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Sustainability Assessment of Iguana Management Units in the Oaxaca Coast Region, Mexico

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Abstract

In order to assess the sustainability of management units, a multicriterial analysis can be applied, as an analytical, hierarchical, and technical process. This research was conducted to determine the environmental, socioeconomic, and legal sustainability indexes of wildlife conservation management units in the coastal region of Oaxaca. All wildlife conservation management units in the state of Oaxaca were visited, and those that were no longer in continuous operation or had ceased to operate were eliminated. Three units were evaluated: 1) CECOREI-UMAR, 2) CTENOSAURA PECTINATA, and 3) BARRA DEL POTRERO. Interviews were conducted with owners, workers, and legal and technical representatives. Fifteen criteria, 29 indicators, and 82 verifiers were evaluated, and framed within four headings: environmental, economic, social, and legal. The management units evaluated have the same sustainability (P>0.05): CECOREI-UMAR (1.2), CTENOSAURA PECTINATA (0.68), and BARRA DEL POTRERO (0.72). It is concluded that the management units comply with the operations and legal, social, and environmental indicators; however, the economic indicator must be addressed.

Keywords: Conservation; Exploitation; Iguanas; Sustainability; Socioecological Development

Introduction

Wildlife management units (UMAs) are registered properties and facilities that operate by mutual agreement, with an approved management plan, within which the status of the habitat and the specimens distributed within are monitored [1]. The objective of UMAs is the integration of environmental, economic, social and legal skills to conserve wildlife. This can be achieved through extensive or intensive management, while also taking into account extractive and non-extractive use [2]. UMAs that meet conservation and income generation objectives for the rural population are scarce, especially in regions with low levels of social and economic development [2-5]. Problems are more significant in units located in more marginalized municipalities [6,7] because rural communities receive less support and training [7]. In contrast, hunting ranches mainly in northeastern Mexico make an important contribution to the human population at a social and economic level [8-13]. In the evaluation of management units, technical problems have been revealed due to a lack of personnel training and deficiencies in the management plan [1,4,14]. Wildlife-related evaluations focus on the production of environmental goods or services [15,16], since these are activities of social interest, with scientific, technological, and political value [17]. The increase in the number of official

records of UMAs is mentioned as an indicator of success [17,18]; however, this increase may not have an impact on the success of the units. In success evaluations, few studies consider indicators of socioeconomic development, wildlife conservation, and legal and technical factors [2,7,18-21]. Therefore, headings that describe the general attributes of sustainability, such as environmental, economic, social, and legal, are applied [5,19,22]. These attributes can be used for sustainability evaluations through multicriteria analysis [23-27]. In the state of Oaxaca, UMAs have not been comprehensively evaluated to determine their economic viability and contribution to the social development of their owners. Therefore, a comprehensive evaluation of operating conditions is necessary to determine the socioeconomic development and conservation of iguana breeding sites. It is hypothesized that the evaluation of sustainability principles in Wildlife Management Units will indicate the factors limiting the establishment and maintenance of breeding sites for green iguanas (*Iguana iguana*) and black iguanas (*Ctenosaura pectinata*). Therefore, the objective is to use multicriteria analysis to evaluate the sustainability of environmental, economic, social, and legal principles in iguana management units in the Oaxaca Coast Region.

Materials and Methods

Study Area

The location of the UMAs distributed throughout the Oaxaca Coast Region was investigated [28,29]. After identifying the UMAs, a visit was conducted to learn about the structure and management plan of each one. Those that were not in continuous operation and those that had ceased to operate were eliminated from the list. Three management units were evaluated due to their relevant characteristics, similarity in structure such as a steering committee, and the social actors involved in the implementation, administration, and financing of the UMAs.

1. The Iguana Conservation and Reproduction Center of the Universidad del Mar (CECOREI-UMAR), at kilometer 128.1 of the Pinotepa Nacional-Puerto Escondido Federal Highway, located at 97°9'02"W, 15°55'3.4"N, 9 masl [30]. It has eight hectares, with three wild species (Iguana iguana, Ctenosaura pectinata, and Struthio camelus) and four domestic species (Meleagris gallopavo, Oryctolagus cuniculus, Ovis aries, and Bos taurus). The land tenure is communal.
2. Management Unit for the Conservation of Ctenosaura Pectinata Wildlife, in the Barra de Navidad area, located at 97°1'20.37"W, 15°49'15.17"N, 29 m a.s.l. [31]. It has 0.54 ha, with 10 wild species (*Iguana iguana*, *Ctenosaura pectinata*, *Crocodylus acutus*, *Crocodylus moreletti*, *Kinosternon herrera*, *Amazona albifrons*, *Amazona farinosa*, *Ara militaris*, *Odocoileus virginianus* and *Leopardus wiedii*), with private land tenure.
3. BARRA DEL POTRERO Iguana Hatchery, at kilometer 179 of the Puerto Escondido-Pochutla highway in the town of Barra del Potrero located at 96°45'30"w, 15°44'05"N, 15 m.a.s.l. [32]. It manages 10 ha, with six wild species (Iguana iguana, Ctenosaura pectinata, Kinosternon herrera, Trachemys scripta, Trachemys scripta elegans, and Rhinoclemmys spp.), also with private land tenure.

A semi-structured interview was designed, incorporating the following headings: environmental, economic, social, and legal [22,33]. In each management unit, five people were interviewed, including workers, the technical manager, and the legal representative. A hierarchy of four headings (environmental, economic, social, and legal), fifteen criteria, twenty-nine indicators, and eighty-two verifiers was used [34]. All survey questions were formulated according to García-Marmolejo [3,18]. However, some modifications were made to the qualitative indicators, and others were eliminated.

Statistical Analysis

A multicriterial analysis was implemented, and normalization was performed using the square root transformation and then the angular arcsine transformation[35]. A Kruskal-Wallis test was then performed [36].

Results

Located Management Units

Fourteen management units were identified in the state of Oaxaca that manage green iguanas (*Iguana iguana*) and black iguanas (*Ctenosaura pectinata*) for collection, exhibition, breeding, and conservation purposes (Table 1), of which three were found to be the most complete.

Sustainability Index

The CECOREI-UMAR, La Barra del Potrero, and Ctenosaura pectinata management units have the same average sustainability index (P>0.05, Table 2). Despite this, in the first management unit, environmental, legal, social, and, to a lesser extent, economic headings are most prominent. In the other units, environmental headings have the lowest degree; however, they receive a higher rating concerning the economic factor (Figure 1).

Environmental Principle

The three management units present a similar environmental sustainability index (P>0.05, Table 2).

However, the four sustainability criteria used in the CECOREI-UMAR are seen as stronger in that they contribute to reducing several activities with ecological impact: they promote habitat management strategies, allow for the diversified use of wildlife, conduct research, and promote strategies for wildlife management and conservation. Meanwhile, the CTENOSAURA PECTINATA and LA BARRA DEL POTRERO management units do not promote habitat management or wildlife conservation strategies, but do allow for the diversified use of wildlife (Figure 2).

Name of UMA	Modality	Scientific Name	Objetive
El Garrobo	Intensive	*Ctenosaura pectinata*	Conservation, recovery, and utilization
Iguanario Pinotepa	Intensive	*Iguana iguana y Ctenosaura pectinata*	Conservation and sustainable utilization
Santa María Huazolotitlán	Extensive	*Ctenosaura pectinata*	Management and conservation
Ojo de Agua	Intensive	*Iguana iguana y Ctenosaura pectinata*	Conservation and ecotourism
Guapinol	Intensive	*Iguana iguana y Ctenosaura pectinata*	Conservation and ecotourism
Criadero de iguanas Chacahua	Intensive	*Iguana iguana*	Management and reproduction
Yutu Cuii Sociedad De Solidaridad Social	Intensive	*Iguana iguana*	Reproduction and commercial utilization
Iguanario Roca Blanca	Extensive	*Ctenosaura pectinata*	Management and conservation
Centro de y Conservación y Reproducción de Iguanas UMAR	Intensive	*Iguana iguana, Ctenosaura pectinata*	Management and reproduction
Ctenosaura pectinata	Intensive	*Iguana iguana, Ctenosaura pectinata,*	Conservation and environmental education
Granja Inter-Activa S.A DE C.V.	Intensive	*Iguana iguana*	Conservation and management
Criadero de Iguanas La Barra del Potrero	Intensive	*Iguana iguana, Ctenosaura pectinata.*	Conservation and ecotourism
Iguanario Todos Santos	Intensiva	*Ctenosaura pectinata e Iguana iguana*	Conservation and sustainable utilization
Iguanario Coopalytan	Intensive	*Ctenosaura pectinata e Iguana iguana*	Conservation and ecotourism

Table 1: Intensive and extensive iguana units registered until October 2017 in the Oaxaca Coast Region.

Economic Principle

The economic sustainability index is similar (P>0.05, Table 2) in CTENOSAURA PECTINATA, BARRA DEL POTRERO, and CECOREI-UMAR (Figure 3). The first two UMAs secure different sources of income through productive diversification, allow for insertion into a market network, and establish a diversified portfolio of external financing sources; however, they mention that it is difficult to obtain utilization rates. CECOREI-UMAR does not have external financing sources and does not have market networks.

UMA	Average	Indicator	Average
CECOREI-UMAR	8.75	Environmental	5.33
CTENOSAURA PECTINATA	5.25	Economic	4.33
BARRA DEL POTRERO	5.5	Social	7
		Legal	9.33
Ji-Squared	2.35	Ji-Squared	3.31
Probability	0.31	Probability	0.35

Table 2: Kruskal-Wallis test for the UMAs.

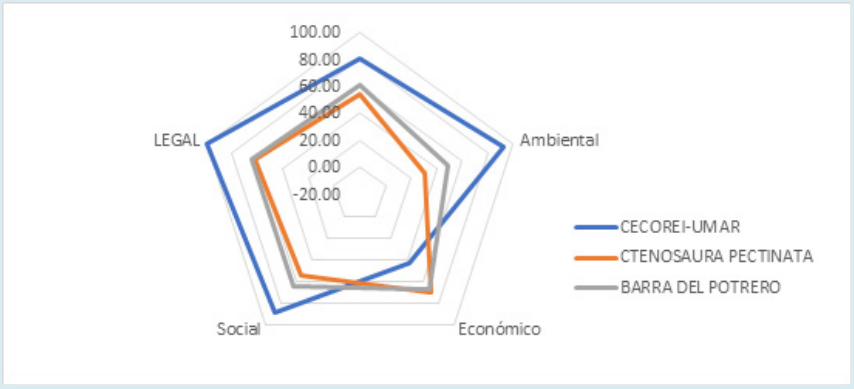

Figure 1: Sustainability index in three sustainable management units of black iguanas *Ctenosaura pectinata* e *Iguana iguana*.

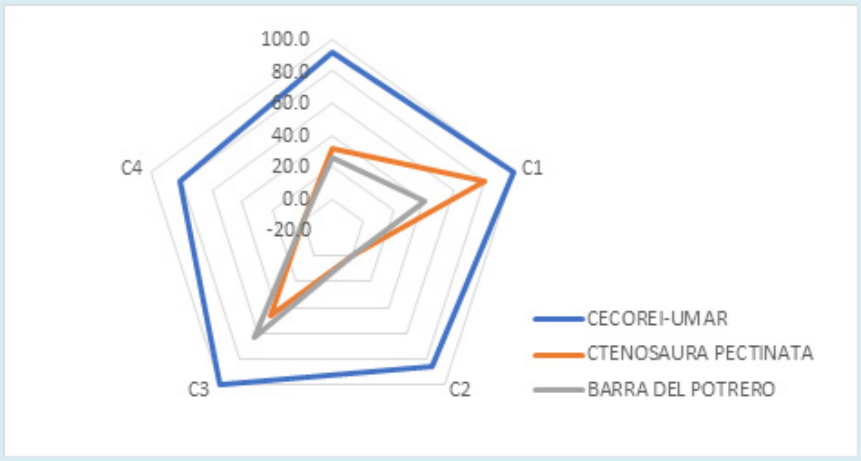

Figure 2: Environmental Principle: C1, Contributes to reducing activities with ecological impact. C2, Promotes strategies for habitat management. C3, Allows for the diversified use of wildlife. C4, Promotes strategies for wildlife management and conservation.

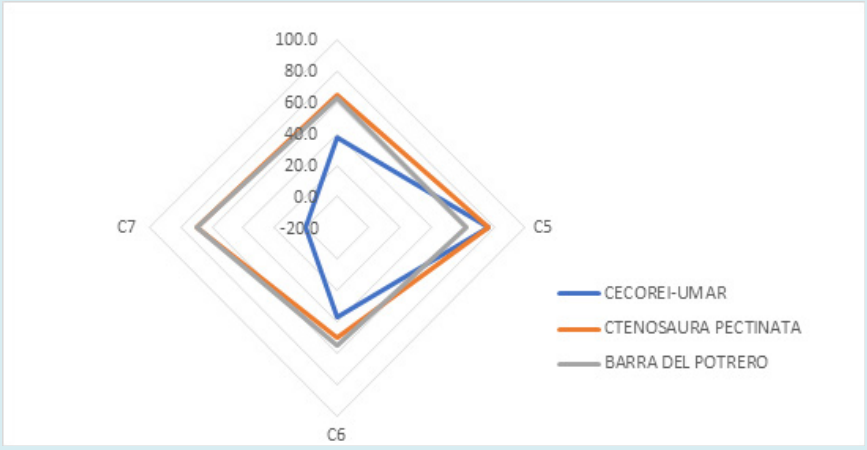

Figure 3: Economic Principle: C5, Productive diversification ensures different sources of income. C6, Enables integration into a market network. C7, Allows for the establishment of a diversified portfolio of financing sources.

Social Principle

The social sustainability index is similar (P>0.05) across management units, though greater economic development is observed in the CECOREI-UMAR UMA, followed by the LA BARRA DEL POTRERO iguana farm and the CTENOSAURA PECTINATA UMA (Figure 4). Two management units promote self-management: CECOREI-UMAR and La Barra del Potrero, while CTENOSAURA PECTINATA does not. The greatest contribution of economic development is observed in CECOREI-UMAR, with zero development in the other two management units. All three management units align on the conservation of cultural diversity and biological diversity.

Legal Principle

All management units have a similar (P>0.05) legal indicator, although the CECOREI-UMAR contributes 100% of the knowledge of legal regulations for harvesting, generates internal regulation and harvesting mechanisms, promotes the legality of harvesting practices, and generates external legal regulation mechanisms (Figure 5).

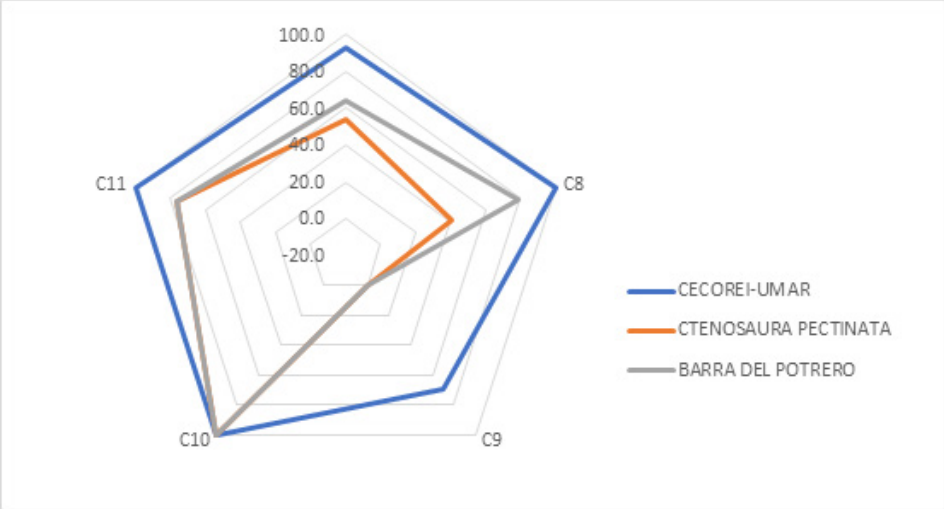

Figure 4: Social principle: C8, Promotes self-management. C9, Economic development. C10, Enables the conservation of cultural diversity. C11, Promotes the conservation of biological diversity.

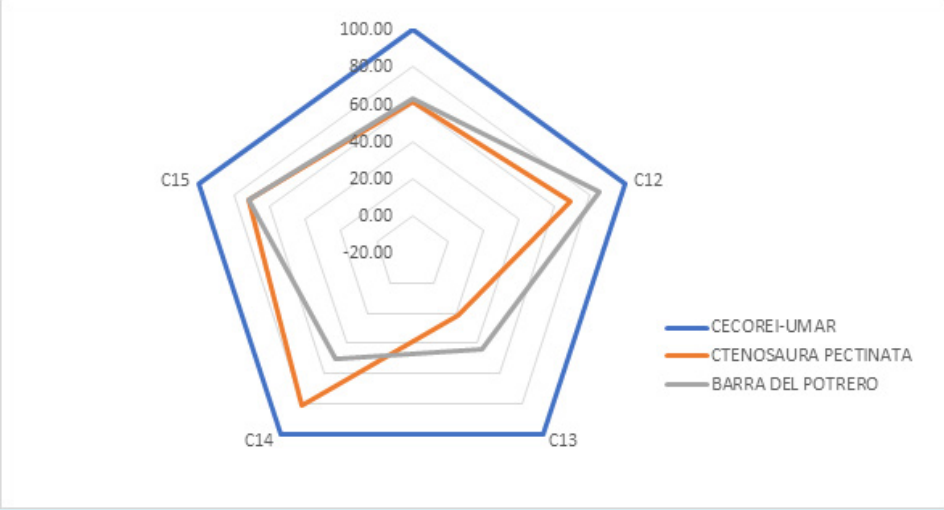

Figure 5: Legal Indicator: C12, Contributes to knowledge of legal regulations for utilization. C13, Generates internal regulation and exploitation mechanisms. C14, Promotes the legality of exploitation practices. C15, Generates external regulation mechanisms.

Discussion

Sustainability Principle

The CECOREI-UMAR has adequate sustainability indices for several reasons: 1) the operating staff and committee are sufficiently trained in wildlife management. Therefore, compliance with environmental objectives has a higher score; 2) maintenance and personnel costs are covered by a teaching and research institution; 3) they carry out research and community outreach activities. A different situation is observed in the UMAs: CTENOSAURA PECTINATA and LA BARRA DEL POTRERO, where the economic criterion is greater, but their environmental, social, and legal contributions are lower. The sustainability values generated indicate the achievements that the evaluated UMAs have achieved with respect to the general objectives of each of them. No indication is made that the UMAs are performing inadequately in their social, environmental, or legal activities. Although rural communities have been encouraged to conserve biodiversity by providing sources of income and alternative forms of production, optimal conditions are not present due to technical, economic, social and political difficulties, particularly in the units evaluated [37]. It is necessary to consolidate self-management measures, economic development, and the preservation of cultural and biological diversity in order to become a stable and profitable productive activity on the Oaxacan coast in the long term. On the other hand, a government policy could be generated to support the wildlife UMAs in an effective manner.

Environmental Principle

Of the three management units evaluated, the CECOREI-UMAR is the only one that does not monitor habitat or wildlife, as it is a registered UMA. Despite managing a small area within its facilities, it does not allow hunting of wildlife within the eight registered hectares and maintains the state of the vegetation. Another advantage of this management unit is that it conducts research that promotes strategies for habitat management and wildlife conservation [38-40]. The CECOREI-UMAR and CTENOSAURA PECTINATA UMAs contribute with maintenance activities, which help reduce the impact on natural resources due to their stated objectives. The opposite is the case in LA BARRA DEL POTRERO, where these activities are minor. The absence of habitat management and conservation regulations in the CTENOSAURA PECTINATA and LA BARRA DEL POTRERO UMAs could be related to the area, type of land tenure, and the location of the property. When the size and extension of the unit is small, maintaining habitat integrity is almost impossible [3,41], due to the concentration of efforts on captive activities. In the Oaxaca Coast Region, during the period 2000-2011, 18,402 ha of jungle, 420 ha of mangroves and 369 ha of forest were lost due to human activities [42]. Even if the evaluated UMAs implemented a habitat restoration program, it would not be enough to address this problem, since other additional measures are needed to regulate land use changes and reduce the deforestation rate in the region, through other national institutions or programs.

The evaluated UMAs promote the diversified use of wildlife activities. Two of them are for commercial purposes, which guarantees the protection and maintenance of a stable population of black (*C. pectinata*) and green (*I. iguana*) iguanas by not utilizing the area's fauna. This situation has led the owners of the UMAs on the Oaxacan coast to establish non-economic protection measures to guarantee the preservation of biodiversity. The opposite occurs in the units in the northern region of the country and the Yucatán Peninsula, where they tend to increase the number of specimens in their facilities through the introduction of individuals captured in their habitat or exceeding the rates authorized by SEMARNAT (National Secretariat of Environmental Protection) to increase their economic profits, accelerating the process of environmental deterioration [4,14,18,19]. Rural communities near management units have a negative impact on their land and wildlife populations due to poaching for personal consumption and commercial purposes [6,17,43]. However, with the data available in this study, it is impossible to estimate and specify the actual impact of hunting on wildlife populations.

Economic Principle

The UMAs show financial instability, as they do not generate direct sources of income for the owners or indirect sources for the community. Furthermore, they lack complementary activities that would allow the owners to cover their own maintenance expenses. Interviews with the owners revealed that the UMAs CTENOSAURA PECTINATA and LA BARRA DEL POTRERO lack ongoing support to cover maintenance costs. It was found that there is active participation by family members, which does not generate expenses or income. The exception is the CECOREI-UMAR, where maintenance and personnel costs are directly financed by an educational institution. The spaces in the UMAs are so small that habitat management and conservation strategies tend to be nonexistent, as the UMA owners do not have sufficient financial resources to implement programs [5,7,44].

Social Principle

The Wildlife Conservation and Productive Diversification Program in the Rural Sector [45] has become outdated, as it does not show strategies to promote the socioeconomic development of rural communities. Nor does it show that the institutions responsible for authorizing and monitoring the units actively train the owners of authorized properties to

provide tools to improve socioeconomic development with the resources available to them, which in turn allow them to consolidate associations in the communities.

It is important to increase training to promote self-management, so that communities can make decisions that favor productive development [5,44]. However, it is unlikely that the federal government will establish training and monitoring programs to determine the effectiveness of the social development of the UMAS, given the limited financial resources allocated to natural resource management and conservation projects [2,14,18]. Self-management is difficult because responsibility falls on the owner, who sometimes fails to create internal policies, as is the case in the CTENOSAURA PECTINATA and LA BARRA DEL POTRERO UMAs, except for CECOREI-UMAR, where an organized group reviews management and makes decisions, and there are internal regulations and management-related executive staff.

The evaluated UMAs are not contributing to social development because they do not encourage active community participation in the management and maintenance activities of iguana breeding farms. The aforementioned deficiencies are a common denominator in the country's UMAs because, even when community members are involved, participation is generally passive and does not provide real economic benefits that allow those involved to live without financial hardship [3,5]. In the CECOREI-UMAR management unit, there are no third-party financial contributions. In contrast, in the other two units, voluntary financial contributions from visitors are a source of income.

The greatest social contribution of the evaluated UMAs is that of environmental awareness activities and cultural development of the species, but despite this, there is a lack of training by authorities so that federal programs can be carried out [45]. In the CECORE-UMAR, issues related to the use of local fauna and flora are addressed since it has qualified personnel. It is known that fauna is used for other traditional purposes, as clothing, tools, pets, as well as for medicinal, ritual and religious purposes, among others [37]. Therefore, environmental education activities should be implemented regarding proper use of species and the reduction of hunting.

Legal Principle

The owners and managers of the assessed UMAs identify that iguanas are in a risk category and are listed in NOM-059-SEMARNAT [46], but they are unaware of the scope. Some interviewees from CECOREI-UMAR and LA BARRA DEL POTRERO commented that the current legal framework is too general and unclear, which generates uncertainty and confusion in its interpretation. Furthermore, some environmental, social, and economic aspects that are considered part of the UMAs and SUMA's objectives are ignored in relation to the current regulatory works [18,44,47]. The owners indicate that the regulatory framework is subject to interpretation by the respective authorities. Therefore, monitoring and evaluation of UMA performance is limited, and management units may be allowed to resort to extracting specimens from natural populations [5,8,11,14]. These factors have a negative impact on biodiversity conservation, making it difficult to assess the actual performance of UMAs and determine their impact on socio-ecological development [3,4].

Available evaluations of UMAs only analyze the number of official records, the number of species, and the territorial area occupied by the units [18,20,21,48]. The regulatory framework for UMAs is not entirely efficient, presenting gaps in the regulation of wildlife management, since the general objectives of the program were not considered during the design of the legal framework, nor were the socioeconomic and environmental conditions of the different regions of the country taken into account.

Conclusion

The evaluation of environmental factors indicates that the management plans in place for the evaluated iguana habitats do not guarantee the long-term conservation of iguana biodiversity for (*C. pectinata and I. iguana*). The economic analysis of the studied UMAs reveals financial instability, as they do not generate direct sources of income for the owners or indirect sources of income for the community. The greatest social contribution of the evaluated UMAs is related to environmental awareness activities. The overall sustainability index of the evaluated UMAs indicates that they allow for the conservation of biological and cultural diversity; however, they make only minimal contributions to the socioeconomic development of their communities.

Conflict of Interest Statement

We declare that we have no conflicts of interest.

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