

Environmental services: traditional agroforestry system with pulquero maguey plants in the Altiplanicie, Hidalgo state

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Abstract

The traditional agroforestry systems in Mexico are an expression of the forms of management and use of natural resources with an antiquity beyond the arrival of Europeans, obtaining environmental services and multiple harvests in prolonged periods are an important characteristic to highlight. The Altiplanicie pulquera region in the state of Hidalgo has the conditions and practice of the agroforestry system with maguey pulquero as the main perennial plant to which management practices can be associated to obtain diverse environmental services and varied products that satisfy human needs. Therefore, this system can help to solve environmental problems in the region and support the local economies of peasant producers.

Keywords: agroforestry, multiple harvesting, socio-economic strategy, soil conservation, water harvesting.

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Currently this capitalist production system ‘devours 25% more resources than nature can replace’ (Bartra, 2009), what would this planet be like if all the countries of the world were in the same economic conditions and overexploited nature at the same time pace of ‘developed’ countries? The current panorama would be catastrophic, perhaps, the end of civilization as it is known.

The great crisis is systemic. This has different manifestations: environmental, energy, food, migration, war and economic crisis. As a whole, each of its manifestations is leading the system to a collapse that has global reach. There is a capitalism of the end of the world (Bartra, 2017).

But of this set, it is the environmental crisis that is calling into question the continuity of human life on the planet. This crisis is about multiple ecological devastation, which includes alterations in the nitrogen and phosphorus cycles, water pollution, the effects of aerosols on the atmosphere, chemical pollution, stratospheric ozone depletion and acidification of the oceans, processes that, together, make up the sixth mass extinction of biodiversity (Giraldo, 2014).

The green revolution as an expression of the attempt to emulate the industrial revolution, seeks to produce food at low cost, in addition to taking advantage of subsidies from the metropolis. This production has a high energy cost, uses fossil energy, agrochemicals and human labor from underdeveloped countries, in addition to the water extracted from these same countries, who also suffer pollution and degradation of their lands under the capitalist agro-export model. Globally, it is estimated that 86% of the water footprint is related to the consumption of agricultural products, 10% to the consumption of industrial goods and less than 5% to domestic uses. (Delgado, 2014).

Faced with this situation, it is urgent to increase food production in a sustainable way, put aside the paradigm of the green revolution and resume production techniques of native peoples that are less harmful to the environment and that allowed the subsistence and development of civilization since the invention of agriculture more than 10 thousand years ago. The recognition and promotion of agroforestry systems for food production has high potential as a sustainable alternative, it is the objective of this document exemplified with the production of annual crops and pulquero maguey.

Region of study and characterization

Historically, the state of Hidalgo has been characterized as a poor state with high social inequality despite its natural wealth: today, for the Economic Commission for Latin America and the Caribbean (ECLAC), the productive structure of Hidalgo it is a non-dynamic territory with low gross domestic product (GDP) per capita, it grows below the country's average and its products per capita are also below the national average (Roldan, 2015).

Regarding its spatial location, Hidalgo is partially located in the Mexico Basin and the mountainous region of the Neo-Volcanic Cordillera, which divides the entity into three large natural regions: 1) the plain, located to the south, and the with greater access to Mexico City

and the central region; 2) the mountainous area, in the mountainous massif that crosses the entity; and 3) La Huasteca, located to the north, which borders San Luis Potosí and Veracruz (Roldan, 2015). The Altiplanicie pulquera hidalguense is part of the first mentioned natural region and it is precisely that proximity to Mexico City and other central states one of its strengths to develop with its own resources, in this case the pulquero maguey and the large quantity of by-products derived from this plant.

This regionalization groups the 84 municipalities of the state of Hidalgo into ten geographic-cultural regions: la Huasteca, the sierras Alta, Baja, Gorda and the de Tenango, the Valle de Tulancingo, the Comarca Minera, the Altiplanicie pulquera, the Cuenca de México and the Valle del Mezquital (Roldan, 2017) (Figure 1).



Figure 1. Regions of the state of Hidalgo. <http://www.inafed.gob.mx/work/enciclopedia/EMM13hidalgo/regionalizacion.html>.

Pulquera plateau

Made up of the municipalities of Apan, Almoloya, Emiliano Zapata, Tepeapulco, Tlanalapa, Zempoala, Epazoyucan and Singuilucan, the climate of the Plateau is reason enough not to sow more than magueys and barley, because these are one of the few plants that resist the frequent frosts that fall in the area, especially in winter when the thermometer usually falls several degrees below zero, but with the absence of snow (INAFED, 2018).

What is an agroforestry system?

The International Council for Research in Agroforestry (1983) defines it as: sustained land management system that increases its total yield, combines crop production with forest and animal species, simultaneously or sequentially on the same land surface and applies management practices that are compatible with the cultural practices of the local population (Iglesias, 1999).

The operation of these systems in a rainfed plot entails several benefits such as: wood production, improvement of the microclimate and soil, contribution of organic matter, nitrogen fixation and carbon dioxide capture, production of foliage and other food and medicinal products, gums, resins and fibers (Iglesias, 1999). An agroforestry system with pulquero agave increases the productivity of the plots, its benefits are permanent and the application of external inputs is minimal and economically within reach of the producer.

A pulquero maguey plantation increases its production with the application of processed manure, a local product within the reach of producers in the Altiplanicie pulquera hidalguense, due to the combination of agricultural and livestock activities. The sheep and goat herds provide the raw material for fertilization, as well as the meat to satisfy the demand for barbecue in the region.

Environmental services of agroforestry systems

It is known that agroforestry systems (SAF) have a greater advantage than conventional monocultures in providing environmental services, a distinctive characteristic due to their Mesoamerican origin, that they have been used since ancient times and that today continue to function to provide basic products that meet the needs of the families. Some of the main environmental services that an agroforestry system provides in the plots and the environment in general are: 1) maintenance of soil fertility/reduction of erosion through the contribution of organic material to the soil, nitrogen fixation and recycling of nutrients; 2) water conservation (quantity and quality) by favoring infiltration and reducing surface runoff that could contaminate water courses; 3) carbon capture, emphasizing the potential of silvopastoral systems; and 4) conservation of biodiversity in fragmented landscapes. These services complement the products that SAF provide (for commercial or family use; eg, firewood, wood, fruits) (Beer, 2003).

The pulquero maguey, and in general all agaves are considered by law as a non-timber forest resource, the official Mexican standard NOM-007-REC-NAT-1997 establishes the procedures, criteria and specifications to carry out the use, transport and storage of branches, leaves or stalks, flowers, fruits and seeds (DOF, 1997).

Taxonomically the genus *Agave* is located in the family Agavaceae. In the American Continent, approximately 310 species are reported, of which there are 272 in Mexico, which is why this country is considered the center of origin of the genus (Granados, 1993). They are plants adapted to arid conditions. Shallow and branched roots, thick cuticle, succulence, sunken stomata, photosynthetic metabolism and acid metabolism of crassulaceae (MAC), attributes that allow it to establish itself in areas lacking water (Granados, 1993) and its environmental advantages are based on these characteristics.

The economic importance of the magueys is established by the main products obtained, the resulting groups are magueys: textile, pulqueros and mezcaleros (Ruvalcaba, 1983). In some regions of Mexico each of these groups has been the basis of the identity, culture and economy, on their exploitation they have developed the prosperity of the region, which is why when suffering changes in the demand for products derived from any group's economic boom have developed or entered into crisis these territories, as an example is the case of henequen in the Yucatán Península

and pulque in the plains of Apan, which includes several municipalities in the state of Hidalgo, Tlaxcala and the State of Mexico and recently the tequila agave in Jalisco and states with designation of origin.

Retention and formation of agricultural soil

The maguey is efficient to form agricultural soil, Ruvalcaba (1983) describes how in the municipality of Epazoyucan, in the state of Hidalgo, and more specifically in a so-called ranch. The techalote, the owner managed to recover between 8 and 10 ha of land on sloping land based on terraces. These structures are part of the highland landscape and an expression of the agroforestry systems that have been established in the region since pre-Hispanic times, the terraces are a fundamental part of the agricultural management that captures, controls rainwater, in addition to allowing the recharging of the phreatic mantles. It also allows the retention and control of soil carryover that allows long-lasting fertility.

The agricultural producers of the region have the knowledge and experience for the design and construction of terraces, as well as those necessary for the planting of magueys on the edges of the terraces, with which successive formation terraces are achieved. Also in the region, terraces have been built with heavy machinery, which facilitates work and requires government support for such actions.

According to a study, the central region of the country where the states of Tlaxcala, Puebla, Hidalgo, Mexico and Querétaro are located, which make up the majority of the Altiplano Central Mexicano, present a high percentage of degradation of their soils that reaches 68%, within which the main causes are due to chemical and water degradation, followed by wind and physical degradation (Moncada, 2013). This degradation process is the result of changes from maize to malting barley, whose passage from harvesting machines requires the partial elimination of terraces, thereby increasing erosion. The result has been a decrease in the importance of the maguey and therefore its abandonment, with which erosion has increased.

The maguey plantations were regularly distributed in ancient times in straight lines from South to North and from East to West. All or most of the boundaries of the properties were planted with maguey plants, and the lands hung; that is to say, on the slopes of the mountains, they were also approached with magueys, to prevent the topsoil, carried away by the water currents, from leaving the rocks barren and bare, as now happens in many farms by the continuous cutting of trees, due to apathy and carelessness or the poorly understood economy of some landowners. Indians were the ones who discovered the properties of this plant and cultivated it, Indians are the ones who today cultivate, transplant and benefit it (Rivera, 1990).

Rainwater collection and control

Terraceado is a very frequent practice, continuing with the previous example (Ruvalcaba, 1983) explains how the same producer took advantage of the maguey-based borders to retain rainwater, for this the producer diverted the water currents in the parts high so that it flowed to their land and there it was distributed throughout the entire arable area, this practice is known as 'water harvesting'. This form of water management is part of the 'moisture syrup production system, which allows sowing to be advanced by up to a month and a half to protect against possible frosts and early hail, at the time of grain filling'.



Figure 2. Ditches for harvesting rainwater in the community of Alvaro Obregon, Españita, Tlaxcala.

Groundwater recharge

The maguey is a plant that, due to its root system and morphology, makes efficient use of water and its management in terraces and trenches helps to retain water and feed the phreatic mantles. Due to the amount of biomass it stores water, an adult pulquero maguey plant can weigh from 800 kg to 1 500 kg depending on the variety. The management of the pulquero maguey has the capacity to retain water and thereby allow the recharge of the phreatic mantles, therefore different agencies seek to implement maguey projects in areas with poor soils and arid climates to reforest and thus take advantage of the multiple benefits environmental conditions of agaves. The Conafor specialist stressed that with these supports offered by the federal agency, firstly, it is to capture water, hence this type of work is carried out because it requires, first, to recharge the aquifers (Notimex, 2018).

Shaping of living barriers

The maguey is not only useful for delimiting land, but it constitutes by itself a living fence that protects from intruders, from the winds, in addition a microclimate is generated that favors the retention of moisture and soil. Normally, among magueys, fruit trees, nopal and other species of trees or plants of interest to farmers are added, they favor soil retention and use and control of rainwater, they form high-quality living barriers that favor the productivity of crops and they are a source of food that complements the producers' diet and increases the productivity and economic value of the plot. In (Figure 3) it is observed how the maguey is interspersed with fruit trees in a plot and with it the uptake of water and the formation of living barriers.

Board formation

The practice of borders and rows is an excellent protection against erosion and landslides. The distance between edges in the sloping part depends on the contour and the slope of the terrain. In them the traditional orientation is maintained. The boards as a whole are left with the inclination dictated by experience so that the silts are deposited along it and, on the other hand, that the speed

of the water runs with saturation and without dragging of the fertile soil (Ruvalcaba, 1983). In (Figure 3) there are boards planted with maguey, fruit trees and ditches for water retention. At present, with the help of technology, excellent quality terraces can be designed based on topographic plans and mathematical calculations; however, it is worth highlighting the accumulated experience of the producers who design their huts and terraces based on their experience. In Mexico, the terrace has been handled since pre-Hispanic times.



Figure 3. Terraces made up of maguey pulque and fruit trees.

Conservation of biodiversity

The maguey alone is capable of attracting animals and insects that are beneficial to crops, among the animals it attracts are bees, hummingbirds, wasps, moths, and bats. These animals play a very important role in pollination and in the control of populations of insects and some rodents. On the ground adjacent to the magueys you can find little mice, cacomixtles, hare, armadillo, badger, gopher, viper, lizards and anthills. Each of these animals plays a role within the trophic chain of the place, for agriculture they are important because they regulate the population of insects and represent a biological control of pests. If the maguey is interspersed with nopal and fruit trees, biodiversity increases and ecological services provided to adjacent crops are accentuated, at the same time the harvested products increase.

Provision of food and medicinal remedies

“Countless are the uses of this plant. All whole serves as firewood and to fence the fields; its stems are used as wood, its leaves to cover the ceilings, as tiles, as plates, or fountains, to make papyrus, to make thread with which footwear, fabrics and all kinds of clothes are made. From the juice that flows and that distills in the middle cavity, cutting the inner shoots or the most tender leaves, they make wines, honey, vinegar and sugar; this juice causes menses, softens the stomach, causes urine, cleans the kidneys and bladder, breaks the stones and flushes the urinary tract ... The roasted and applied leaves heal seizures and relieve pain ... This plant alone could easily provide everything necessary for a frugal and simple life, since it is not damaged by storms or the rigors of the climate, nor is it withered by drought. There is nothing else that gives better yield (Hernández, 1959).

In addition to all the ecological services that the pulquero maguey provides and that have already been described, there are the multiple benefits it provides to peasant families. The products with the highest commercial value are mead, pulque, red and white worms, as well as the stalks that are used to make barbecue. But for a peasant family the maguey has a wide variety of uses. The stalks are used as containers to serve food in the field during lunch and dinner, they are also used to drink pulque. The spikes can be used as needles to close the sacks. The mezotes or dried stalks are used as fuel to heat food on the farm or in homes.

From the stalks and roots you can obtain countless remedies to alleviate diseases, you can also extract fiber for the production of fabrics, baskets, brooms, brushes and paper. The own mead and pulque have nutritional and healing properties, there are a large number of studies in this regard where the nutritional content of these drinks is demonstrated that they do have a great nutritional value. With them you can make a large number of dishes such as atoles, tamales and bread. Dried mead produces highly nutritious honey that can be used to make jams, cookies, gruels, flavored water, and skincare items.

The quiole, the egg and the maguey flowers are the basis of several nutritious and delicious dishes that are part of the diet of peasant families. Pulque waste is used as a catalyst for the production of compost that will later be applied to corn, beans, squash, broad beans and wheat crops. The pulquero maguey is a useful plant for the peasant of the central Mexican highlands, its use is comprehensive and is an excellent complement to some of the family's needs. Figure 4 shows how producers in the region intensify the plantation of pulquero maguey in a more intensive way, combining it with annual crops such as corn, beans, broad beans, pea and barley. Some producers are closing more and more the spaces between melgas. These crops take advantage of all the benefits of a living maguey fence that were already mentioned above.

The most common way is to sow it, as the image illustrates, is in rows forming metepantle (Metl: maguey; Pantli: border, row) although some producers in the region sow it in furrows to make the most of the rainwater (Figura 5).



Figure 4. Agave pulquero plantation combined with annual crops.



Figure 5. Intensive plantation of maguero sown in furrow, municipality of Zempoala, Hidalgo.

Carbon dioxide sequestration

Due to the size of an adult maguero plant and the large amount of biomass it possesses... due to their physiological characteristics, agaves are among the plants with the highest efficiency in the use of water and in the capture of atmospheric CO² that are known (García, 2007). Therefore, the agave pulquero is a plant that can contribute significantly to the capture of CO² as a result of the use of fossil fuels that contribute to global warming. In addition, it is a plant that is not competitive with other species for water given the minimum amount that it requires of the liquid for its development. CAM metabolism allows you to obtain net carbon gains with minimal water loss (sifupro.org.mx)

Rural tourism services

Rural tourism is an alternative that is already taken advantage of by maguero producers, they use their plantation, the colonial architecture together with the products derived from the maguero to offer tours of the plantations, show the management of the maguero, the varieties that they handle

and offer food and drinks based on maguey, mead and pulque. Rural and cultural tourism represents another option for producers who can take advantage of the same plantations to attract visitors since the beauty of the plant itself, the route through the maguey plants, its tradition and culture are of interest to the inhabitants of urban areas that wish to know a little about this ancient tradition (Narvaez, 2015).

Example of a traditional agroforestry system

Agave and corn have been fundamental as a nutritional basis in the life of the peoples of Mexico throughout its history (Figura 6).



Figure 6. Pulquero maguey interspersed with corn. <http://www.pedrodiegoalvarado.com/obra-paisajes.htm>.

This way of working has not changed among current peasant families, it is used for the advantages that the maguey offers as a living barrier and the biodiversity that it attracts and with it the benefits to annual and perennial crops that are associated with the maguey such as fruit trees. Despite the abandonment of the maguey for almost 100 years, subsistence producers continue to use it to retain the soil in sloping areas. They are used on a 10 or 5 degree slope in rainfed lands where water and wind can remove the soil. This was observed in all the municipalities that comprise the Altiplanicie pulquero region, soil conservation and care of the maguey is carried out because it is convenient to maintain their productive lands, such as in the municipalities of Epazoyucan, Zempoala, Tlanalapa, Singuilucan and others.

In the Figure 7 shows the results of an opinion survey on the current situation of the pulquero maguey in the pulquera region of Hidalgo, where the perception of abandonment, neglect and extinction of the crop dominates. There is a minority that shows resilience to the problem of theft of mixiote, these are the mixioteros, penqueros and chiniqüileros, who along with their use find ways to combat the problem by establishing surveillance, penetration of the meyolote and union between producers. However, with proper care, according to Narvaez (2015) and supported by case

studies, the example of which is the company Pulcata, Puebla, it has practically been shown that pulquero maguey grown with sufficient care can be usable for mead from the eight years of planting, before the leaves are used for ximbo (chicken dish with nopales cooked in small leaves), suckers or even escamole ant hills that are very well associated with this plant.

Situación del cultivo

Se ha incrementado su siembra 19%
 Se ha disminuido su siembra 19%
 En abandono la planta 19%
 Se ha sustituido por otros cultivos 5%
Está en proceso de extinción 38%

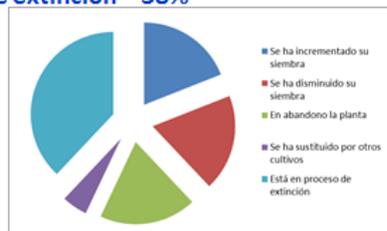


Figure 7. Results of surveys on the cultivation situation in the Altiplanicie pulquera hidalguense.

This advantage of the pulquero maguey cannot be wasted, unlike fruit or shade trees that take many more years to develop, the maguey offers many benefits in less time and with the advantage that it begins to generate income to the producer in less time. It is a plant that offers benefits to annual crops and that has no problems to associate with perennial crops that adapt to the climatic and edaphic conditions of the Altiplanicie pulquera hidalguense since it can be intercropped without any problem with crops such as apple, plum, tejocote, pear, peach, capulin, apricot and nopal, which are profitable crops and are in demand by the market.

The pulquero maguey has the advantage of not competing for water with most crops, on the contrary, its own nature tends to capture even the dew and the nocturnal humidity and fog, benefiting the adjacent plants, therefore the pulquero maguey offers more advantages than other plants including trees that take longer to develop to increase the productivity of annual and perennial crops because it begins to generate income before the eight years of its full development and because of the multiplicity of environmental and economic benefits than by itself generate.

Conclusions

The pulquero maguey is a feasible alternative to reverse the environmental crisis, solve the economic problems faced by the producers of the Altiplanicie pulquera, not only as a monoculture, but also by recreating the traditional agroforestry system that was created since pre-Hispanic times, where biodiversity is favored, which allows the rational use and conservation of natural resources, manages to coexist with the pests generated by the monoculture of the maguey and obtaining multiple benefits.

It is proven that the pulquero maguey combined with annual and perennial crops such as fruit trees that adapt to this region of the state of Hidalgo is an efficient system and with the cultivation of other trees that require little water, tolerant to frost, constitutes the agroforestry system traditional that is fundamental for the efficient use and management of natural resources and the production of a large quantity of food and other types of satisfiers that meet the needs of the peasants of the Altiplanicie pulquera of Hidalgo.

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