered production costs	Deforestation
	Corruption			

Table 5. To maintain and problematic aspects on artisanal mezcal production in Santiago Matatlán.

	Dimensions attributes			
	Social -Cultural	Institutional - Political	Economic	Environmental
	Lack on producer's education and training	Impacts on uses and costumes system	Economic difficulties to reach other markets	Water misused and pollution
	Limited available information			Improper vinasses disposal
	Traditional technologies displacement by political strategies	NOM impact on traditional ways of production	Lack on value recognition of producer own labor and expertise	Agave shortage by other industries
	Mezcal organoleptic characteristics loss			Non environmental impact perception

Most of the identified aspects are more related with producer's practices and decisions as the practice of certain techniques, use of certain materials, chemicals use, costs determinations, tax payment, wild agave conservation, community collaboration and organization, complementary crops production, vinasses disposal. Other aspects as market movements, mezcal recognized value, regulations existence, CRM capacity or the distribution of governmental support, are defined on a stronger way by external production agents (from other subsystems), in this cases producers can be influence by the taken decision from them but have a smaller role on the determination of that situations.

Some of the identified aspects are very specific from Santiago Matatlán artisanal mezcal, however market, commercial models, taxes and regulation conditions, problems with governmental support and deforestation, are aspects that have impact in the artisanal mezcal industry beyond the case study subsystem.

VI.2 Study case sustainability attributes

Operational sustainability meaning for the study case requires to specify it attributes (Astier, Masera, & Galván-Miyoshi, 2008). Once, to maintain and problematic aspects are clear, the desirable characteristics and conditions of the mezcal production, are settle by the development of

attributes by each of the sustainability dimensions, in order to generate a more complete (holistic) understanding of sustainability.

SOCIAL – CULTURAL

Conservation of historical knowledge on mezcal production allow the conservation of organoleptic richness through the use of artisanal techniques and materials in mezcal production. Technologic improvements can be applied to enhanced process efficiency while conserve artisanal ways of production.

Producers contribute to the conservation of the social capital[2], by maintaining their role in the community; their participation in local festivities and events is recognized, as well as in the decision making processes inside the community. Produced mezcal is sold not only in national and international markets, but also for local and regional consumption.

Maguey and mezcal producers are organized and work together to stabilize their condition, face agave market fluctuations, retailers and consumers lack on artisanal value appreciation and conserve mezcal essential values.

Producers has the opportunity to improve the infrastructure of their factories, as well as to receive governmental support; this benefits can be reach by all type of producers no matter the volume of it production.

Actual maguey and mezcal producers and new generations have the possibility to received education, training and preparation, which allow them to improve their business strategies, improve production efficiency and act environmental responsibly.

INSTITUTIONAL – POLITICAL

Regulations that guarantee product quality are inclusive, consider traditional ways of production, have a focus on mezcal organoleptic characteristics conservation and are stablish or updated through democratic processes.

[2] It exists an extended discussion on social capital definition, in this case, social capital is understood as social relations and structure, or in other words, the trust attitudes that occur in a framework of cooperation and reciprocity (Durston, 2002).

Wild agave use is regulated and monitored, in order to guarantee their conservation and availability in local, regional and national scale.

Interest on mezcal certification persist while certification is economic accessible and it is available for those who want it through an efficient process.

Producers meet their tax responsibilities. In addition, taxation rates consider differences between artisanal and industrial production, so that stimulate small producers, who have register, to pay taxes.

Governmental support programs are planned according to agave and mezcal producer's context and needs; it application respect local uses and customs system and is not condition by political preferences.

ECONOMIC

As market tendencies on artisanal products valorization grows, artisanal mezcal demand continues growing, so it production provides paid employment not only for municipality / regional inhabitants but for producer's family members, condition which allow the possibility of better life conditions for the families while migration is reduced.

Producers give an economic value for their work and expertise. Production costs are calculated properly, so mezcal sell price by producers consider cover all production costs and profit, which allow them to improve their factories, pay for certifications if they want and reach other markets.

Added value through volunteer certifications and traditional – cultural value of the spirit, are recognize by retailers and consumers, who buy mezcal at a price that worth it.

Received benefits by retailers are distributed within the value chain.

Maguey and mezcal producers stabilize their economic situation by income sources diversification as development of complementary crops, job and commercial activities performance; this allow also the possibility to face market variations, specially periods of agave shortage or when it demand increase.

ENVIRONMENTAL

Environmental impacts are recognized by maguey an mezcal producers, so they perform environmental good practices, as avoid chemicals use, soils improvement by organic materials use,

ecological management of plagues and weeds, waste reduction strategies, use of alternative energies, reuse of chilling water and proper vinasses disposal.

Maguey together with mezcal producers and political actors, develop strategies to reduce deforestation, avoid agave shortage by other industries, conserve wild agave diversity and promote the use of "*capón /sazón*" agaves in mezcal production in order to guarantee mezcal quality.

Conservation activities, as wild agave seeds collection and cropping as well as infant wild agave plantation, are done by farmers and mezcal producers.

Sustainability attributes allow the identification of important areas where action and decision should be taken, indicators were defined according to it. In this case, defined attributes implied not only the mezcal producers in Santiago Matatlán, also stakeholders from other systems or organization levels (scales) are involved, as the case of legislators and members of the CRM, retailers and consumers, due to the influence of their acts or decisions in the determination of maguey / mezcal production.

During the formulation of the attributes, the general context of the mezcal as well as the specific situations that take part in the study site, were considered. Some attributes may apply in the general context of artisanal mezcal production in Oaxaca, however this should be done carefully because in it conception, attributes were thought for Santiago Matatlán.

VI.3 Study case sustainability indicators

Once study case sustainability attributes, objectives and conceptualization are settle, is possible to define indicators (Astier, 2008). Indicators selection, consider the f availability of information, an easy to understand language, sensibility to change and preferably, it application to factory scale (Astier, 2008; Pintér *et.al.,* 2012), however in some cases, indicators are part of other scale in order to monitor attributes on an integrative way.

Described attributes or desirable characteristics, lead the determination of indicators, easy to understand representations of these attributes, it is also necessary to determine the relevant evidences in the reality, which allow the recognition of the indicator state and finally the scale or level where the information of the evidence can be taken.

A proposal of indicators for sustainability assessment in the case of artisanal mezcal production in Santiago Matatlán, is presented for each dimension in order to allow a complete understanding of the mezcal production conditions.

Table 6. Social-cultural dimension indicators

Attributes	**Indicators**	**Evidences**	**Scale of application**
Conservation of organoleptic richness through the use of artisanal techniques and materials in mezcal production.	Use of artisanal materials and techniques	- Earth kiln use - Stone / Tahona Mill use - Maul Mill use - Wood tub fermentation - Cupper still - Clay still - Glass or wood ageing containers	Mezcal factory
Technologic improvements enhanced efficiency while conserve artisanal ways	Grinding efficiency	- Size of the bagasse - Use of a motor to move the stone from the tahona	Mezcal factory
	Fermentation effiency	- Register of the process time duration - Infraestructure to weather protection - Use of cultivated yeasts	Mezcal factory
	Temperature control distillation	- Use of gas grill - Use of a termometer	Mezcal factory
Conservation of historical knowledge on mezcal production	Continuity of production of artisanal mezcal	- Palenque antiqueness - Palenque original owner - Family background: number of generations who has produced mezcal	Mezcal factory
Social capital of maguey / mezcal producers.	Involvement in social activities	- Intensity of participation on community social practices (frequency / level of involvement) - Intensity of participation on community decisions	Maguey producer & Mezcal factory
Organization between maguey and mezcal producers	Cooperation between maguey and mezcal producers	- Agreements existance between maguey and mezcal producer - Participation in existing organizations	Maguey producer & Mezcal factory

Table 6. Social-cultural dimension indicators			
Attributes	**Indicators**	**Evidences**	**Scale of application**
Factories development	Improvement of factories infraestructure conditions	- Cement floor - Ceiling - Walls or bard - Bathroom - Sewer system or septic tank - Electricity - Water availability	Mezcal factory
Producers training and preparation	Literacy	- Reading and writing habilities	Maguey producer & Mezcal factory
	Education level	- Last education degree obtained	Maguey producer & Mezcal factory
	Development of bussiness and technical habilities	- Records - Diplomas - Certificates	Maguey producer & Mezcal factory

It is important to recognize critical indicators, it means those indicators which change have more influence in the system behavior than the others, which condition have a stronger impact in the development of the maguey / mezcal production and are important aspects of consideration for decision making. Critical indicators are identified for each dimension.

In the case of social indicators, the use of artisanal techniques and materials, as well as the continuity of production of artisanal mezcal, are essential in this study case. If both of this indicators have a totally negative tendency, is probable that the ways of production and the relations around them change, so the full production of mezcal, it organoleptic characteristics and the socioeconomical relations too.

Table 7. Institutional-Political			
Attributes	**Indicators**	**Evidences**	**Scale of application**
Supportive Legal Framework	Existing Legal Framework	- Regulations include artisanal techniques	National regulations
	Democratic processes on actualization and	- (Level of) Participation in CRM meetings - Participation on meetings where discussions about	Maguey producer & Mezcal factory

Table 7. Institutional-Political			
Attributes	**Indicators**	**Evidences**	**Scale of application**
	formulation of the regulations	actualization of the NOM take place	
Protection of Wild Agave	Regulation of wild agave	- Permission on wild agave gathering	National and State regulation
	Control and Sanction Practice	- Monitoring implemented - Sanctions (fees, ...) raised	National and State regulation
Interest on certification persistence	Number of CRM associate members	- Associate members register	Maguey producer & Mezcal factory
Certification feasibility	Certification capacity of the producers	- Inscription membership payment - Annual membership payment - Mezcal production certification payment - % of certified mezcal production - Mezcal production fullfilment of NOM requirements	Mezcal factory
	Certification capacity of the CRM	- Number of verifiers - Visits frequency - Time that certification takes	Maguey producer & Mezcal factory
Favorable tax situation	Fulfillment of fiscal responsibilities	- Tax registration - Tax payment - Tax declaration	Maguey producer & Mezcal factory
Appropriate supportive governmental programs	Encompassing programs	- Consultancy when planing strategies - Participation in public consultancies - Maguey and mezcal producers censuses - Participation in censuses	Maguey producer & Mezcal factory
	Access to program benefits	- Programs reports - Number of beneficiaries - Producers knowledge on supportive programs - Infraestrucuture or production improvements as a result of being beneficiary of a program	National or Statal agencies Maguey producer & Mezcal factory

Table 7. Institutional-Political			
Attributes	**Indicators**	**Evidences**	**Scale of application**
	Impact of the program	- Continuos use of the introduced technology or infraestructure improvements	Maguey producer & Mezcal factory

In the case of institutional-political indicators, identified critical indicators are the existing legal framework, certification capacity of the producers'. If the existing legal framework do not support, regulate and care the artisanal ways of production or even worse if legislation is against it, artisanal ways of production could be threatened and totally change.

The opposite tendency would be that the existing legal framework support artisanal ways of production and seek to improve techniques conserving the essentials, for example the materials, and promote efficiency in techniques, which will have an impact in social and economic dimensions.

In the case of the certification capacity of the producers, if the indicator increase it could have many origins, for example changes on the legal framework, improvements in the factory infrastructure, adoption of control systems or practices along the process.

If producer's certification capacity decreased, there also can be different reasons, as a drop in their economic capacity due to changes in the market or to disadvantageous relations, another reason could be an inappropriate modification on the process. The certification capacity of the producers depends on many factors, is important not only to measure it but to understand the origin of the change as it can have different origins, and actions should be taken in different areas to improve the referred capacity.

Table 8. Economic dimension indicators			
Attributes	**Indicators**	**Evidences**	**Scale of application**
Paid employment for community & family members	% of employees who receive a salary (maguey and mezcal production)	- Total of palenque employees' (part time & full time) - Palenque employees' recognition of receiving a salary	Maguey producer & Mezcal factory
Migration reduction	% of employees who were migrants	- Total of palenque employees' (part time & full time)	Maguey producer & Mezcal factory

Table 8. Economic dimension indicators			
Attributes	**Indicators**	**Evidences**	**Scale of application**
		- Palenque employees' who were migrants	
Producer own work valorization	Producer own income	- Producer designation of an own salary	Maguey producer & Mezcal factory
Mezcal production as a profitable business	Cost-benefit ratio	- Formal calculation of production costs - Sale price	Maguey producer & Mezcal factory
Mezcal gain marketing added value	Market differenciators	- Organic product certification - Kosher certification - Brand registration - Bottling - Labeling	Maguey producer & Mezcal factory
Recognition of mezcal cultural value	Bottle labeling	- Labeling include information about the place of production and/or the used materials and techniques	Mezcal factory and retailers
Profit equitable distribution through the chain value	% of benefit that the producer obtains from the final sell price	- Agreements between producer and retailers	Maguey producer & Mezcal factory
Diversity of income sources	Development of complementary jobs and commercial activities	- People involved in maguey/mezcal production, perform also other activities as sell of convenience products, artisanal products, furniture, etc. - People is part of other business. - People involved in maguey/mezcal production, is also involved in construction activities, etc.	Maguey producer & Mezcal factory
	Development of complementary crops	- Development of other crops with crops as squash, beans and corn, among others	Maguey producer

Between economic dimension indicators, a critic indicator is the cost benefit ratio. If maguey and mezcal producers do not received a benefit from their work, they could be forced to prioritize the

development of other economic activities and cropping, in order to satisfy essential needs, as food and services costs, that is not possible to cover with maguey/mezcal sales. The impact of this situation could go beyond maguey / mezcal producers, affecting suppliers as well as retailers, and probably leading important changes on the economy of the municipality.

In the opposite scenario if the benefits present an important increase, maguey / mezcal producers probably could improve their ways of production, making them more efficient; another possibility is that the mezcal production increase which could lead to a high demand of maguey, generating pressure on the ecosystem.

On an intermediate scenario, the cost and benefits ratio, will present variations due to the maguey demand and price, as well as because mezcal market fluctuations. What could be expected is that the producers received always a benefit, which imply a proper and continuous calculation of the costs, and continue improvement on process efficiency.

Table 9. Environmental dimension indcators

Attributes	**Indicators**	**Evidences**	**Scale of application**
Environmental good practices performance in maguey production	Development of mixed crops	- Maguey cropping mixed with crops as squash, beans and corn, among others	Maguey producer
	Soil quality conservation practices	- Use of organic matter/wastes to improve soil - Vegetation cover - Crop rotation - Fallow periods	Maguey producer
	Ecologic plagues and weeds management	- Use of mechanical tools to weed control - Use of pheromone traps to plagues management - Use of chemicals to weed control - Use of chemicals to plagues management	Maguey producer
Environmental good practices performance in mezcal production	Use of alternative energies	- Solar panel installed	Mezcal factory
	Reuse of chilling water	- Water recirculation system	Mezcal factory

	Use of wood with permission	- Type of use wood - Places (or people) wherer wood is bought	Mezcal factory
	Vinasses management	- Storage, dehydratation and neutralization, vinasses pit - Vinasses filter - Vinasses treatment equipment - Vinasses management plan	Mezcal factory
	Reuse of Bagasse	- Use as fuel in mezcal production - Use as fuel in houses - Use to improve soils - Use to craft making	Maguey producer & Mezcal factory
Conservation of maguey diversity	Performance of conservation activities	- Seeds collection - Wild maguey nursery area - Wild maguey plantation - Reforestation activities with wild maguey	Maguey producer & Mezcal factory

Regarding environmental indicators, two critical indicators has been identified, soil quality conservation practices and performance of conservation activities. A positive tendency of both indicators referred the conservation of the ecological be that support maguey and mezcal production, conversely a negative tendency could lead to a critic situation on the ecosystem health and maguey availability, so the hole production of mezcal would be affected. In both cases, is important to recognize the situation origins.

As seen in the previous tables, the application of the indicators is planned to perform at the level of the maguey producer or in the mezcal factory, however the information to determine some indicators can be available in other levels, which could represent a difficulty when talking about information gathering.

There is an extended discussion about the use of universal or location specific indicators (Altieri, 2002), universal indicators allow it application in different environments and scales while allow the comparison of the sustainability condition between them. On the other hand, the strength of a local specific SAF is that allow to recognize the heterogeneity of the area and assess specific aspects that could lead to get closer to sustainability. Understanding of the scale is important to make a proper interpretation of the indicator condition, this understanding could permit make adjustments and apply the SAF in broader scales (Altieri, 2002).

VII. DISCUSSION

By analyzing different cases of sustainability assessment, it was found a lack of frameworks for the assessment of local situations that allow the development of specific strategies which lead to sustainability. At the same time, it was identified that mezcal production implies much more than the produced liters every year; social, economic and political phenomena are around it. That is why it seems to be an opportunity the creation of a SAF that allow a better and structured understanding of the current mezcal situation, and also give the possibility to identify critic aspects where strategies that lead to sustainability are needed.

It was understood that an accurate and proper sustainability assessment requires more than a set of indicators, it is necessary to understand the case study as a system where materials and energy are transformed and social, economic, politic and environmental relations take place. So it is needed to structure a support framework that make visible this.

It was also important to be place among the different proposals on sustainability and its implications, this gave a reference point about where to go, when talking about sustainability. There are sustainability assessment cases where the general definition of sustainability, the one set in the Brundtland report, was taken as a reference. For the case of this research that definition was considered very wide and open, that is why it was done the research of other sustainability conceptualizations.

During the research it was analyzed the theoretical framework of agroecology, which was used with two purposes: the description of the agroecosystem where artisanal mezcal production is made as well as the conceptualization of sustainability.

Artisanal mezcal production can be understood through agroecology framework due to its strong relation with agricultural activities, it development mainly in rural areas and social, economic and political relations that are involved. The focus of agroecology on: natural base conservation, improvement on production, minimize environmental impacts and meet of the human needs, lead to the proposed definition of sustainability for the present research.

Another criterion to choose the agroecology as a reference was it consideration of traditional ways of production and of the better use of locally available natural base. Through the research on artisanal mezcal production history, importance as well as social-environmental dimensions, it was found that mezcal production has been strongly related with maguey, a plant with high cultural and

agricultural relevance in the local scale; in addition, the knowhow of artisanal ways of production have been transmitted through generation to generation in the last 60 years at least, in some cases people consider it as a familiar tradition.

In this research the description of the agroecosystem was very general, in order to understand how the raw material is transformed, when and where other inputs are needed and which stakeholders are involved. It was not done a balance of materials and energy because it was not necessary to accomplish the objectives of the research, however it can be done in the future to generate a more detailed description of the agroecosystem behavior, so more specific strategies that lead to sustainability can be developed.

Through agroecology, using literature information and from the field work (top down – bottom up focus), it was settle the support framework that allow the proposal of the sustainability attributes and the respective indicators. The value of considering this mixed focus, is that it allows to determine relevant attributes, not only in the theory or according to previous research, but also according to what stakeholders said that is relevant, so different interest and preferences were considered, to avoid a bias in this sense, during the field work interviews were applied to actors from different sectors, from the maguey / mezcal producers to academics.

It is also important to mention that the characterization of the agroecosystem as well as the attributes determination, is limited by the researcher ability and experience to reflect the reality; even the intention of presenting an objective description and proposal, it is impossible to set apart the subjectivity (Galván-Miyoshi, 2008), this could be a weakness of this work, which can be reduced by the collaboration of different profesionist and stakeholders as well as by the done search of the system complexity description (Galván-Miyoshi, 2008).

The SAF from artisanal mezcal production in Santiago Matatlán, includes general objectives and derived from it, sustainability attributes were defined, as specific conditions that this specific system should develop to get closer to sustainability objectives according to agroecology framework.

The understanding of sustainability attributes should be done not only through the sustainability conceptualization but also through the understanding of the current situation of Santiago Matatlán artisanal mezcal production, the involved relations and forces, only when considering this both sides, attributes can make sense.

It was decided to determine attributes according to the four sustainability dimensions in order to propose, holistically, sustainability implications, so indicators could be set without missing any important aspect.

The final proposal in this work is a set of indicators divided in sustainability dimensions in order to allow a holistic assessment. This proposal considered that each indicator would be analyze and not the creation of an index. An index allows an easy view of the general condition of a system, however is difficult to interpret and to recognize the origins of the obtained result, so decision making and development of strategies, to get closer to sustainability, is more difficult and less accurate (Galván-Miyoshi, 2008).

In this case indicators are the starting point for an analysis of the system condition, are just a part of the assessment. The result that would be obtained of each indicator is not enough to understand what is happening in the system, it should be deeply analyze, recognizing the origins of it condition as the respective impacts and relations with other indicators.

Even when most of the information to assess the indicator is available at the maguey or mezcal production level, when the interpretation of the indicator would be done, is important to consider what is behind it; external forces at different scales as national and international market behavior, regional and national politic situations or global environmental conditions, could have an influence in decision making of the mezcal and maguey producers. A future research can consider a detailed analysis or even a developement of a model of the influence and importance of this external forces.

An important reference, to make indicators interpretation, are defined sustainability attributes and objectives as well as the done context description. When talking about the context description, it must be considered that this description includes mezcal history and the present time situation when the research was done, but reality is in constant change so an update should be appropriate in the future.

Moreover, the knowledge and understanding of one indicator alone do not allow to recognize what is happening on the system, that is why is proposed to make a multi-criterial analysis. Through this kind of analysis, is possible to see the behavior of a group of indicators and to make an integrative analysis that lead to create strategies to maintain the system on the desire direction. Is important to remember that systems are subjected also to matters beyond stakeholders control, so indicators should be monitored constantly to detect changes and adjust or create new strategies.

In this case it is recommended to apply the proposed indicators to identify critical areas where strategies and action is needed, then while strategies are applied and after action were taken; specific times to monitor the indicators should be defined depending on the dimension and type of done strategy, some indicators could require more time than others to reflect a change.

Multicriterial analysis could be used to compare indicators conditions in different moments from different dimensions, because they allow the identification of aspects that are left lagged or if the critical indicators are not having a desirable behavior, so is possible to prioritize action and decide between options.

Designed SAF strength is that allow an analysis of strategies impact in the four dimensions; which allow it formulation through the consideration of the complexity that is involved in maguey / mezcal production which can lead to a better definition of the steps to achieve more effective results.

The SAF proposed in this research is the first step to apply a sustainability assessment of artisanal mezcal production in Matatlán, work on influence of external forces, limits definition and tools to apply the assessment should be done in the future to complement this research, and allow the application of the SAF result of this research.

VIII. CONCLUSIONS

Within what is said about sustainability, an important difficulty is how to apply it in the reality and how to make decisions according to it. This could be solved through the development of SAF, composed by sustainability conceptualization, objectives and attributes, which lead the development of indicators. The development of an accurate SAF requires a deep comprehension of the system to assess.

Due to the complexity of the phenomena in the system where it is immersed and the lack of a framework that guide decision making, the present research identified as necessary a SAF development for the artisanal mezcal production in Santiago Matatlán, Oaxaca.

A description and analysis of the context where artisanal mezcal production takes place, was done considering history and current situation. An analysis of the used materials and energy, it transformation, the involvement of different stakeholders and the system dynamics, was done according to the agroecosystem framework, in order to present a systemic analysis of the reality. The analysis of the relations and values was conducted through four sustainability dimensions (social-cultural, institutional-political, economic and environmental) in order to have an integral perspective.

Sustainability concept and objectives, were taken from the agroecology framework, due to the characteristics of the system where the artisanal mezcal production takes place; both of them, guide the identification of aspects to maintain and to change, which finally allow the development of a proposal of indicators for each dimension.

The proposal is composed by 40 indicators, most of them were designed to be applied at artisanal mezcal factory scale (*palenque*) in order to guide decision making of maguey and mezcal producers, who are the operative actors of the system and has the power to enhanced sustainability in the practice as well as to receive the direct effects of it (positive or negative).

There were identified critical indicators, it means those with greater weight which are considered strategic in maguey / mezcal production as well as in decision-making. To enhance decision-making when analyzing indicators, it would be useful to develop a guide or a model in a future research.

It is recommended that the analysis of the indicators condition would be made by a multicriterial analysis, within indicators of each dimension and between dimensions, during the different stages

of a project or strategy (at least planning, application and post application). The analysis and indicators interpretation, must also considers an analysis of the condition origin, the influence of external forces and the relation with other indicators.

The application of the SAF result of this research, requires future investigation on the analysis of the external forces that influence decision making of maguey and mezcal producers, generalities of this are settle in chapter IV, however it is required a deeper analysis that make it more visible, a model could be develop to explain these dynamics.

It is also needed the design of tools that allow information gathering to determinate indicators condition; aspects to consider when creating these tools are the scale of application and the evidences set for each indicator.

The value of the present research is that proposed SAF, constitute the first step and the infrastructureor support to achieve a sustainability assessment of artisanal mezcal production in Santiago Matatlán, Oaxaca.

Annexes

Annex 1. Matrix for the analysis of field work information

			Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
			1	2	3	4	5	6	7	8	9						
Historical and cultural mezcal production background	Santiago Matatlan	Mezcal High Volume Production					X						X				X
		Mezcal is the Main Activity					X			X							
		Historical Production	X	X	X	X	X		X								
		Quality Mezcal Production															
		Location near to Oaxaca city								X							X
		Had an historical influence in the region								X							X
		Palenques Abundance Background					X		X								
	Personal and Family	Mezcal Family Tradition	X	X	X	X	X		X	X	X		X			X	X
		Family Production Continuity	X	X	X	X	X		X	X	X						
		Knowhow Family Background	X	X	X	X	X		X	X	X		X			X	
	Mezcal	Tradition Considerer		X	X								X				
		Use of mezcal as exchange device								X							
		Considers own mezcal artisanal	X	X	X	X	X	X	X	X	X						
		Artisanal due to composition (100% agave)							X								
		Artisanal by technique			X	X	X	X	X		X		X	X			X
		Artisanal by the avoiding of the use of chemicals				X	X		X					X			
		Artisanal by Materials			X	X		X			X		X	X			
		Artisanal by Tradition												X			
		Artisanal by Production Volume								X							X
		Artisanal because of quality perception	X	X	X						X			X		X	
		Artisanal because of market demand							X	X				X		X	X
		Artisanal because of tradition	X	X													
		The product is consume locally			X	X	X				X					X	
Agave	Cultivated	Have agave production	X	X	X	X	X		X	X	X						
		Local cultivation	X	X	X		X		X	X	X						
		Outside the municipality cultivation															
		Espadin Cultivated Specie		X	X	X	X		X	X	X						
		Cultivate own land		X	X	X	X		X	X	X						

			Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
			1	2	3	4	5	6	7	8	9						
		Cultivate rent land				X			X	X							
		Non-written Rent Agreement							X								
		Written Rent Agreement				X			X								
		1000 -1500 plants per Ha							X								
		>1500-2000 plants per Ha				X	X										
		>2000-2500 plants per Ha															
		Reproduction by "hijuelos" Gather			X	X	X		X	X	X						
		Reproducción mediante tratamiento de quiote				X				X							
		Reproduction by seeds					X										
		Buys "hijuelos"								X							
		Fertilizer use															
		Herbicide use															
		Organic fertilizer use							X								
		Plagues and diseases in the last two years				X			X								
		Polyculture with agave		X		X	X		X		X						
	Wild	Agave Gatherer							X					X			
		Gathers A. potatorum (Tobalá)							X								
		Gathers A. rhodacantha (Quixe)							X								
		Gathers A. karwiinski (Madrecuixe)							X								
		Gathers A. marmorata (Tepeztate)							X								
		Gathers A. americana var. oaxcensis (Arroqueño)															
		Local Gather							X					X			
		Outside the municipality Gather												X			
		Carries out wild agave conservation activities					X		X	X	X			X	X		
		Works on in vitro reproduction												X			
		Wild Agave Seeds Gather							X	X				X	X		
		Wild Agave Nursery					X		X	X	X			X	X		
		Own Land transplantation					X				X						
		Wild Land transplantation							X					X			
	Purchase / Buy	Buys A. angustifolia Haw	X	X	X	X		X	X		X			X			
		Buys A. potatorum (Tobalá)	X	X	X	X		X	X	X				X			
		Buys A. rodacanta (Cuishe)		X	X				X					X			

			Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
			1	2	3	4	5	6	7	8	9						
		Buys A. karwiinski (Madrecuishe)	X						X	X				X			
		Buys A. marmorata (Tepextate)	X		X				X	X				X			
		Buys A. americana var. oaxcensis (Arroqueño)				X		X		X				X			
		Buys Local Agave	X														
		Selects the agave		X		X		X	X								
		Selects capon / sazon agave		X	X	X		X	X								
		Selects "mature" agave				X					X						
		Do not select the agave	X		X	X					X						
		Negotiate Agave Price		X					X								
		Market Sets Agave Price	X		X						X						
Production	Raw Material & Tools	A. angustifolia Haw 5Kg/l - 8 kg/l Performance	X		X	X	X	X	X		X						
		A. angustifolia Haw 16 kg/l Performance		X													
		Wild Agave 12 kg/l a 20 kg /l Performance	X		X												
		Earth kiln	X	X	X	X	X	X	X	X	X			X			
		Stone / Tahona Mill	X	X	X	X	X	X	X		X			X			
		Maul Mill															
		Mechanical Shredders								X							
		Wood Tub Fermentation	X	X	X	X	X	X	X	X	X			X			
		Plastic Tub Fermentation			X												
		Cupper Still	X	X	X	X	X	X	X		X			X			
		Clay Still		X						X							
		Cultivated Yeast Fermentation						X						X			
		Chemical Substances Fermentation	X														
		Animal Use	X	X	X	X	X	X	X		X			X			
		Wood Use	X	X	X	X	X	X	X	X	X			X			
		Other Combustible Use						X						X			
		Aged and Rest in Barrel	X	X		X	X	X			X			X			
		Aged and Rest in Glass	X	X		X	X	X		X	X			X			
	People Involved / Workers	Hire Day Laborer	X	X	X	X	X	X	X	X	X						
		Full Time Workers	X					X		X	X						
		Family Involvement	X	X	X	X	X	X	X	X	X		X				

			Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
			1	2	3	4	5	6	7	8	9						
	Costs	The producer have a salary			X	X	X	X		X							
		The family receives a salary				X	X	X		X	X						
		Knows production costs	X	X	X	X	X	X	X	X	X						
		Has Calculted production costs			X		X	X		X	X						
		Agave cost		X	X	X	X	X	X	X	X						
		Wood cost		X	X	X	X	X	X	X	X						
		Bottle cost			X	X	X	X		X	X						
		Label cost			X	X	X	X		X	X						
		Animal price					X	X		X	X						
		Depreciation cost					X	X		X	X						
		Merchandising cost					X	X		X	X						
		Certification cost					X	X		X	X						
		Labor cost		X	X		X	X	X	X	X						
		Services cost					X	X		X	X						
	Environment & Waste	Perception of low/no environmental impact	X	X			X		X		X		X	X		X	
		Reforestation activities												X			
		Well water use	X	X		X	X		X								
		Water used from the municipality water-supply				X	X	X									
		Use of municipality supply energy			X	X	X	X	X	X	X						
		Use of solar energy	X		X												
		Use of legal wood				X	X		X	X							
		Use of local wood and does not know if it has permission	X	X	X	X				X							
		Use of gas as fuel						X									
		Compost production with agave fibers (bagasse)						X								X	
		Compost production with agave leafs (stalk)				X		X									
		Agave fibers (bagasse) disposal in fields	X	X	X	X	X	X	X	X	X						X
		Agave leafs (stalk) disposal in fields				X		X	X		X						X
		Use of agave fibers (bagasse) in other activities	X	X	X		X	X	X	X			X			X	X
		Use of agave leafs (stalk) in other activities		X		X		X	X				X				
		Field or River Vinasse Dispose	X	X	X	X	X										

			Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
			1	2	3	4	5	6	7	8	9						
		Vinasse Harmful Perception	X					X		X				X		X	X
		Treatment of vinasses															
		Storage of vinasses in the Soil holes								X	X						
		Vinasses treatment with lime before field/river disposal						X		X							
		Vinasses filtration before field/river disposal						X						X			
		Cooling water is used in the same process				X	X	X									
		Cooling water is used to irrigate	X						X								
		Perception of low/no harmful properties of the vinasses	X	X			X										
Commercialization	Regulations, registers and certifications	Has a registered brand	X		X	X	X	X		X	X			X			
		Tax Payment	X			X	X	X		X	X			X			
		There is no regulation on wild agave use									X			X			
		CRM agave crop register															
		Mezcal CRM certification	X		X	X	X	X		X	X			X			
		Partly Certificated Product	X			X										X	
		Organic certification					X			X	X						
		Do not have a brand but interested				X			X								
		Do not have CRM Certification but interested							X								
		Do not have Organic Certification but interested					X										
		Certification Positive Perception				X	X	X	X		X		X		X		
		NOM Positive Perception			X						X						
		Certification Negative Perception		X	X					X				X		X	X
	Positioning	Bulk Sale	X	X	X	X			X								
		Bottle Sale	X	X	X	X	X	X		X	X			X		X	
		Local Sale	X	X	X	X	X		X					X		X	X
		State Sale	X	X	X	X	X	X		X				X			X
		Country Sale	X			X	X	X		X	X			X		X	X

			Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
			1	2	3	4	5	6	7	8	9						
		Exportation Sale				X	X	X		X	X			X		X	X
		Retail Sale	X	X	X	X	X		X		X						
		Manufacture for other Brands				X	X				X						
		Retailer Association				X	X				X						
		Retailer disadvantageous relationship		X						X							
		Growing Mezcal Demand Perception	X			X		X			X					X	
	Bad Quality Perception	High smoky flavor					X										
		High spiciness					X										
		High alcohol concentration					X										
		Very low alcohol concentration															
		Gritty Flavor															
	Mezcal appreciation	Lack on mezcal appreciation in the society				X				X				X		X	
		Product positioning need								X							
		Increase of valorization														X	
		Perception of Fare payment according to mezcal value								X							
		Fare payment is related to cover the costs, training, support, equipment								X			X			X	
		Develop activities related with mezcal education						X		X			X	X			
	Taxes	Missed information about taxes payment						X	X	X		X				X	X
		Unequal artisanal and industrial taxation										X				X	
		Perception of taxes as a problem						X	X	X				X		X	
	Price	Price Covers Cost Perception	X		X	X	X			X	X						
		Profit Perception	X	X	X	X	X		X	X	X						
		Producers doesn't know how to determine the price of their product												X		X	X
Current Situation /Status Quo	Benefits	Sell more mezcal or more easily	X	X	X	X	X										
		Some benefit more than others perception		X					X								
		Employ generation	X					X	X	X			X	X	X		
		More touristic activities in the region	X		X			X	X				X				

			Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
			1	2	3	4	5	6	7	8	9						
		The community infrastructure has improved due mezcal activities	X	X													
		Community infrastructure has not improved due mezcal activities						X									
		Do not perceives municipality improvement				X			X								
		Migration has decrease						X	X		X			X		X	
		Migrants come back to work in mezcal related activities					X	X					X	X	X	X	
		New generations have better education	X										X				
		Family and Palenque benefits perception	X		X	X	X		X				X				X
	Participation	Support community activities or events					X	X						X			
	Organizations	Producers or Retailers organizations knowledge	X	X	X				X		X		X	X			X
		Was part of an organization	X	X													
		Is part of an organization		X							X						
		Organizations Distrust Perception	X	X	X	X	X		X	X				X			X
		Organizations Need Perception				X				X			X		X		
		Cooperation between producers and retailers in order to balance quantity and quality						X		X			X		X		X
		Cooperation between agave producers and mezcal producers to ensure the production and settle the prices								X						X	
		Organization Leaders Distrust Perception		X	X			X									X
	Political aspects	Influence on production equipment		X	X			X		X							
		Influece on agave crops														X	
		Lack on government support to small mezcal producers	X		X	X			X		X						
		Political influence percibe as positive						X									
		Political influence percibe as negative		X	X			X		X						X	X
	Economic Activities	The production of Agave or mezcal is the main activity	X		X	X	X			X	X						
		Mezcal production by season		X					X							X	
		Have complementary crops		X					X							X	

		Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
		1	2	3	4	5	6	7	8	9						
	Do complementary commercial activities		X		X			X							X	
	Perform another job	X	X					X							X	
Problematic	Producers lack on education and training								X			X	X	X		
	Lack on mezcal memory								X						X	
	Lose of identity								X							
	Lack of Social responsability in producers and retailers								X							
	Lack of organization between mezcal stakeholders								X							
	Production in large quantities is considered as a problem because it quality decrease		X							X		X			X	
	Competition with other industries on agave uses													X		X
	Lack on formal research and information about mezcal						X		X					X	X	
	Obstacles due to lack of education								X		X	X		X		X
	Obstacles due to lack of taxation information and traning								X		X		X	X	X	X
	Obstacles due to lack of local infraestructure							X	X							
	Obstacles due to lack on technology for mezcal production															X
	Obstacles due to lack of economic resources							X			X	X				X
	Obstacles due to regulatory norms														X	
Enviromental Impacts	Water Pollution Perception	X		X			X						X			
	Less Water Availability Perception			X												X
	Agave shortage due to buying from Jalisco tequila producers			X	X	X		X							X	
	Soil degradationn Perception							X								
	Less Agave Availability Perception	X			X	X			X						X	
	Future Wood consumption problem Perception	X			X					X			X			
	Forests Lose Perception				X				X	X		X	X			

			Mecalproducers									CEO / Financial EXpert -Taxes	Writter / Mezcal Educational Tours	Marketing Manager	President / CRM	Mezcal Distributor - Co owner	Master of Science / CIIDIR
			1	2	3	4	5	6	7	8	9						
Future	Industry	The artisanal mezcal production will continue	X	X		X	X	X		X	X		X			X	
		The artisanal mezcal production will change		X						X							
		The artisanal mezcal production will increase	X				X			X					X	X	
		Artisanal technification changes						X		X	X			X			X
		Creation of more mezcal brands						X	X	X					X		
		Involvement of bigger brands in the mezcal industry												X			
		Consideration of gas use to distillation					X	X									X
		Increase on mezcal selling	X			X			X				X			X	
		Price would reflect the mezcal value			X						X						
		It is a challenge is to keep the artisan production		X			X	X	X		X		X			X	
	Problematic and needs	Lack on Agave availability to meet the demand	X	X					X	X	X	X				X	
		Increase of mezcal production costs due to shortage of mezcal	X				X			X						X	
		Periods of high agave availability vs periods of low agave availability							X						X		
		The new legal framework about komil							X								
		Water availability							X								
		Need of better regulations according to regions and traditions														X	
		Need of a framework about artisanal products												X			

REFERENCES

Aguirre Rivera, J. R., Charcas Salazar, H., & Flores Flores, J. L. (2001). *El maguey mezcalero potosino*. San Luis Potosí: Universidad Autónoma de San Luis Potosí.

Altieri, M. A. (2002). Agroecology: The science of natural resource management for poor farmers in marginal environments. *Agriculture, Ecosystems and Environment*, *93*(1-3), 1–24. http://doi.org/10.1016/S0167-8809(02)00085-3

Altieri, M., & Nicholls, C. (2000). *Agroecología: Teoría y práctica para una agricultura sustentable.* (First). México D.F.: PNUMA.

Álvarez, L. R. (2003). *Geografía general del estado de Oaxaca* (4th ed.). Oaxaca: Carteles editores.

Astier, M. ; G. C. (2008). Formulación de indicadores socioambientales para evaluaciondes de sustentabilidad de sistemas de manejo complejos. In Y. Astier, Marta ; Masera, Omar R.; Galván-Miyoshi (Ed.), *Evalacuación de la sustentabilidad. Un enfoque dinámico y multidimensional* (First). Valencia: SEAE / CIGA / ECOSUR / CIEco / UNAM / GIRA / Mundiprensa / Fundación Instituto de agricultura Ecológica y Sustentable, España.

Astier, M., & González, C. (2008). Formulación de indicadores socioambientales para evaluaciones de sustentabilidad de sistemas de manejo complejos. In *Evaluación de la sustentabilidad. Un enfoque dinámico y multidimensional.* (pp. 73–94). Valencia: EAE / CIGA / ECOSUR / CIEco / UNAM / GIRA / Mundiprensa / Fundación Instituto de Agricultura Ecológica y Sustentable, España.

Bautista, J. A., Ramírez Juárez, J., & Smit, M. (2015). Origen, auge y crisis de la agroindustria del mezcal en Oaxaca. In *Agua de las verdes matas. Tequila y mezcal* (1st ed., pp. 109–122). Mexico: CONACULTA / INAH / Artes de México.

Bautista, J. A., & Smit, M. A. (2012). Sustentabilidad y agricultura en la " región del mezcal " de Oaxaca. *Revista Mexicana de Ciencias Agrícolas*, *3*(1), 5–20. Retrieved from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-09342012000100001&lng=es&nrm=iso&tlng=es

Bautista, J. A., & Terán M., E. (2008). Estrategias de producción y mercadotecnia del mezcal en Oaxaca. (Spanish). *Cotidiano - Revista de La Realidad Mexicana*, *23*(148), 113–121. http://doi.org/0186-1840

Bautista, J., Orozco, S., & Terán, E. (2015). La disminución de la producción artesanal de mezcal en la Región del mezcal de Oaxaca , México. *Revista Mexicana de Ciencias Agrícolas*, *6*(6).

Bianco, C., Kraus, T., & Vegetti, A. (2004). *La hoja. Morfología extrna y anatomía.* Argentina: Universidad Nacional de Río Cuarto.

Bond, A., Morrison-Saunders, A., & Pope, J. (2012). Sustainability assessment: the state of the art. *Impact Assessment and Project Appraisal*, *30*(1), 53–62. http://doi.org/10.1080/14615517.2012.661974

Bowen, S. (2015). *Divided Spirits. Tequila, mezcal and the politics of production* (Darra Gold, Vol. 1). Oakland: Uiversity of California Press. http://doi.org/10.1017/CBO9781107415324.004

Bowen, S., & Valenzuela Zapata, A. (2009). Geographical Indications, Terroir, and Socioeconomic and Ecological Sustainability: The Case of Tequila. *Journal of Rural Studies*, *25*, 108–119.

Bravo, H. E. (1937). *Las Cactáceas de México*. Universidad Nacional de México.

Carrillo, L. A. (2007). Los destilados de agave en México y su denominación de origen. *Ciencias*, *87*, 41–49.

Castillo, R. M. (2002). Agroecología: Atributos de Sustentabilidad. *Inter Sedes*, *3*(5), 25–45.

Conabio. (2006). *Mezcales y Diversidad*. (C. N. para el C. y U. de la Biodiversidad, Ed.) (2ª ed.). México, D.F.

CRM. (2015). *Informe 2015*. Oaxaca.

CRM. (2016a). *Informe 2016*.

CRM, C. R. del M. (2016b). *Informe 2016*.

Durston, J. (2002). El capital social campesino en la gestión del desarrollo rual. *CEPAL*. http://doi.org/10.1017/CBO9781107415324.004

Espinosa Paz, H., Arredondo Velásquez, C., Cano García, M. A., Canseco lópez, A. M., & vázquez Quintana, F. (2002). *La materia prima para producir el mezcal oaxaqueño. Catálogo de la diversidad de agaves.* Santo Domingo Barrio Etla: INIFAP, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias.

Font Quer, P. (1953). *Diccionario de Botánica*.

Fraser, E. D. G., Dougill, A. J., Mabee, W. E., Reed, M., & McAlpine, P. (2006). Bottom up and top down: analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management*, *78*(2), 114–27. http://doi.org/10.1016/j.jenvman.2005.04.009

Gallopin, G. C. (2006). *Los indicadores de desarrollo sostenible: aspectos conceptuales y metodológicos*. Santiago, Chile: FODEPAL.

Galván-Miyoshi, Y. (2008). Integración de indicadores en la evaluación de sustentabilidad: de los índices agregados a la representación multicriterio. In *Evalacuación de la sustentabilidad. Un enfoque dinámico y multidimensional*. SEAE / CIGA / ECOSUR / CIEco / UNAM / GIRA / Mundiprensa / Fundación Instituto de agricultura Ecológica y Sustentable, España.

Galván-Miyoshi, Y., Masera, O., & López-Ridaura, S. (2008). Las evaluaciones de la sustentabilidad. In *Evaluación de sustentabilidad. Un enfoque dinámico y multidimensional.* (First, pp. 41–58). Valencia: EAE / CIGA / ECOSUR / CIEco / UNAM / GIRA / Mundiprensa / Fundación Instituto de Agricultura Ecológica y Sustentable, España.

Garcia Mendoza, A. (2007). Los agaves de México. *Ciencias*, *87*, 14–23.

Gentry, A. H. (1982). *Patterns of neotropical plant species diversity. Evolutionary Biology*.

Gibson, R. B. (2006). Sustainability assessment: basic components of a practical approach. *Impact Assessment and Project Appraisal*, *24*(3), 170–182. http://doi.org/10.3152/147154606781765147

Gobierno del estado de Oaxaca 2010-2016. (n.d.). Mapa Regiones. Retrieved from http://www.redoaxaca.oaxaca.gob.mx/index.php/features/catalogo-de-map

Gutiérrez González, S. (2015). Riqueza organoléptica de lso agaves mexicanos. In *Agua de las verdes matas. Tequila y mezcal* (1st ed., pp. 215–224). Mexico: CONACULTA / INAH / Artes de México.

H. Ayuntamiento Constitucional Santiago Matatlán. (2014). *Plan Municipal de Desarrollo. Santiago Matatlán. Tlacolula Oaxaca*. Retrieved from https://my.cloudme.com/v1/ws/:matatlan/:PMDMatatl/PMDMatatl.pdf

Huerta Rosas, R., & Luna Zamora, R. (2015). Los caminos del mezcal y el tequila. In *Agua de las verdes matas. Tequila y mezcal* (1st ed., pp. 43–66). México: CONACULTA / INAH / Artes de México.

Illsley Granich, C., Gómez Alarcón, T., Rivera Mñendez, G., Morales Moreno, M., García Bazán, J., Ojeda Sotelo, A., … Mancilla Nava, S. (2005). *Conservación in situ y manejo campesino de magueyes mezcaleros*. México D.F.

IMPI. (2015). *Resolución por la que se modifica la Declaración de Protección de la Denominación de Origen Mezcal*.

INAFED, I. N. para el F. y el D. M. (2010). Santiago Matatlán. Retrieved from http://www.inafed.gob.mx/work/enciclopedia/EMM20oaxaca/municipios/20475a.html

Larson, J., & Aguirre, X. (2015). Normas de etiquetado y dilución de significados en la comercialización de mezcal y otros destilados de maguey en México. In *Agua de las verdes matas. Tequila y mezcal* (1st ed., pp. 157–182). Mexico: CONACULTA / INAH / Artes de México.

Luna Zamora, R. (1991). *La historia del tequila, de sus regiones y sus hombres*. CNCA.

Malhotra, N. K. (2004). *Investigación de mercados*. Pearson educación.

Martínez-Salgado, C. (2012). El muestreo en investigación cualitativa: principios básicos y algunas controversias. *Ciência & Saúde Coletiva*, *17*(3), 613–619. http://doi.org/10.1590/S1413-81232012000300006

McEvoy, J. (2014). *Holy Smoke! It´s Mezcal! A Complete Guide from Agave to Zapotec* (1st ed.).

Meadows, D. (1998). *Indicators and Information Systems for Sustainable Development*. The Sustainability Institute.

Medellín-Milán, P., Avalos-Lozano, J. A., & Nieto-Caraveo, L. M. (2011). Más allá de la Economía Ecológica, la construcción de nichos de sostenibilidad. *POLIS Revista Latinoamericana*, *29*, 2–21.

Parris, T. M., & Kates, R. W. (2003). Characterizing and measuring sustainable development. *Annual Review of Environmental Resources*, *31*(1), 275–301. http://doi.org/10.1146/annurev.earth.31.100901.144746

Pintér, L., Hardi, P., Martinuzzi, A., & Hall, J. (2012). Bellagio STAMP: Principles for sustainability assessment and measurement. *Ecological Indicators*, *17*, 20–28. http://doi.org/10.1016/j.ecolind.2011.07.001

Rodríguez Sosa, J., & Zeballos, M. (2007). *Evaluación de proyectos de desarrollo local. Enfoques,*

métodos y procedimientos. (DESCO, Ed.). Lima.

SAGARPA. (2006). *Plan rector del sistema nacional maguey mezcal*. San Luis Potosí.

SAGARPA. (2011). *Impactos Maguey-Mezcal*.

Sánchez López, A. (2005). *Oaxaca tierra de maguey y mezcal* (2nd ed.). Oaxaca: CONACYT.

Sandoval Casilimas, C. (1996). *Especialización en teoría, métodos y técnicas de investigación social*. *Módulo*. http://doi.org/958-9329-18-7

Sandoval, C. A. (1996). *Investigación Cualitativa*. Bogotá: ICFES, Instituto Colombiano para el Fo.

Sarandón, S. (2002). El desarrollo y uso de indicadores para evaluar la sustentabilidad de los agroecosistemas. *Agroecología: El Camino Para Una Agricultura Sustentable*, 393–414. Retrieved from http://wp.ufpel.edu.br/consagro/files/2010/10/SARANDON-cap-20-Sustentabilidad.pdf

Sarandón, S. J., & Flores, C. C. (2009). Evaluación de la sustentabilidad en agroecosistemas: Una propuesta metodológica. *Agroecología*, *4*, 19–28. Retrieved from http://revistas.um.es/agroecologia/article/view/117131

SCFI, S. de C. y F. I. NORMA Oficial Mexicana NOM-070-SCFI-1994, Bebidas alcohólicas-Mezcal-Especificaciones, DOF Diario Oficial de la Federación 64 (1997).

SCFI, S. de C. y F. I. (2016). PROYECTO de Norma Oficial Mexicana PROY-NOM-070-SCFI-2015, Bebidas alcohólicas-Mezcal-Especificaciones. *DOF Diario Oficial de La Federación*.

SEDESOL. (2014). Catálogo de Localidades, Resumen municipal, Municipio de Santiago Matatlán.

Serbia, J. M. (2007). Diseño, muestreo y análisis en la investigación cualitativa. *Holográmatica*, *3*(2007), 123–146.

Serra Puche, M. C., & Lazcano Arce, J. C. (2015). Etnoarqueología del mezcal: su origen y su uso en Mesoamérica. In *Agua de las verdes matas. Tequila y mezcal* (1st ed., pp. 23–42). Mexico: CONACULTA / INAH / Artes de México.

Valenzuela Zapata, A. G. (2006). Agave Azul. Historia por venir. *Patrimonio Cultural Y Turismo - Cuadernos*, *15*, 145–157.

Valenzuela Zapata, A., Regalado Pinedo, A., & Mizoguchi, M. (2008). Influencia asiática en la producción de mezcal en la costa de Jalisco. El caso de la raicilla. *México Y La Cuenca Del*

Pacífico, *11*(33), 91–116.

Vela, E. (2014). Los usos del maguey. *Arqueología Mexicana. El Maguey*, 56–65.

Wu, J. and T. W. (2012). Sustainability indicators and indices: An overview. *Handbook of Sustainable Management*, 65–86.

Zizumbo-Villareal, D., & Colunga-García Marín, P. (2007). La introducción de la destilación y el origen de los mezcales en el occidente de México. In *En lo ancestral hay futuro* (First, pp. 85–112). Mexico: Centro de Investigación Científica de Yucatán, A.C. / CONACYT / SEMARNAT.