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Indicators of sustainability with emphasis on the state of conservation of the tropical dry forest

Indicadores de sostenibilidad con énfasis en el estado de conservación del bosque seco tropical

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ABSTRACT

Tourism planning processes are developed under sustainability indicators. For this reason, decision-makers and planners need management tools to assess the degree of sustainability, in particular biological indicators. This research was carried out within the protected area of Machalilla National Park, with the objective of determining sustainability indicators, with emphasis on the conservation status of the tropical dry forest of the commune of "Agua Blanca", within the framework of the project "Sustainability indicators for environmental management focused on tourism. Phase 1. Methodological theoretical references". For the identification of species with potentialities for key biological indicators based on their representativeness, singularity and monitoring possibility, a simple random probabilistic sampling was carried out through the establishment of 28 transects of 20 m x 100 m, with a group of variables such as height, abundance, diameter, basal area and frequency. Harvesting practices were also considered in relation to the conservation status of these species. Criteria and indicators were generated for the qualification of conservation objects, as well as the key ecological attributes of the "Agua Blanca" commune and forest species as biological indicators, aimed at biodiversity conservation, which constitutes a useful tool for restoration in the context of Ecuador's dry forests.

Keywords: ecology; ecotourism; species; conservation of biodiversity.

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RESUMEN

Los procesos de planificación turísticas se desarrollan bajo indicadores de sostenibilidad. Por tal razón, los decisores y planificadores necesitan contar con los instrumentos de gestión que les permitan evaluar el grado de sostenibilidad, en particular indicadores biológicos. Esta investigación se realizó dentro del área protegida Parque Nacional Machalilla, con el objetivo de determinar los indicadores de sostenibilidad, con énfasis en el estado de conservación del bosque seco tropical de la comuna "Agua Blanca", en el marco del proyecto "Indicadores de sostenibilidad para la gestión ambiental enfocada al turismo. Fase 1. Referentes teóricos metodológicos". Para la identificación de las especies con potencialidades para indicadores biológicos claves en base a su representatividad, singularidad y posibilidad de monitoreo, se realizó un muestreo probabilístico aleatorio simple mediante el establecimiento de 28 transectos de 20 m x 100 m, con un grupo de variables como la altura, la abundancia, el diámetro, el área basal y la frecuencia. También se consideraron las prácticas de aprovechamiento en relación con el grado de conservación de esas especies. Se generaron criterios e indicadores para la calificación de los objetos de conservación, así como los atributos ecológicos claves de la comuna "Agua Blanca" y especies forestales como indicadores biológicos, encaminados a la conservación de la biodiversidad, lo que constituye una herramienta útil para la restauración en el contexto de los bosques secos del Ecuador.

Palabras clave: ecología; ecoturismo; especies; conservación de biodiversidad.

INTRODUCTION

The global plan of action for the conservation, sustainable use and development of forest genetic resources, Food and Agriculture Organization of the United Nations, FAO, (2014), states that Forest Genetic Resources (FGR) are the hereditary material found within and among species of woody plants and trees, which have real or potential social, scientific, environmental or economic value. According to this international organization, FGRs are essential for the adaptation and protection of ecosystems, landscapes and production systems; however, they are subject to increasing pressures and unsustainable use.

Among the priority areas (PA) of the aforementioned plan (FAO, 2014) is PA 1: improving the availability of and access to information on forest genetic resources, which in its strategic priority four provides for promoting the establishment and strengthening of information systems (databases) on forest genetic resources in order to encompass available traditional and scientific knowledge on the uses, distribution, habitats, biology and genetic variation of species and their populations.

In Latin America, forests face major challenges from deforestation (which peaks in the region), forest degradation, climate change, poverty and food insecurity. Other problems relate to the loss of genetic resources and irreplaceable social and cultural attributes (FAO, 2013). In this sense, this work aims to build categories for conservation objects, key ecological attributes, indicators and make a current qualification for the commune "Agua Blanca", in the context of the dry forests of Ecuador.

Ecuador is an environmentally diverse country, classified into three major continental physiographic regions: The Coast, the Highlands and the Amazon National Biodiversity Institute (INB, 2015). According to this institution, the loss of forest habitats in Ecuador, added to the historical losses, mainly during the first 70 years of the twentieth century, form a country with areas ecologically compromised in their capacity to host viable populations and sustain ecosystem processes in the medium and long term.

Ecuador's biological diversity, knowledge, practices, innovations and associated technologies are recognized by Ecuadorian society as one of the most important strategic resources of the State, protected as an essential part of its heritage and managed in such a way that the goods and services generated contribute to the sustainable development of the country and to the good living of its citizens, Ministry of the Environment (MAE, 2016).

The gaps in the generation of information related to criteria and indicators for the current qualification of conservation objects, key ecological attributes of the commune "Agua Blanca", constitute the problem of the investigation, for which a sample was made by the method of transects in the path "Shadow of the carob trees", through which it was possible to deepen the composition and structure of the forest, to understand the level of conservation and the way in which human intervention influences, through the impacts of the practices or techniques used by the community members during the harvesting of timber and non-timber products, with a minimum footprint in the ecosystem from which they benefit in a sustainable manner.

n view of the above, it is hypothesized that a set of sustainability indicators will guarantee a responsible environmental management focused on the conservation of the tropical dry forest of the "Agua Blanca" commune, based on the knowledge of its conservation status; likewise, it will make it possible to categorize the conservation objects, the key ecological attributes that generate elements for the subsequent monitoring of the conservation status of the forest of the "Agua Blanca" commune, in addition to the impact caused by the exploitation activities generated for local benefit. The objective of this work was to determine the sustainability indicators of the "Agua Blanca" commune with emphasis on the conservation status of the tropical dry forest, and it is the result of one of the tasks of the project "Sustainability indicators for environmental management focused on tourism. Phase 1. Theoretical methodological references", in which professors and students of forestry engineering and tourism careers were integrated in the State University of the South of Manabí.

MATERIALS AND METHODS

Area of study

The community "Agua Blanca" is located in the province of Manabí, Puerto López canton, of the Machalilla parish, 12 km from Puerto López, approximately 5 km from the main road Jipijapa-Puerto López and 80 meters above sea level. It is bordered to the north by the Machalilla parish, to the south by the Chongón and Colonche mountain ranges, to the east by the Julcuy parish and to the west by the main Jipijapa-Puerto López road.

The community is crossed by the Buenavista River, which goes from the parish of La América, Jipijapa canton, to Puerto López, flowing into the Pacific Ocean. The influence of the Humboldt stream and the El Niño stream, as well as the orographic conditions have made the territory located in special zones. From May to October, and until December 14, a permanent garúa is produced, with variable intensity, according to the degree of cooling of the sea waters. As a consequence of these factors there are two defined zones: Dry Forest and Tropical Forest. Between February and April there is the highest rainfall, the average annual rainfall is 424 mm, with an evaporation of 879 mm. The relative humidity reaches 84%, the average annual temperature is 24 ºC (CLIMATE-DATA.ORG, 2015).

Methodology

Visits of approach to the commune "Agua Blanca" were carried out, followed by exploratory tours of field, to know the main natural, archaeological values and aspects of the culture manteña. Visits were made to the "Agua Blanca" commune to request permits for research; in addition, we participated in the workshops and talks carried out within the framework of the project "Sustainability indicators for environmental management focused on tourism. Phase 1. Theoretical and methodological references", from the Tourism course of the South Manabí State University PROG-002-DIP.PROY. CONV-001-DIP- (2017), to which Ecotourism-Forest belongs, and whose objective of the project was to define a system of environmental indicators designed for tourist destinations, taking into consideration the territorial dimension in some localities of the southern zone of Manabí.

The empirical method of the interview and the survey was used. The first was conducted with key informants, who in this commune are represented by local leaders and tour guides. The survey (Annex 1) was carried out with the objective of investigating the socio-cultural, economic and ecological aspects of the sample. Statistical procedure

Once the population linked to the activities in the forest and its biological components were known (in "Agua Blanca" 36), the number of people to be surveyed was calculated, using the formula proposed by Morales (2012), as a result of which 34 people were surveyed. According to these authors, when the size of the population is known, the necessary sample is smaller and its size is determined by Equation (1):

$$n=N/((1+e^2(N-1)) /z^2pq) \quad (1)$$

Where:

n= size of the sample we want to know.
N= known population size.
e: expected error. And since no error greater than 3 % is required, e = 0.03.
z= 1.96 for a 95 % confidence level,
α = 0.05.
pq: population variance = 0.25.

According to Morales (2012), since the variance of the population is unknown, the greatest possible variance is placed, because the greater the variance, the greater the need for a greater sample. The variance in the dichotomous items (two mutually exclusive responses) is equal to pq and the greater variance (the greater diversity of responses) is given when p = q = 0.50 (half of the subjects respond yes and the

other half respond no) so that in this formula [1] pq is always equal to (0.50) (0.50) = 0.25 (it is a constant).

e: error expected to be made. And since no error greater than 3 % is required, e = 0.03.

The survey included 12 questions aimed at finding out about the direct and indirect uses and associated values of the tropical dry forest of the "Agua Blanca" commune. These were divided into five blocks called surveys, uses, motivations (in the motivations block there are two blocks: one seeks the reason why the villagers are based on forest conservation, governed by the laws for being part of the Machalilla National Park (MNP) and its criteria, while the other side seeks what is the interest, importance or cultural beliefs to conserve the forest) and values, focused on different interests, such as ecosystem services, forest conservation, cultural, tourism potential, spiritual and others.

Block one is considered a survey. It looks for information about the origin of the inhabitants of the commune "Agua Blanca". The information collected is based on how long they have lived in the commune and how they arrived, thus identifying the birth rate and migration that exist and what are the reasons for migrating to the commune.

Block two considered the uses. The different uses that people give to the forest were investigated. The use is understood as the effective use of the good or service. This block explains the relationship between people and the forest, evidenced through the use of the goods and services it offers, as well as flora and fauna. The data here were catalogued in three ways: use of useful forest plants, use of useful trees within the forest, and use of wild animals by them.

Block three considered the motivations, the search for information on the reasons that motivate or could motivate the inhabitants to conserve the forest, expressed in the criteria on which the community members base the conservation of the forest as part of a protected area, in this case the MNP.

To construct categories for conservation objects, the size of the conservation object, its condition, and the landscape context were taken into account (Negrete *et al.,* 2015; Orozco, Romero, and Rudas, 2018).

Size is a measure of the area or abundance of the locations of the conservation object. For the "Agua Blanca" commune, the size is the area covered by that property, in this case 55 000 ha. For species of plants and animals, the size takes into account the area of occupation and number of individuals, in "Agua Blanca" on the trail "la sombra de los algarrobos" with a length of 4.4 km, 28 transects of 2,000 sq. m. were established, for a total of 5.6 ha sampled.

The condition is an integral measure of the composition, structure and biotic interactions that characterize the location, expressed by the IVIE obtained from the "Agua Blanca" sampling. This includes factors such as: reproduction, age structure, biological composition, the presence of characteristic patch types in ecological systems, evidenced by the dominance of *Prosopis pallida* in the path "The shadow of the carob trees".

The landscape context is an integral measure of two factors: the dominant environmental regimes and processes that establish and manifest the location of conservation objects and connectivity. Connectivity includes factors such as: species' access to the habitats and resources necessary to complete their life cycle, as is the case of the characteristic tropical dry forest species of the "Agua Blanca" commune; the fragmentation of communities and ecological systems, expressed in the spatial distribution of the species that have determined the microlocalization of ecotourism trails. Finally, the ability of any conservation object to respond to environmental changes through dispersion, migration or recolonization, expressed in the role played by local fauna (goats, zainos, birds, among other wild animals), which contribute to the dispersion of these species. The recolonization expressed in the dominance of the *Prosopis pallida* species in the sampling sites.

The indicators proposed in this research were constructed from the criteria of Larrea *et al.,* (2015), which set out the theoretical bases for the development of state and response indicators, based on attributes, indicators and scales; and from the theoretical bases for the development of driving force and pressure indicators, all in close relation with the National Biodiversity Strategy (NBS), the Aichi goals proposed by the secretariat of the Convention on Biological Diversity (CBD).

The criteria of Negrete *et al.,* (2015) and Orozco, Romero and Rudas (2018) were taken into account in order to issue a current rating for the "Agua Blanca" commune. These indicators have a direct relationship with contributing to or complying with at least one of the results of the NBS and, consequently, with the Aichi goals proposed by the CBD, which corresponds to what is proposed for the implementation of the relevant public policies contained in the GNP. Likewise, these indicators serve to monitor the integrity of the ecosystem, in addition to the contribution that could be generated from the ENB.

RESULTS AND DISCUSSION

Results of the survey, related to the assessment of the territorial context of the commune "Agua Blanca", with emphasis on its sustainable development from the perspective of sustainability.

The majority of respondents were between 38 and 47 years old. Almost 50 % of the respondents are women, reflecting the fact that female participation is active in the commune. According to the data obtained, the level of academic studies is of regular state; 50 % of the respondents have a primary education preparation.

Table 1 presents the results of the frequency distribution of the educational levels of the people in the "Agua Blanca" commune, as well as their distribution by gender (Table 1).

Table 1. - Distribution by educational level of respondents between genders, expressed as a percentage

Datos	Ninguno%	1° de primaria %	3° de primaria %	Primaria %	Secundaria %	Total %
Masculino	5,9	0	2,9	20,6	23,5	52,9
Femenino	5,9	5,9	0	29,4	5,9	47,1
Total	11,8	5,9	2,9	50,0	29,4	100

Table 2 shows the results of the investigation related to the time they have been living in the "Agua Blanca" commune (Table 2).

Table 2. - Time of residence and how it arrived in the commune, expressed in years and in percentages respectively

Cómo llegó a la comuna / Tiempo viviendo en la comuna	Nació aquí %	Casado %	Familiar %	Por trabajo %	Otras causas %
1-5 años					
5-10 años					
más de 10 años	88,24	2,94	2,94	2,94	2,94

The results of the surveys carried out to the inhabitants of the commune "Agua Blanca" demonstrated the place occupied by women in the community, which corroborates what Deere, Lastarria-Cornhiel and Ranaboldo (2011), who stated that, for rural women, the importance of the place is a source of life and a factor of production; a deep and multiple dimension that gives meaning to their life and their role before the family group, constituting their identity. Strengthening women's access to and control over land is not only a question of agricultural development and food security, but also of human rights and justice for women.

The results of the questions in block three showed that 88 % of the respondents consider it important that their commune be part of the MNP, one of the reasons why this forest is not destroyed or unreasonably harvested**.**

In relation to ecosystem goods and services, Figure 1 presents the results of question 10, which asked whether these people recommend visiting the "Agua Blanca" commune.

The reasons why "Agua Blanca" respondents recommend visiting the commune, in particular the ecotourism trails, are related to its main source of net income, since, to walk the trails, at the main entrance everyone must pay 5.00 U.S. dollars, which, with an average of 300 visitors per month, the income reaches 1 500 dollars, only for entrance to the commune premises. If visitors buy handicrafts, food, fruits, among others, income rises (Figure 1).

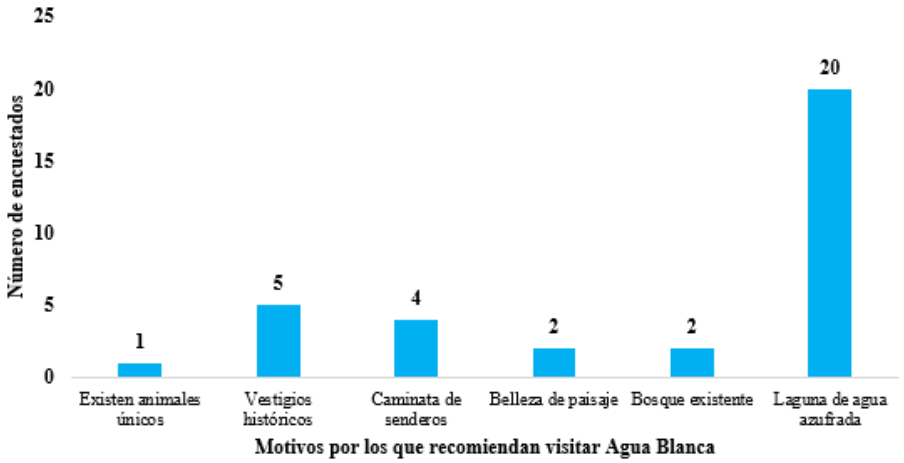

Fig. 1. - Reasons why "Agua Blanca" respondents recommend visiting the site

The perception that the inhabitants of the commune "Agua Blanca" have of the protection of the forest is due to the fact that their greatest motivation in protecting this ecosystem is that it constitutes their main source of employment and income; on the other hand, it was verified that these people feel this place as a legacy received from their ancestors and in this way they demonstrate how to express it (Figure 2). Another of the justifications to protect this forest is the diversity of wild animals that inhabit it and that are added to the income from bird watching, which makes tourists from all over the world that visit the commune.

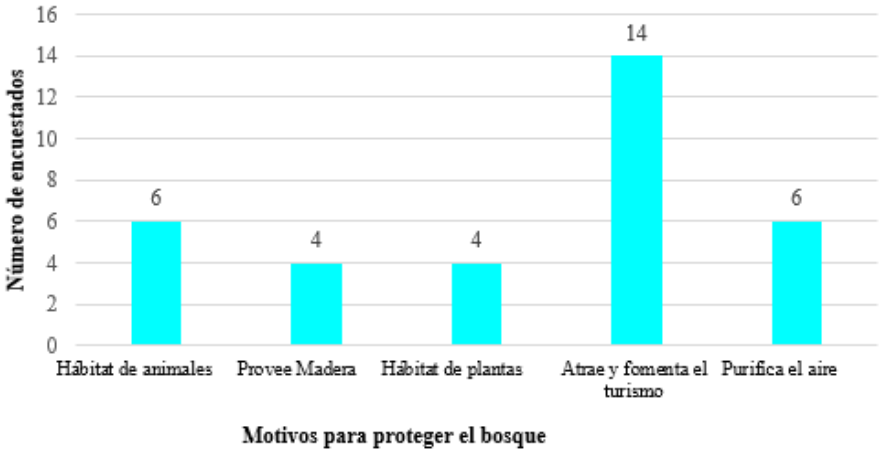

Fig. 2. - Reasons why "Agua Blanca" respondents agree to protect the forest

The results of question 12, block five, showed that the residents are waiting for the conservation of the forest because it is their way of living day by day, as evidenced by the 25 % of the people surveyed who consider that without the forest and its attractions the entrance of tourists to the community would not exist. In his opinion, Mr. Franklin Joselo Ventura Asunción, considers it important to conserve the forest "for preserving the natural and cultural heritage", given the beliefs, customs and ancestral legacy that they have in their commune and are very present within the young inhabitants, demonstrated in the opinion of one of the surveyed participants of 21 years of age named Kassandra Ventura:

"My community is a quiet and welcoming place and not to destroy nature, because it is a sacred commune".

Among the reasons that prevent the inhabitants of "Agua Blanca" from destroying the ecosystem are: the conservation of plant species, the promotion of tourism, an activity that is the main source of work and income in the commune, the existing biodiversity, air purification, landscaping, and animal conservation. Others argued the cultural heritage of the commune referred to by Mr. Franklin Joselo Ventura Asunción.

Results of the construction of categories for the objects of conservation, key ecological attributes, indicators and current qualification of the commune "Agua Blanca".

The assessment of the territorial context of the "Agua Blanca" commune, with emphasis on its development from the perspective of sustainability in relation to the NBS and concerning the AICHI goals, gave the following indicators (Table 3).

Table 3. - Proposed attributes and indicators for the tropical dry forest of the commune "Agua Blanca"

Atributo	Indicador	Escala	Relación ENB
Fuerzas motoras económicas	1. Índices de diversificación y concentración económica del empleo	Presión e impacto	Resultado 2
Composición	2. Cambio en los patrones de riqueza de especies de flora en el bosque seco tropical de la comuna Agua Blanca en base a su distribución geográfica remanente	Especie	Resultado 14
	3. Diversidad de la comunidad de plantas vasculares	Comunidades	Resultado 7 y 16
	4. Índice de biodiversidad y riqueza ecológica de especies y hábitats	Ecosistema y especies	Resultado 8
Estructura	5. Diversidad estructural de los bosques del Ecuador	Paisaje	Resultado 7 y 16

In a more summarized form, it can be observed the distribution of each one of the categories, attributes, scales and qualification of the indicators already identified, of which an overall result per indicator was added, reflecting the expected conservation and sustainability approach (Table 4).

Table 4. - Categories, scale attributes, indicator ratings and results

Objeto de conservación	Categoría	Atributo clave ecológico	Indicador	Calificación actual	Resultados
Bosque seco tropical de la comuna Agua Blanca	**Fuerzas motoras económicas**	Presión e impacto	1. Índices de diversificación y concentración económica del empleo.	Muy Bueno	Contribuir con la protección del bosque, el conocimiento de usos tradicionales, manejo y aprovechamiento que permita establecer parámetros para la regulación de estas actividades usadas por la comuna.
	Composición	Especie	2. Cambio en los patrones de riqueza de especies de flora en el bosque seco tropical de la comuna Agua Blanca en base a su distribución geográfica remanente	Muy bueno	Conservar el ecosistema representativo del PNM y el de la comuna Agua Blanca que ofrecen condiciones para el mantenimiento de la biodiversidad a nivel local y regional.
		Comunidades	3. Diversidad de la comunidad de plantas vasculares	Muy bueno	
		Ecosistema y especies	4. Índice de biodiversidad y Riqueza ecológica de especies y hábitats	Muy bueno	
	Estructura	Paisaje	5. Diversidad estructural de los bosques del Ecuador	Muy bueno	La diversidad hace referencia a la variedad de arreglos espaciales de la vegetación asociada al tipo de ecosistema en que se encuentra el bosque y a los sitios de importancia cultural para el uso y manejo del territorio y la biodiversidad que se encuentran al interior del parque y la comuna y así contribuir con la protección del bosque asociados al uso material e inmaterial realizado por la comuna.

Regardless of age, educational level and gender, it seems to suggest that future strategies for the management and conservation of the tropical dry forest of the "Agua Blanca" commune do not require specific interventions to include the differentiated perception by these groups. However, as suggested by other researchers, the analysis of socioeconomic and demographic variables is relevant to the design of strategies for the management and conservation of tropical dry forests, which include the voice of more vulnerable groups, such as youth, women and people with different levels of education.

With the indicator of the indices of diversification and economic concentration of employment, with the attribute of driving and economic forces at the scale of

pressure and impact, the increase in food security was measured from the perspective of its economic, social and environmental value; at the same time as forest cover is maintained or increased. This ratifies the dependence of the inhabitants of the "Agua Blanca" commune on the use, uses and benefits of the goods and services of the forest.

In the indicators of diversity of the vascular plant community and the index of biodiversity and ecological richness of species and habitats, with the attribute of composition at the scale of species, community and ecosystem, reference is made to the number of organisms that compose an ecosystem, including their abundances and frequencies, generally reported at the level of measurements, generating indexes of richness and diversity of species.

In table 3, the attributes and indicators for the study area were presented. According to Larrea *et al.,* (2015), a planning exercise should include a proposal for indicators that can be monitored to improve knowledge about the conservation status of several key components of biodiversity, as well as the impacts resulting from the various interactions that are established between human societies and ecosystems, as occurs in the tropical dry forest of the "Agua Blanca" commune.

In relation to the "Motor and economic forces", these indicators, as cited in Larrea et *al.,* (2015), have been particularly relevant as explanatory factors of habitat loss through the expansion of the agricultural frontier, deforestation and degradation of tropical ecosystems in Ecuador and other neighboring countries. Also included in this group are those related to direct impacts of climate change, hunting and capture of game species of importance to terrestrial ecosystems, as well as those related to ecosystems. Both issues have been identified by the CBD and several scientific publications as two of the main sources of direct pressure on biodiversity.

Improving the availability of and access to information on forest genetic resources in the Global Plan of Action (FAO, 2014), in its strategic priority four, aims to promote the establishment and strengthening of information systems (databases) on forest genetic resources in order to cover available traditional and scientific knowledge on the uses, distribution, habitats, biology and genetic variation of species and their populations; hence one of the contributions of this work.

According to Andrade, Sandino and Aldana (2017), the concept of ecological integrity acquires its own space in conservation strategies. Thus, the set of species diversity and functional diversity, in relation to a state that represents its integrity, entails the appearance of an emerging faculty of biodiversity: more diversity of responses in an ecosystem determines its "ecological resilience". In the case of the "Agua Blanca" commune, the indicators of structural diversity, with an attribute of structure, refer to the physical configuration or structural patterns of the tropical dry forest and in the numbers of strata an almost uniform distribution at landscape scale was observed.

Present qualification for the commune "Agua Blanca"

After evaluating the territorial context of the "Agua Blanca" commune, with emphasis on its development from the perspective of sustainability, and characterizing the composition and structure of that forest formation, the evaluated indicators are in an ecologically desirable state, so it is likely that little human intervention is required to maintain the natural ranges of variation (Table 4).

The valuation of the territorial context of the commune "Agua Blanca" showed that they contribute to sustainability, reflected in the habits of use and conservation that they make of the tropical dry forest.

The composition and structure of the tropical dry forest of the "Agua Blanca" commune is the result of the exploitation and use practices of its inhabitants, with a focus on sustainability.

The present qualification for the commune "Agua Blanca", from the perspective of its objects of conservation, its key ecological attributes and indicators is very good, that is to say, it is in an ecologically desirable state.

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