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Socio-environmental Study and Ecological Footprint in the Mixtec Community of El Calvario

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ABSTRACT

Subject: Currently, it is very difficult for communities to receive funding for their development, as they often lack efficient evaluations or significant impact to support such funding. Therefore, it is vitally important for research to help make these communities visible by applying instruments that describe their situation. In this sense, two of the most important tools are the socio-environmental diagnosis and the ecological footprint, which are rarely determined in various communities.

Methodology: To determine this, Likert-type surveys and interviews with key stakeholders were conducted to identify areas for improvement within the community.

Results: The most relevant findings were the need to pave the road leading to the community, which hinders marketing and increases the cost of its products and/or the residents' labor. Another issue is the management, disposal, and elimination of waste. The greatest waste identified is the bagasse from agave, which must be valorized. Additionally, efficient water collection systems are needed, and finally, there is a lack of medicines and an available family doctor.

Implications: As a result of this study, various strategies are proposed to provide continuity to the areas of opportunity identified in the El Calvario community.

Conclusions: It is important to listen to the community's context so that they become the promoters of change, without harming the environment and nature.

Keywords: Ecological footprint, socio-environmental, interviews and key actors.

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INTRODUCTION

The socio-environmental study is a tool used to provide a diagnosis through instruments, techniques, and methodologies to propose solutions to the social, economic, and environmental problems identified in the study (Armenta *et al.*, 2012). On the other hand, the ecological footprint is an environmental indicator of the impact a society has on its surroundings, considering the resources required and the waste generated for the maintenance of that society's production and consumption model (Rees and Wackernagel, 2000). The Mixtec community of El Calvario began its agricultural activities with the cultivation of poppy, a crop that was later discontinued to avoid violence among the residents. Currently, they are dedicated to the cultivation and use of *Agave cupreata*, as well as the production of fruits (peach, guava, avocado), some vegetables (lettuce, cilantro, radish, green beans), and cereals (corn), the making of some rustic wooden utensils, and

the production of artisanal mezcal. The community has an ejido of 840 hectares located south of the city of Chilpancingo de los Bravo, Guerrero, and is home to around 120 families, 90% of whom speak indigenous languages, particularly Mixtec. Access is via dirt roads, which make it difficult to obtain basic services and sanitation (López *et al.*, 2021). Due to its location, the community has experienced slow development in all its sectors. By conducting these studies, we will be able to identify areas of opportunity to improve and/or correct, with the aim of developing strategies to preserve its natural environment, promote economic development, and improve the social well-being of all community members.

MATERIALS AND METHODS

Community Approach: The El Calvario community was selected due to the connection with one of its residents, who shared that few people are interested in the sustainable and enduring development of the community. In this context, they mentioned that in the past, they were involved in poppy cultivation, but for various reasons, they no longer grow illicit plants and now focus on other agricultural crops of interest, without harming their surroundings. This is why the socio-environmental diagnosis is conducted and the ecological footprint is determined.

Socio-environmental Diagnosis: To conduct the socio-environmental diagnosis, key stakeholders were identified in order to carry out interviews and surveys with the residents of the El Calvario community. Beforehand, the purpose of the questions was explained, and informed consent was obtained to protect the identity and data of each respondent, based on the Helsinki Declaration. Both the surveys and interviews included questions about the origins of the community, geographical description and location, environmental aspects of the region, population density, education, health, religion, customs, traditions, and the main economic activities (Adapted from Armenta *et al.*, 2012).

Ecological Footprint: To conduct the ecological footprint diagnosis, Pareto analysis (80/20 rule) was used (Izar and González, 2004), applying Likert surveys to 20% of the population. The main needs for each community member's subsistence were strategically selected. The surveys consisted of closed-ended questions, which were later weighted to identify areas of opportunity and areas of deficiency within the community. The categories included in the surveys are: sensitivity and participation, physical-natural environment, natural systems, basic services, mobility, and waste management.

RESULTS AND DISCUSSION

An approach was made to the El Calvario community for the application of surveys to the residents and key stakeholders of the community for the socio-environmental diagnosis and ecological footprint assessment (Figure 1).

Socio-environmental Diagnosis: Through the application of surveys, a qualitative description was then made for each category in the socio-environmental diagnosis. The results obtained are shown in Table 1.

The areas that show the greatest need for attention are primarily those related to mobility, as it enables access to basic products and the marketing of their goods and/or performance of work. According to Armenta *et al.* (2012), a socio-environmental study

Figure 1. Interaction with the community in its environment.

Table 1. Description of the ecological footprint diagnosis in the El Calvario community.

Category	Description
Community origins	The residents indicate that the community arose from a landslide that occurred in Metlatónoc belonging to Tlapa de Comonfort, which led them to migrate to the El Calvario community on February 14, 1976 and settle in that new settlement.
Description and geographic location	Orographically, the community is considered a mountain range, with a temperate climate and oak-pine vegetation predominating. The roads are not paved so the location is difficult to access, the water resource is supplied through springs and in the case of air, the residents consider it to be of good quality due to the abundance of native vegetation.
Environmental aspects of the region	The perception of environmental degradation is minimal since the number of inhabitants is small, however, they affirm that there are firewood extraction areas that can cause some type of damage by constantly using this resource.
Population density	The population is made up of adult women and men, children and a few older adults. Its composition is 52% women and 48% men.
Education	The maximum degree of education is primary since there is a strong tendency to abandon studies to join the agricultural field.
Health	There is a health center without medical personnel.
Religion, customs and traditions	They are Catholic, but they are governed by signs of the moon and some animals.
Economic activity	Family farming and the production of artisanal mezcal.

must include political issues, environmental education, strategies for strengthening the local economy, and community participation. This study is a general diagnosis, focused on seeking development strategies to improve these areas. Furthermore, the aim is to generate community participation and to include public policy topics in order to bring resources to the community that will enable its development. Other important aspects to highlight are those outlined in the socio-environmental diagnosis by Cabral *et al.* (2022), which emphasizes that one of the most critical issues for communities in environmental matters is the transfer of scientific knowledge and contributing to the dualism of conservation *vs.* development.

In this regard, the care of natural resources must be of vital importance to everyone. With the results presented, it was possible to assess that despite the productive activities in the community, there is no significant deterioration, and development would come with management after the development of strategies. González *et al.* (2019) highlights other aspects, such as the socio-environmental conflicts threatened by mega-projects involving mining, oil extraction, infrastructure construction for industrial expansion, housing, and agrochemicals, regardless of environmental degradation, population displacement, and the depletion of natural resources for their purposes. This particular issue must be of vital importance for the El Calvario community, as its development should be focused on sustainable development. Regarding the ecological footprint diagnosis: With the results obtained from the ecological footprint survey, a description was made for each category (Table 2), and then they were weighted to establish the significant impacts (Table 3).

Table 2. Description of the ecological footprint diagnosis in the El Calvario community.

Category	Description
Sensitivity and participation	In terms of participation, the community is governed by uses and customs and sensitivity; it is considered respectful of the coexistence between its members.
Physical-natural environment	They comment on minimal environmental damage due to the extraction of natural resources, and the landscape remains in good condition, but the dependence on the use of firewood for cooking and to produce artisanal mezcal is emphasized.
Natural systems	The soil is clayey with a high amount of organic matter for agriculture, the climate is predominantly temperate and agroforestry activity is practiced with wood species and with the implementation of crops for self-consumption.
Basic services	Access to basic services is considered unstable. The water is distributed to the community through a nearby spring, the drainage service is supplied through registers without connection to drainage systems, there is an electricity service which must be paid in the nearest community (Llanos de Tepoxtepec), finally, in terms of food, the community produces beans, pumpkin and corn, but there are complications in buying food from the capital and there is no transportation.
Waste management	There is no adequate management of waste generated by the community since the most used practice for its elimination is burning it. In terms of sanitary discharges, there is no specific area for its treatment due to the lack of service. drainage, on the other hand, in the existing mezcaleras the bagasse is thrown into the open air.
Socioeconomic aspects	The main economic sector is agriculture and the production of artisanal mezcal, the population lives in wooden houses and very few in concrete. In social welfare, everyone indicates that they have what is necessary to survive.

Table 3. SWOT Matrix for the El Calvario Community.

Strengths	Opportunities
• Participation and organization in the community, production of artisanal mezcal and maguey plantations	• Marketing of mezcal, rejection of bagasse, and designing an ecotourism model
Weaknesses	**Threats**
• Lack of road to the community, medical service and waste reuse	• Unfair prices in the sale of mezcal, lack of maguey for production, deficiency in marketing channels

With the results obtained for each category, a weight of 0.25 was applied to the total number of questions (Likert surveys) within the diagnosis, on a scale from 1 to 5, where 1 indicates a critical impact, signaling an area that requires immediate intervention, and 5 indicates an area with an adequate level of organization and development. The evaluated categories were: physical-natural environment, sensitivity and participation, natural systems, basic services, mobility, waste management, and socio-economic aspects, with significant impacts of 4, 5, 4, 1, 1, 1, and 3, respectively. Once the surveys were completed and the methodology used was weighted, it was identified that the areas needing improvement are as follows: mobility, basic services, and waste management. This analysis had a great deal of community involvement, as it clearly reflected the concerns of the residents, as well as the potential strategies to be followed for the community's development.

On the other hand, Páez (2000) describes the inclusion of energy consumption, per capita income, and the human development indicator in the study for a better evaluation. In this sense, the present paper did not delve into these aspects, as the goal was to create an overview that describes the situation of each area of the community, and once evaluated, to seek strategies to improve these areas. It is also important to mention that our sampling included interviews with key actors, who are of vital importance for the community's development, as they are the ones who can bring about an ideological change. Macedo *et al.* (2024) mention in their ecological footprint analysis for the life cycle, corporations, and cities that it is important to understand the reasons behind the accelerated pace of production and consumption in society, so that we can accurately quantify the degradation of natural resources and identify the waste generated within a given population. This will allow for the migration to sustainable technologies to create a sustainable life. Finally, the application of indices will also be of vital importance for measuring the different areas of opportunity. However, the best tool to counteract environmental deterioration will be environmental planning, where all levels of government and the community provide an early warning system for the preservation of natural resources and the potential utilization of waste.

To develop a better analysis, an Ishikawa diagram (Figure 2) (Ishikawa K., 2013) and a SWOT matrix (Ponce Talancon, 2006) were created for the community in question, as described in Table 3.

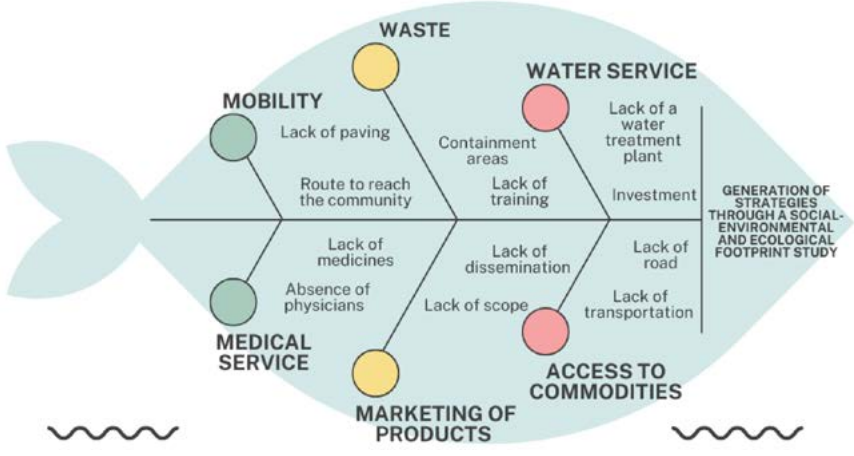

Figure 2. Cause-and-effect diagram for the addressed community.

CONCLUSIONS

Based on our study, several strategies are proposed to continue addressing the opportunities identified in the El Calvario community. These strategies begin with improving mobility conditions by seeking funding to pave the 12 kilometers connecting the community to the "Autopista del Sol." This will lead to numerous benefits, such as facilitating the commercialization of products to the city of Chilpancingo and surrounding communities, access to basic services like supply inputs, and revaluing their potential waste to create new environmentally friendly products. Another strategy to be developed is the potential for the community to create a tourist route with a restaurant, mezcal tasting, and outdoor activities. This would provide economic benefits, ensure access to quality health services and education, and, lastly, the construction of dry toilets that, using organic waste, could generate compost for use as fertilizer. There is a strong commitment to continue preserving natural resources and strengthening new initiatives for the sustainable development of the community and social well-being.

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