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MANAGEMENT AND EXPLOITATION PRACTICES OF NATURAL RESOURCES IN THE MICROREGION OF ABEJONES, OAXACA

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ABSTRACT

Indigenous communities conserve their local practices around natural resources, which contribute to the conservation of nature and the satisfaction of their dietary and sociocultural needs. The objective of the study was to analyze the practices of exploitation and management of natural resources in indigenous spaces of Oaxaca. The ethnoecological method was used: the structured interview and field visits. It was found that interview respondents implemented different types of agricultural practices, with the following standing out: sowing of associated or interspersed crops, construction of retention walls (*bordos*), and terraces and leveling. Soil management was carried out in a differentiated way; in two sites they use manure from backyard animals and in another community they use domestic waste. The water management practices were different per community and were subject to their culture; the management of irrigation water by gravity stood out, and to a lesser extent the harvest of rainwater. The harvest of plants, fungi and the exploitation of wild animals were also frequent. Rituals are still practiced that are devoted to the soil, to a lesser extent to water, to the mountain and to animals. It is concluded that the communities of study conserve their practices that were developed locally.

Keywords: conservation, indigenous communities, worldview, traditional management.

INTRODUCTION

Inhabitants of the indigenous communities of the world have a different worldview of man and nature to perform local practices and therefore appropriate nature, to satisfy their dietary and sociocultural needs (Millán-Rojas *et al.*, 2016), since they are linked in a system of knowledge and beliefs (Reyes-García and Martí, 2007). These practices are characterized by being friendly with nature and contribute to their conservation (Richeri *et al.*, 2013; Tomás and Cuervo, 2014), contrary to the practices proposed in the conventional model, which contribute to the deterioration of nature. However, modernization processes are provoking social, environmental and economic phenomena that disarticulate the indigenous life and, therefore, are causing the gradual abandonment of their productive practices. Despite this, they are still found in zones of high cultural, ecological and agrodiversity (Toledo and Barrera-Bassols, 2008).

Mexico is characterized by its cultural diversity, and there are around 68 indigenous languages and 364 linguistic variants (Instituto Nacional de Lenguas Indígenas-INALI, 2009). Ecological diversity is observed in different ecosystems and resources such as water, soil, flora, fauna and with great agrodiversity, due to the variety of agroecosystems and domesticated species (Jiménez *et al.*, 2014). In studies carried out with ethnic groups

such as Zapotec, Maya, Nahua, Purépecha, among others, it is shown that traditional agricultural practices are still present in the management of their natural resources, and many of them are associated to traditional agroecosystems (Moreno-Calles *et al*., 2013).

At the national scale, Oaxaca is the state with highest ethnic cultural diversity (Barabas, 2008), which is home to around 1.2 million indigenous inhabitants made up of 16 ethnic groups and speakers of 20 indigenous languages and 66 variants (Instituto Nacional de Estadística y Geografía-INEGI, 2013). In addition, it has the highest ecological diversity, with different ecosystems, more than 12,500 species of flora and fauna, and has the highest number of ecosystems where agriculture, livestock production, forestry, fishing, hunting and harvesting are practiced, and they function as centers of domestication (Ordóñez and Rodríguez, 2008). This indicates that these practices are latent in the state. The objective of the study was to document the practices of use and management of natural resources in Abejones, Analco and Yareni, Zapotec municipalities in the Sierra Juárez of Oaxaca. The hypothesis set out was that the rational use and management of natural resources and of the family production unit still persists in the indigenous municipalities of the Sierra Juárez of Oaxaca, Mexico.

MATERIALS AND METHODS

Location and general characteristics of the space under study

The study was conducted in three municipalities of the Sierra Juárez of Oaxaca, where communal property prevails and which are ruled by the system of Habits and Customs. San Miguel Abejones is located on coordinates 17°24'-17°35' LN and 96°34'-96°43' LW, in an altitudinal range of 1,100 to 3,100 masl. It has a surface area of 122.5 km^2 and 882 inhabitants. The municipality of San Juan Evangelista Analco is located on coordinates 17°23'-17°26' LN and 96°30'-96°35' LW, in an altitudinal range between 1,200 and 3,000 masl, has a surface area of 15.55 km^2 and there are 413 inhabitants; and the municipality of Santa Ana Yareni is located on coordinates 17°21'-17°26' LN and 96°34'-96°41' LW, in an altitudinal range between 1,200 and 2,900 masl, with a surface area of 43.38 km^2 and 918 inhabitants. The municipalities of study belong to the Zapotec ethnic group and the inhabitants of the municipalities still conserve their native language in different percentages: Yareni (98.7%), Abejones (97.5%) and Analco (42.2%).

Because of their geographic and climatic characteristics, they present different vegetation structures. Abejones is made up of pine-oak forests and xerophytic material (65.8%), low deciduous forest or dry forests with shrubs (13.5%), induced pasture (8.2%), and the rest is destined to agriculture (11.9%) and the urban zone (0.4%). Analco has pine-oak forests (23.9%), low deciduous forest or dry forest with shrubs (31.3%), agricultural areas (41.6%) and urban zone (3.0%). Yareni has pine-oak forests and xerophytic material (39.0%), low deciduous forest or dry forest with shrubs (17.5%), agricultural areas (41.0%) and urban zone (2.4%) (INEGI, 2005a; INEGI, 2005b; INEGI, 2005c; INEGI, 2016). The main crops in the agricultural areas are *milpa*, corn, bean, wheat, pea and potato. The most important livestock producing activity is breeding sheep under controlled grazing, which has been gradually substituted by raising cattle, in addition to horses and smaller species.

The principal resources are water, soil, flora, fauna and those related to the forest resources, and for their management and exploitation they have developed agricultural practices.

METHODOLOGY

The ethnoecological method proposed by Toledo (1991) was used, since it allows the study of the forms of appropriation of nature by human beings, to articulate the local knowledge with science, in order to contribute to the resolution of environmental problems. In addition, it offers a conceptual framework to approach indigenous knowledge systematically and integrally. According to the objectives set out, the following stages are covered for the identification of practices: 1. Preliminary view of the existing resources in the area under study (description of the types of vegetation, soil, flora, fauna, relief, etc.); 2. Understanding of the forms of appropriation of natural resources, in terms of the perception of peasant *praxis*: distinguishing the strategies of management and exploitation of natural resources. It is proposed that these are of geographical, physical, ecogeographical and biological type, which are linked to belief systems of original cultures and which generally manifest in rituals.

Research techniques

The research techniques to gather information were structured interview and field visits as a complement to the first. The first were carried out through a guide to address themes related to practices of management and exploitation of natural resources, as well as rituals. It was structured with closed and open themes, which allowed its complementation and codification (García-del Barrio *et al.*, 2011). The interview was applied during 2018 to the heads of the family units selected. The field visits were carried out in cultivation and forest zones of the three communities with the participation of knowledgeable people assigned by local authorities to observe the types of management that they conduct.

Size of the sample and approach of the study

The study population was integrated by 600 family units, and from these a sample of 10% was taken, distributed proportionally in the municipalities of Abejones (22), Analco (13) and Yareni (25). The sample selection was made by convenience, and this consisted in selecting the study subject based on their availability to be interviewed (Otzen and Manterola, 2017), and to determine whether the sample was representative the margin of error was calculated obtaining as a result 0.064 (6.4%), which was calculated through the simple sampling formula:

$$n = \frac{Z \cdot p \cdot (1-p)}{e^2} \quad e = \sqrt{\frac{Z \cdot p \cdot (1-p)}{n}}$$

where e: margin of error; n: 60 (size of the sample); Z: 1.96 (level of confidence of 95%); p: 0.933 (probability of occurrence: 93.3% apply chemical fertilizer to the soil).

The approach of the study was mixed, and the results were interpreted through parametric statistics and non-parametric tests of square-Chi (c^2) with a significance level of 0.05. In addition, Spearman's correlation analyses (r) were carried out to confirm de degree of association between the variables studied. This type of analysis allowed explaining the results obtained to greater depth (Hamui-Sutton, 2013).

RESULTS AND DISCUSSION

Practices of geographic landscape management

Management of the slope

The study space is characterized by having average slopes of 60%, since it is located in the V-shaped basin of the Río Grande; however, there are small areas with slopes of 40%, reason why producers implement different types of agricultural practices focusing on avoiding soil erosion, water runoffs and moisture retention. The most important practices that were conducted in the three municipalities were sowing crops associated or interspersed in furrows on the edge and conserved by all the interview respondents. This practice consists in placing the *milpa* crops into furrows against the slope, following a curve that allows avoiding water runoffs and soil erosion.

Another agricultural practice that is carried out to a lesser extent is the construction of retention walls or banks, it is conserved more in Yareni (64%) and Abejones (54.5%) and to a lesser extent in Analco (30.8%); this is perhaps explained because it is a practice that is considered of greater difficulty due to its high construction cost. Pérez *et al.* (2017) report that they are used in communities of Tlaxcala and Valle de Toluca. It consists in building walls with rocks placed against the slope and sometimes reinforced with tree, shrub or herbaceous vegetation, which helps to improve the support of the walls and keeps them from collapsing (Figure 1).

In turn, the plant species are used as boundaries, firewood and fodder in family units. They are built in the plots destined to the cultivation of bean, wheat and *milpa*, and to

Figure 1. Retention walls in Yareni (left) and individual terraces in Abejones (right).

a lesser proportion in orchards or gardens, which are spaces located close to the farmer's house and where ornamental, fruit trees and vegetables are sown, and animals are bred under the backyard system.

Another important practice was the construction of individual terraces, which 40.9% of people practice in Abejones; a statistically significant difference was found (c^2=18.28; p<0.01) between municipalities. They were built in gardens and consisted in building circular holes around fruit trees (Figure 1); with the objective of capturing rainwater, containing the soil's erosion, forming a zone for organic matter accumulation, and improving the soil's fertility.

Another common practice was the construction of terraces, and a statistically significant difference was found (c^2=60.00; p<0.01) in the municipalities, since it is only practiced by the totality of the producers of Yareni in the *milpa*, bean, broad bean, squash, wheat and pea, primarily. In a study conducted in communities of Valle de Toluca, Estado de México, it is mentioned that they are Pre-Hispanic agricultural practices and have the main function of retaining moisture and soil accumulation to improve the soil's fertility and they are common in mountainous zones (Pérez-Sánchez and Juan-Pérez, 2013). For their part, Lasanta *et al*. (2013) argue that they contribute to having an adequate zone for the production of foods and for environmental value, by contributing to the soil's conservation and taking advantage of water. However, in addition, they have a cultural function by conserving ancestral knowledge, and they have an aesthetic function by constructing an attractive landscape.

Likewise, there is an agricultural practice called leveling, which consists in flattening zones with strong slopes destined exclusively to the construction of housing. A statistically significant difference was found (c^2=23.23; p<0.01) in this agricultural practice between municipalities, since 100% of the inhabitants from Abejones and Analco perform it and only 48% of the inhabitants from Yareni do, which is explained because this municipality has a lower slope and because they prefer flat zones for the construction of their housing.

Practices of physical type

Soil management

This practice is related directly with the control of the soil's fertility through the use of organic fertilizers such as manure from backyard animals, which in addition are a source of food, work power, and economic income for producers. This practice was conducted in a differentiated manner in each municipality and with different frequency. Yareni (56%) was characterized by using bovine, equine, ovine, caprine, rabbit and poultry manure. Instead, in Abejones (36.4%) and Analco (23.1%) the interview respondents used bovine, equine and poultry manure. This is why the amounts of fertilizer used were varied and simple, since it is collected in the backyard and then applied in the cultivation area at the time of performing soil farming or directly at the foot of the plant during the first task, without a composting process. There are family units where it is not used, and it is because they do not have backyard animals. Huerta-Muñoz *et al.* (2019) mention that in Santa María Nepopualco, Puebla, this practice is very similar.

Another practice in fertility control of the soils is the application of domestic wastes such as those from food and animals (feathers, egg shells), ash from the fireplace, and plant residues (leaves and branches) from tree pruning, etc., applying them directly to the soil during the agricultural cycle. In this practice a statistically significant difference was found (c^2=19.72; p<0.01), since in all of the family units from Abejones and Yareni it is common, while in Analco it is conducted by 61.5% of the farmers. The rest of the family units have implemented the elaboration and use of other types of fertilizer; they mentioned that 30.8% produce worm castings and 7.7% bokashi through the use of local inputs that they learned about through the training programs that various government institutions imparted.

A positive correlation was found between the use of inorganic fertilizers and the application of worm castings (r=0.732; p=0.001) and bokashi (r=0.487; p=0.001), which indicates that learning in the elaboration of modern organic fertilizers has decreased the use of chemical fertilizers. In this sense, it was found that 69.9% of the family units use chemical fertilizer in Analco and 100% of the producers in Abejones and Yareni do, in very low amounts, with significant differences between communities (c^2=15.49; p<0.01). In the three communities they use on average two packs of ammonium sulfate or a pack of ammonium sulfate combined with one of 18-46-00 to fertilize a hectare, representing a formula of 20.5-00-00 and 19.2-23-00, very low amount if it is compared to 115-46-00 recommended by Aragón and Suketoshi (2014). They manifest that they use it because they receive it as part of the support provided by government programs, since for them it is very difficult to apply due to the cost and the distance.

Water management

Water management practices are different in the municipalities and they are subject to their culture. In the three municipalities all of the peasants practice and recognize water management by gravity, whose source of supply are the small springs that are generally connected to the water deposits or tanks (Figure 2).

Water distribution is through embankment canals to the cultivation plots by gravity, and within the plots they irrigate through the use of furrows or *melgas* (pieces of land ready for sowing). This type of works contributes to the conservation and the availability of the resource. In this regard, in La Guajira, Colombia, they report the development of ancestral practices for the exploitation, conservation and availability of this resource (Daza-Daza *et al*., 2018). The Tzotzil ethnic group in Chiapas also uses spring water as the main source of supply, and practices have been developed for its exploitation primarily by gravity and haulage. These practices have favored its conservation (Soares, 2007).

In this sense, it is important to highlight that a recent practice that is not as common is harvesting rainwater. In Yareni, 20% of the interview respondents indicated that they use this technique because they suffer from water scarcity in prolonged drought seasons and sometimes in short periods during the rainy season. The technique consists in the construction of waterways on the edges of their house's roofs and in the construction of underground cisterns for its storage. In Abejones, it is practiced by 13.6%, and it is

Figure 2. Small dams for water storage in Analco.

absent in Analco. In this sense, Arboleda (2016) reports that in a rural community from Colombia similar management systems are operated to capture rainwater. In the three municipalities the producers indicated that they built drain canals for the management of rainwater when it is intense, since landslides cause damage to the cultivation plots and their infrastructure.

A statistically significant difference was found (c^2=11.25; p<0.01) between municipalities, with Analco (30.8%) being the place where more water haulage for domestic use was performed, since the springs are close to their households and ease their management. In Abejones, it is 4.5% and this practice is not carried out in Yareni because they are far from the springs. A statistically significant difference was found (c^2=60.00; p<0.01) in spring water management by pumping, since it is practiced by all the inhabitants of Yareni because they are located in the lower part of the basin, which is why pumping is necessary. In this sense, Ocampo-Fletes and Escobedo-Castillo (2006), in farming communities of Puebla, demonstrated different forms of water management since this increases its availability and conservation.

Practices of biological type

Harvest of plants and fungi

Regarding the exploitation of the plants, it was found that all of the interview respondents practice this activity in their territory, especially in cold zones where pine-oak forests are located, and this is where plants of at least five species of pines (*Pinus* spp.) and seven species of oaks and live oaks (*Quercus* spp.) are abundant; the zone is low deciduous forest and agricultural zones. This is why it is considered that it is a common activity in

indigenous zones that allows the exploitation of species without causing deterioration and which favors their conservation (Gómez-Pellón, 2018). The harvest is carried out manually and it is necessary to know the plants. Mainly fruits, seeds, stems and leaves are harvested. Pods and shoots are extracted from species such as huaje (*Leucaena* spp.) and guajilote (*Parmentiera* spp.) for food, without extracting the plant, which benefits their conservation. The harvest of some plants requires the use of traditional tools to allow their efficient reproduction and conservation, which is the case of the plant known as rough horsetail (*Equisetum hyemale* L.), of medicinal use, which is extracted with a straight shovel. Reed (*Arundo* spp.) is extracted with a claw and is used in the three communities to build houses, utensils and handcrafts; and it is only used in rites and ceremonies in the municipalities of Abejones and YareGerritsen *et al*. (2009) argue that in communities of Jalisco, common reed (*Phragmites australis*) is exploited taking into account its conservation and constitutes an important source of income for its inhabitants. Likewise, it is found that in shrub type plants such as poleo (*Satureja macrostema*) are of economic and cultural importance as is the case of the community of San Miguel Mixtepec, Oaxaca, and their harvest (manual and with machete) favors sprouting and allows their conservation (Ortega-Ortega and Vázquez-García, 2014). This happens in the municipalities of study. Other species such as mallow (*Malva* spp.), acacia (*Acacia* spp.), dandelion (*Taraxacum* spp.) and acahual (*Melampodium* spp.), are used for fodder through grazing, without being extracted from their habitat. Tomás and Cuervo (2014) point out that in Spain, through the traditional management of livestock, fodder species are used better by favoring their regeneration and conservation.

There are other wild plants that are part of the cultivation systems that are present in the municipalities of study, which have an indirect management before their harvest, since all the interview respondents mentioned that it consists in maintaining wild species within the cultivation systems, which contribute some benefit and are not detrimental to it (González and Reyes, 2014). In this type of species, edible plants become important such as green amaranth (*Amaranthus hybridus*), watercress (*Nasturtium officinale*), purslane (*Portulaca oleracea*), mustard (*Brassica rapa*), chepiche (*Porophyllum* spp.), green tomato (*Physalis philadelphica* Lam.), etc., and these are harvested during the rainy period both in wild spaces and within the *milpa* area. It is important to highlight that in communities of Chinantla in Oaxaca, herbaceous species associated to the traditional *milpa* cultivation are reported, and they are a substantial part of traditional agroecosystems that favor their conservation (Mateos-Maces *et al*., 2016). These plants as a group are known as *quelites*, and they are also part of the diet and consumption of indigenous families; ecologically, they maintain the diversity of products, participate in the ecological control of pests, soil erosion and fertility, and contribute to retaining soil moisture, etc., in traditional systems (Altieri, 2016).

There is locally another way of managing these types of species before their harvest and it is called promotion or induction, which consists in increasing the density of species within the ecosystem or agroecosystem (Gual and Rendón, 2018). This practice is conducted for the management of species such as pine (*Pinus* spp.) and live oak (*Quercus* spp.), used mainly for firewood, construction, furniture elaboration and tools. For this

purpose, organic wastes are cleared from the forest to allow the fall of seeds, as well as their germination, growth and reproduction. In this sense, a statistically significant difference was found (c^2=60.00; p<0.01) between municipalities; in Abejones and Analco, 100% of the farmers recognized this type of management, and in Yareni it was absent.

Another important resource is the harvest of fungi in the municipalities of study. This practice is carried out by inhabitants based on the complex knowledge that they have about them, and at the same time of their environment, such as growth habits, reproduction season, size, color, etc., which allows not to confuse them with poisonous species. Their harvest takes place in rainy seasons and it is done in a special way, when they are hunting in the forest, collecting firewood or during agricultural activities. From experience, they only harvest edible species, cutting only the fruit and they leave the mycelium, the fungi that are in condition of being consumed, as well as small, old and inedible fungi which are not harvested in order not to affect the system. This way of harvesting is similar to the one conducted in a Purépecha community in Michoacán, where the deterioration of the species is not caused (Servín and Alarcón, 2018). In Analco, it was found that the way of harvesting is very careful due to processes of awareness, knowledge, training, etc.; they cut them with machete or knife, not by hand shaking to spread the spores, and later only the head (pileus) is collected and the stem (stipe) is left, which allows their later reproduction and conservation. Table 1 shows the fungi recognized by inhabitants in the study zone.

Hunting and animal collection

Concerning this theme, it was found that a first way of exploiting wild animal species is collecting or hunting them with the aim of obtaining foods and eliminating the ones considered damaging (pests). Their collection is carried out in Yareni (76%), Analco (69.2%) and Abejones (59.1%), and the ones that stand out for their importance are insects such as cockroaches (order: Blattodea), spiders (order: Aranea), scorpions (order: Escorpión), ants (family: Formicidae) and rodents such as rats (*Ratus* spp.). Reptile species such as coral snakes (*Micrurus* spp.), rattle snakes (*Crotalus* spp.), are exterminated because they are considered to be dangerous. Some species are edible such as bees (*Apis mellifera*)

Table 1. Type of fungi recognized in the study space.

Local name	Indigenous name	Scientific name
Pine tree mushroom	*Be'ya yerhi*	*Neolentinus* spp.
Animal excrement mushroom	*E'ya ixke' kuayu*	*Agaricus* spp.
Milky mushroom	*Be'ya nisi*	*Lactarius* spp.
Beard mushroom	*Bea luxhubesi*	*Hericium* spp.
Big mushroom	*Bea bela*	*Amanita* spp.
Yellow mushroom	*E'ya dee*	*Amanita* spp.
Dear antler mushroom	*E'ya rexhunu*	*Ramaria* spp.
Bird foot mushroom	*Be'ya ni'ini*	*Laccaria* spp.
Bull tongue mushroom	*Be'ya losee*	*Albatrellus* spp.

and grasshoppers (*Sphenarium* spp.). The latter have a high cultural and economic value for the communities of Oaxaca (Sosa *et al*., 2015).

Another way of exploiting the animal species is through hunting by laying traps. There are no differences between municipalities, although 40.9% mentioned they performed this practice in Abejones, while 30.8% in Analco and 24% in Yareni. Hunting is practiced individually or as a group and it is done cautiously and silently, and specifically to obtain food for the family. The first when the peasant goes out to perform field activities (sowing, crop cleaning, harvesting, looking after animals, and collecting plants). They hunt edible birds such as woodpeckers (*Dryocopus* spp.), sparrows (*Passer* spp.), mockingbirds (*Mimus* spp.), roadrunners (*Geococcyx* spp.), chachalacas (*Ortalis* spp.), and sparrow hawks (*Buteogallus* spp.), considered a plague for crops. They also hunt mammals such as opossum (*Didelphis* spp.), fox (*Urocyon* spp.), wild boar (*Pecari* spp.), skunk (*Conepatus* spp.), *cacomixtle* (*Bassariscus* spp.), armadillo (*Dasypus* spp.), coyote (*Canis* spp.).

Hunting mammals is commonly done in an organized way and especially by family groups. It is practiced by expedition with dogs and in hikes, there is a statistically significant difference (c^2=18.28; p<0.01) regarding this variable, with Abejones (40.9%) being the only one that hunts deer (*Odocoileus* spp.), considered as one of the mammals of highest importance in the community. In this context, there is the fact that knowledge and hunting techniques have been developed for its exploitation in Guerrero (López-González *et al*., 2018). Hunting is also conducted by night expedition, and a statistically significant difference was found (c^2=7.23; p<0.02); it is practiced in Analco by 30.8% of interview respondents and in Yareni by 24%, with the most notorious decrease shown in Yareni and absent in Abejones. This type of hunting is present in the community of Santiago Tlatepusco, Chinantla region of Oaxaca, and here it is managed traditionally for fauna management, to strengthen social relationships between members of the group and the community, and this is where the social value of this activity stands out (Ibarra *et al*., 2011).

Rituals

Rituals are conserved in the three municipalities, with a statistically significant difference present (c^2=15.98; p<0.01) between communities. In Abejones (100%), the ritual practiced fundamentally is for the land, which consists in placing a wood cross, offering prayers and making floral offerings with the use of wild species, sacrifice of hens, and "offering" mezcal and beer to the land during important activities of the agricultural cycle; it is done at the beginning of it as an act to ask for permission to farm, to ensure that the crop is free of pests and diseases, and at the end of the harvest as an act of gratitude to the soil. These activities are familiar and with the participation of people who intervene in the mutual help or *Guetza.* In this context, Castillo (2016) describes them when speaking about the worldview of a Mixe community, and defines rituals as practices of gratitude to nature through offerings that include drink, food, sacrifices, prayers and other inputs. Since nature is considered by indigenous people as "sacred", they must maintain a balance with it through a principle of reciprocity, defined by exchanges and acts of gratitude

(Maldonado, 2015). This is contrary to the predatory logic of industrialized zones where nature is considered as a material good (Molina, 2015).

The offerings are practiced in a differentiated way in the three municipalities; in Yareni, 84% practices them and in Analco they are practiced to a lesser extent (46.2%) (c^2=15.98; p<0.01). In these two communities there is a negative correlation between the variable religion and the ritual for the land (r=-0.88; p=0.001), indicating that only inhabitants of the Catholic religion conserve them and that those who belong to another religion no longer share this worldview (García, 2014; Montesi, 2016), with the municipality of Analco being the one most affected.

Another practice of this type is the ritual for water, although it is performed to a lesser extent: in Abejones, 36.4% of inhabitants, in Analco 30.8%, and in Yareni 16%. This ritual consists of making offerings to the various and intermittent bodies of water (springs) located in the forest zone that interconnect to the supply tanks for human consumption. They take place especially in the rainy season and as an act of gratitude to the water's owner; each community performs offerings once per year. This result is similar to that found in the Province of Imbabura, Ecuador, since similar water rituals are conducted here as an act of gratitude, emphasizing respect towards this resource, where this act favors its care and equitable distribution (Trujillo *et al.*, 2018). In relation to the ritual for the mountain, it was found that it is practiced in Abejones (18.2%), Yareni (16%) and it is no longer practiced in Analco. As a family, small altars are placed in the field adorned with wild flowers; families pray, offer food, drink such as mezcal and beer to the mountains to ask for healing or for the recovery of a member of the family. In addition, they ask for water, an abundance of resources and harvests.

In the study space, the ritual for animals has decreased, as well as their conservation. Abejones (49%) is the place where this practice is conserved most, and it decreases in Analco (30.8%) and Yareni (20%). This ritual is performed specifically by hunters and they do it when the hunter is initiated in these activities or at times when the probability of hunting decreases. The act consists in sacrificing domestic animals (chickens or turkeys) to pour blood on the ground or simply perform prayers while pouring drink (mezcal, soft drinks or beer) on the soil to make an exchange with the "owner" of the animals. They consider that the "owners" are supernatural beings and intermediaries between nature and human beings; this impacts the adequate use of nature (Campanera, 2018). This result is very similar to the one found in Maya communities in Yucatán, where they mention that the "owners" of the animals are the ones that take care of them, and that they affect hunters if they do not comply with the rules of exploitation of animal species (Herrera-Flores *et al.*, 2018).

CONCLUSIONS

It can be said that the municipalities of study still conserve their agricultural practices for the exploitation and management of their natural resources, and many of them favor the conservation of natural resources. It can be indicated that it is not a local practice, since it is present in various spaces of indigenous communities in the world. Among the

agricultural practices, the management of the land slope stood out in the municipalities of study; it was found that individual terraces are conserved in Abejones and in Yareni, terraces. Instead, Abejones and Analco are distinguished by performing leveling practices for the construction of housing. The morphology of the land plays an important role here, to conduct or undertake one or another agricultural practice. When it comes to soil fertilization, it was found that inhabitants maximize their resources efficiently, and they use manures of animal origin and domestic wastes. However, although to a lesser extent, they are also implementing new fertilization techniques with the use of worm castings and bokashi. These fertilization techniques are helping to decrease the use of chemical fertilizers.

In water management, they have small dams and they harvest rainwater; the latter is a technique that has recently been used to supply water to the family, their crops and backyard animals. These results indicate that farmers adapt new techniques that contribute to improving their family production unit. Another resource that indigenous communities use is the diverse plants and fungi, through harvesting, tolerance and promotion; the latter is practiced in Abejones and Analco. They also use wild animal species through hunting, and it is performed through manual hunting, by laying traps, and with expedition with dogs. The latter is practiced in Abejones, and hunting by expedition at nights is practiced in Analco and Yareni. This reaffirms that resources are exploited not only from the family production unit, but also the animal and plant resources offered by nature.

However, for the exploitation of resources obtained by inhabitants, both in their production unit and in nature, they perform rituals to ask the gods for their permission to adequately take advantage of natural resources. Of the rituals that are still conserved, there are rituals for animals, the land, water and mountains. In the conservation of these traditions, factors such as religion and age intervene; that is, these variables influence the loss or conservation of these rituals. It is important to highlight that despite economic globalization, peasants and indigenous people continue to celebrate their rituals to obtain their resources rationally, both those from agriculture and those from nature.

REFERENCES

Altieri, MA. 2016. Los quelites: usos, manejo y efectos ecológicos en la agricultura campesina. Leisa Revista de Agroecología, 32(2), 28-29.

Aragón, CF, y Suketoshi S. 2014. VC-152, nueva variedad de maíz para los Valles Centrales de Oaxaca. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA) e Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP). pp: 17-18.

Arboleda, MN. 2016. Diagnóstico del sistema de aprovechamiento del agua lluvia en el consejo comunitario de la comunidad Negra de los Lagos, Buenaventura. Revista Luna Azul, (43), 29-55. https://dx.doi.org/10.17151/luaz.2016.43.3

Barabas, AM. 2008. Cosmovisiones y etnoterritorialidad en las culturas indígenas de Oaxaca. Antípoda. Revista de Antropología y Arqueología, (7), 119-139. https://doi.org/10.7440/antipoda7.2008.06.

Campanera, RM. 2018. Humanidad territorializada. Madres, dueños y personas que cuidan. AIBR. Revista de Antropología Iberoamericana, 13(2), 189-212. https://doi.org/10.11156/aibr.v13i2.68518.

Castillo, CM del C. 2016. Los que van al cerro: imágenes de la cosmovisión mixe en Oaxaca, México. *In*: B. Carrera M, y Z Ruiz R. (eds). Abya Yala Wawgeykuna. Artes, saberes y vivencias indígenas americanos. España: Acer-VOS. pp: 134-151

Daza-Daza, AR, Rodríguez-Valencia N, y Carabalí-Angola A. 2018. El recurso agua en las comunidades indígenas

wayuu de La Guajira Colombiana. Parte 1: una mirada desde los saberes y prácticas ancestrales. Información Tecnológica, 29(6), 13-24. http://dx.doi.org/10.4067/S0718-07642018000600013

García, MC. 2014. Aculturación del pueblo indígena mixe, Oaxaca, México. Estudios Históricos, (12).

García-del Barrio, L, Pina ILJ, y Pueyo VJC. 2011. La relación entre el tutor y el residente: la entrevista estructurada y algo más. Radiología, 2(53). 102-107. https://doi.org/10.1016/j.rx.2010.09.010.

Gerritsen, PRW, Ortiz-Arrona C, y González-Figueroa R. 2009. Usos populares, tradición y aprovechamiento del carrizo: estudio de caso en la costa sur de Jalisco, México. Economía, Sociedad y Territorio, 9(29), 185-207.

Gómez-Pellón, E. 2018. Sostenibilidad del medio rural y patrimonio inmaterial: a propósito de los conocimientos tradicionales de las plantas. Scripta Nova, 22(590). https://doi.org/10.1344/sn2018.22.19772.

González, JA, y Reyes ML. 2014. El conocimiento agrícola tradicional, la milpa y la alimentación: el caso del Valle de Ixtlahuaca, Estado de México. Revista de Geografía Agrícola, (52-53), 21-42. https://doi.org/10.5154/r.rga.2014.53.002.

Gual, DM, y Rendón CA. 2018. Manejo y aprovechamiento. *In*: Gual, DM. (ed). Taxonomía de los usos y manejo de la biodiversidad de México para la construcción de sistemas de información. México: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. pp: 135-146.

Hamui-Sutton, A. 2013. Un acercamiento a los métodos mixtos de investigación en educación médica. Investigación en educación médica, 2(8), 211-216. https://doi.org/10.1016/S2007-5057(13)72714-5

Herrera-Flores, BG, Santos-Fita D, Naranjo EJ, y Hernández-Betancourt SF. 2018. Creencias y prácticas rituales en torno a la cacería de subsistencia en comunidades del norte de Yucatán, México. Etnobiología, 16(1), 5-18.

Huerta-Muñoz, E, Cruz-Hernández J, y Aguirre-Álvarez L. 2019. La apreciación de abonos orgánicos para la gestión local comunitaria de estiércoles en los traspatios. Estudios sociales, 29(53). https://dx.doi.org/10.24836/es.v29i53.702.

Ibarra, JT, Del Campo C, Barreau A, Medinaceli A, Camacho CI, Puri R, y Martin GJ. 2011. Etnoecología chinanteca: conocimiento, práctica y creencias sobre fauna y cacería en un área de conservación comunitaria de la chinantla, Oaxaca, México. Etnobiología, 9(1), 37-59.

INEGI (Instituto Nacional de Estadística y Geografía). 2013. Conociendo Oaxaca. México. INEGI.

INEGI (Instituto Nacional de Estadística y Geografía). 2005a. Prontuario de información geográfica municipal de los Estados Unidos Mexicanos. Ecatepec de Morelos, México. Pág. Web: http://www.inegi.org.mx/contenidos/app/mexicocifras/datos_geograficos/20/20001.pdf.

INEGI (Instituto Nacional de Estadística y Geografía). 2005b. Prontuario de información geográfica municipal de los Estados Unidos Mexicanos. In: https://www.inegi.org.mx/contenidos/app/mexicocifras/datos_geograficos/20/20359.pdf.

INEGI (Instituto Nacional de Estadística y Geografía). 2005c. Prontuario de información geográfica municipal de los Estados Unidos Mexicanos. In: http://www.inegi.org.mx/contenidos/app/mexicocifras/datos_geograficos/20/20196.pdf.

INEGI (Instituto Nacional de Estadística y Geografía). 2016. Panorama sociodemográfico de Oaxaca 2015. México, Aguascalientes: INEGI.

INALI (Instituto Nacional de Lenguas Indígenas). 2009. Catálogo de las Lenguas Indígenas Nacionales. Variantes lingüísticas de México con sus autodenominaciones y referencias geoestadísticas. México: INALI.

Jiménez, SCL, Sosa RJ, Cortés-Calva P, Breceda SCA, Íñiguez DLI, y Ortega-Rubio A. 2014. México país megadiverso y la relevancia de las áreas naturales protegidas. Investigación y Ciencia, 22(60), 16-22.

Lasanta, T, Arnaéz J, Ruiz FP, y Renault MNL. 2013. Los bancales en las montañas españolas: un paisaje abandonado y un recurso potencial. Boletín de la Asociación de Geógrafos Españoles, (63), 301-322. http://dx.doi.org/10.21138/bage.1616.

López-González, M, Bustamante-González A, Vargas-López S, Morales-Jiménez J, Pérez-Ramírez N, Guadarrama-Luyando R, y Díaz-Hernández H. 2018. Conocimiento y aprovechamiento local del venado cola blanca (Odocoileus virginianus mexicanus) en Iliatenco, Guerrero. Agroproductividad, 11(10), 127-132. https://doi.org/10.32854/agrop.v11i10.1256.

Maldonado, AB. 2015. Perspectivas de la comunalidad en los pueblos indígenas de Oaxaca. Bajo el Volcán, 15(23), 151-169.

Mateos-Maces, L, Castillo-González F, Chávez JL, Estrada-Gómez SJA, y Livera-Muñoz M. 2016. Manejo y aprovechamiento de la agrobiodiversidad en el sistema milpa del sureste de México. Acta Agronómica, 65(4), 13-421. http://dx.doi.org/10.15446/acag.v65n4.50984.

Millán-Rojas, L, Arteaga-Reyes TT, Moctezuma-Pérez S, Velasco-Orozco JJ, y Arzate-Salvador JC. 2016. Conocimiento ecológico tradicional de la biodiversidad de bosques en una comunidad matlatzinca, México. Ambiente

y Desarrollo, 20(38), 111-123. https://doi.org/10.11144/Javeriana.ayd20-38.cetb.

Molina, BVA. 2015. Existencia equilibrada. Metáfora del buen vivir de los pueblos indígenas. Polis, Revista Latinoamericana, 14(40), 143-163. http://dx.doi.org/10.4067/S0718-65682015000100008

Montesi, L. 2016. Vivir en (dis)continuidad: reconfiguración de subjetividades religiosas en una comunidad ikojts de Oaxaca. Desacatos, (50), 122-137. DOI: https://doi.org/10.29340/50.1545.

Moreno-Calles, AI, Toledo VM, y Casas A. 2013. Los sistemas agroforestales tradicionales de México: una aproximación biocultural. Botanical Sciences, 91(4), 375-398.

Ocampo-Fletes, I, y Escobedo-Castillo JF. 2006. Conocimiento tradicional y estrategias campesinas para el manejo y conservación del agua de riego. Ra Ximhai, 2(2), 243-371.

Ordóñez, M de J, y Rodríguez P. 2008. Oaxaca, el estado con mayor diversidad biológica y cultural de México, y sus productores rurales. Ciencias, (91), 54-64.

Ortega-Ortega, T, y Vázquez-García V. 2014. Satureja macrostema: situación ambiental, conocimiento local y roles de género. Madera y Bosques, 20(2), 71-86. https://doi.org/10.21829/myb.2014.202165.

Otzen, T, y Manterola C. 2017. Técnicas de muestreo sobre una población a estudio. International Journal of Morpholgy, 1(35), 227-232. http://dx.doi.org/10.4067/S0717-95022017000100037.

Pérez, SJM, Moctezuma PS, Sales JC, Reyes ML, y Juan PJI. 2017. Manejo del suelo en la agricultura tradicional de laderas en Tlaxcala y el Valle de Toluca, México. *In*: F. Carreño M., C. Rodríguez S. y J. A. Castellanos (eds). Patrimonio biocultural. Experiencias integradoras. México: Universidad Autónoma de Chapingo, México. pp: 79-99.

Pérez-Sánchez, JM, y Juan-Pérez JI. 2013. Caracterización y análisis de los sistemas de terrazas agrícolas en el Valle de Toluca, México. Agricultura, Sociedad y Desarrollo, 10(4), 397-418. https://doi.org/10.22231/asyd.v10i4.133.

Reyes-García, V, y Martí Sanz N. 2007. Etnoecología: punto de encuentro entre naturaleza y cultura. Ecosistemas, 16(3), 45-54.

Richeri, M, Cardoso MB, y Ladio A. H. 2013. Soluciones locales y flexibilidad en el conocimiento ecológico tradicional frente a procesos de cambio ambiental: estudios de caso en Patagonia. Ecología Austral, 23, 184-193. http://dx.doi.org/1667-782X.

Servín, CLS, y Alarcón-Cháires PE. 2018. Conocimiento tradicional de los hongos silvestres comestibles en la comunidad p'urhépecha de Comachuén, Nahuatzen, Michoacán. Acta Universitaria, 28(1), 15-29. http://dx.doi.org/10.15174/au.2018.1277.

Soares, D. 2007. Acceso, abasto y control del agua en una comunidad indígena chamula en Chiapas. Un análisis a través de la perspectiva de género, ambiente y desarrollo. Región y Sociedad, 19(38), 25-50. https://doi.org/10.22198/rys.2007.38.a556.

Sosa, MY, Pérez PR, González PGE, Manzanero MGI, y Rodríguez-Ortiz G. 2015. Conocimiento tradicional y valor cultural de *Sphenarium* spp. En valles centrales de Oaxaca. Revista Mexicana de Agroecosistemas, 2(2), 75-86.

Toledo, VM. 1991. El juego de la supervivencia. Un manual para la investigación etnoecológica en Latinoamérica. Chile: Consorcio Latinoamericano de Agroecología y Desarrollo.

Toledo, VM, y Barrera-Bassols N. 2008. La memoria biocultural. La importancia ecológica de las sabidurías tradicionales. España: Icaria.

Tomás, CR, y Cuervo MA. 2014. Conocimiento local y culturas tradicionales como base para el desarrollo sostenible: El caso del uso y manejo de las dehesas de encina en el suroccidente peninsular. Etnicex, (6), 21-43.

Trujillo, CA, Moncada RJA, Aranguren CJR, and Lomas, TKR. 2018. Meanings of water for the Fakcha Llakta indigenous community of Otavalo, Ecuador. Ambiente & Sociedade, 21. http://dx.doi.org/10.1590/1809-4422asoc0100r3vu18l1ao.ma.