



Agroecological diagnosis of cocoa cultivation in small farmers of Manabí

Diagnóstico agroecológico del cultivo de cacao en pequeños agricultores de Manabí

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ABSTRACT: The research conducted an agroecological assessment of cacao cultivation on 60 smallholder farms in the Cañales area of Manabí province, using field surveys and an analysis of environmental, economic, and social components. The average Overall Sustainability Index was 2.27, reflecting a moderate level of sustainability. The environmental component yielded an index of 1.60, indicating limitations in crop diversity, conservation areas, and soil management. The economic component scored 2.37, with acceptable productivity but conditioned by the use of external inputs and the presence of pests. The social component reached 2.84, highlighting community integration, although with deficiencies in services and knowledge of sustainable practices. Based on these results, a comprehensive agroecological management strategy was proposed to improve productive resilience, agroecosystem sustainability, and the well-being of the producers.

Key words: Agroecology, farmer, indicators, sustainability..

RESUMEN: La investigación realizó un diagnóstico agroecológico del cultivo de cacao en 60 fincas de pequeños agricultores del recinto Cañales, Manabí, mediante encuestas de campo y el análisis de componentes ambientales, económicos y sociales. El Índice de Sustentabilidad General promedio fue de 2,27, lo que refleja un nivel medio de sostenibilidad. El componente ambiental presentó un índice de 1,60, evidenciando limitaciones en diversidad de cultivos, áreas de conservación y manejo del suelo. En el aspecto económico se obtuvo un valor de 2,37, con productividad aceptable pero condicionada por el uso de insumos externos y la presencia de plagas. El componente social alcanzó 2,84, destacando la integración comunitaria, aunque con deficiencias en servicios y conocimiento sobre prácticas sostenibles. Con base en estos resultados, se propuso una estrategia de manejo agroecológico integral orientada a mejorar la resiliencia productiva, la sostenibilidad del agroecosistema y el bienestar de los productores.

Palabras clave: Agroecología, Agricultor, indicadores, sustentabilidad.

INTRODUCTION

Agroecological diagnosis is a comprehensive evaluation tool that analyzes agricultural systems from an environmental, social, and economic perspective. This approach, grounded in the principles of agroecology, makes it possible to identify strengths, detect limitations, and discover opportunities to promote sustainability (1).

Agroecology, defined as a discipline that integrates ecological principles into agricultural production, has

established itself as a viable alternative for promoting sustainable rural development. In Ecuador, a country characterized by its rich biodiversity and a large rural population engaged in agriculture, agroecological practices represent a potential solution to various economic, social, and environmental challenges. However, the advancement of agroecology faces multiple obstacles that require in-depth analysis to fully understand its potential and overcome the limitations hindering its implementation (2).

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The use of science and technology is essential to prevent environmental contamination and increase food production without resorting to the indiscriminate exploitation of natural resources. In this context, promoting agroecology emerges as an ideal alternative, understood as the application of ecological concepts and principles to the design and management of sustainable agroecosystems. This involves implementing agricultural practices based on technical and scientific knowledge, integrating the ecological, agronomic, and social processes involved in production (3).

Sustainability indicators are key instruments for measuring and guiding progress toward more sustainable development across different sectors and industries. These indicators integrate economic, social, and environmental dimensions, following the Triple Bottom Line (TBL) approach, and are essential for making informed decisions and promoting sustainable practices (4).

MATERIALS AND METHODS

Study location and samples

The population considered for conducting this study consisted of a total of 70 cocoa farms in the Cañales area, Pichincha canton, Manabí province; whose geographic coordinates are: -0.957319, -79.861137. This research was aimed at all cocoa farmers seeking agroecological options for the sustainable management of their crops.

Study management

In the study area, 70 farms dedicated to cocoa production and marketing were found in the Cañales area. Visits were planned to an estimated sample of 60 cocoa farms, collecting information on social, economic, and environmental aspects

through technical surveys designed for this study. These data were subsequently tabulated and analyzed, generating tables and graphs to interpret the results obtained. For this purpose, sustainability indicators detailed in Table 1 were used.

Study design

The study was conducted in the field, collecting information through surveys. Once the data were tabulated, the necessary results were obtained for subsequent interpretation. The structure and approach of the work were oriented toward a qualitative model, classified as descriptive, narrative, and inferential (Tables 2, 3, and 4).

RESULTS AND DISCUSSION

Analysis of data obtained from surveys on the environmental, economic, and social aspects of practices carried out in cocoa cultivation in the Cañales area (Manabí)

The evaluation of environmental sustainability in 60 cocoa farms showed an average of 1.60 points, placing the production system at a low to medium sustainability level. Among the favorable aspects, adequate vegetation cover and the presence of gentle slopes stand out, conditions that contribute to soil conservation and ecosystem stability (Figure 1). However, relevant weaknesses were identified, such as the absence of crop diversification, partial implementation of soil conservation practices, and the lack of areas designated for environmental protection. These limitations reduce biodiversity and the resilience of production systems, highlighting the need to implement more comprehensive agroecological approaches that strengthen the environmental sustainability of the evaluated farms.

Table 1. Formulas for calculating sustainability indicators and index

Indicators	Fórmulas
Sustentabilidad ambiental (IA)	$\frac{(A1 + A2) \div 2 + (B1 + B2) \div 2 + (C1) \div 1}{3}$
Sustentabilidad económica (IK)	$\frac{2((A1 + A2 + A3 + A4 + A5) \div 5) + B1 + (C1 + C2 + C3) \div 3}{3}$
Sustentabilidad sociocultural (ISC)	$\frac{2((A1 + A2 + A3 + A4) \div 4) + B1 + C1}{3}$
Index	Formula
Sustentabilidad general (ISG)	$\frac{(IA + IK + ISC)}{3}$

Source: Sarandón, 2002

Table 2. Sub-indicators and standardized values for assessing environmental sustainability

Code Sub-indicators	Standardization Scale				
Environmental indicators	0	1	2	3	4
A1 Vegetation cover	<25 %	25-50 %	50-75 %	75-99 %	100 %
A2 Crop diversification	Monoculture	Low diversity	Medium diversity	High diversity	Fully diverse
B1 Predominant slope	>20 %	16-20 %	11-15 %	6-10 %	0-5 %
B2 Soil conservation	No ground cover	With ground cover	Living barriers	Green manure	Agricultural terraces
C1 Protected zones	<1 %	1-3 %	3-6 %	6-10 %	>10 %

(A) Soil life conservation, (B) Erosion risk, (C) Biodiversity management. Source: Sarandón, 2002

Table 3. Sub-indicators and standardized values for assessing economic sustainability

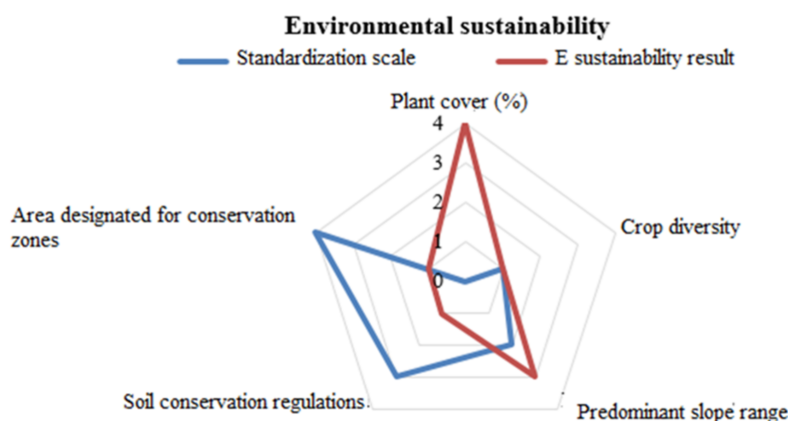
Code Sub-indicators	Standardization Scale				
Economic Indicator	0	1	2	3	4
A1 Productivity	<0.3 t ha	1-1.5 t ha	1.5 - 2 t ha	2 - 2.5 t ha	>2.5 t ha
A2 Cob size	Very small	Small	Medium	Large	Very large
A3 Pest insect incidence	>20 %	16-20 %	11-15 %	6-10 %	<5 %
A4 Disease incidence	>20 %	16-20 %	11-15 %	6-10 %	<5 %
A5 Plantation density	800	1000	1111	1200	>1200
B1 Monthly income	50	100	150	200	>250
C1 Production diversification	1 Product	2 Products	3 Products	4 Products	>4 Products
C2 Dependence on external inputs	81 a 100 %	61 a 80 %	41 a 60 %	21 a 40 %	0 a 20 %
C3 Number of commercialization routes	1 route	2 routes	3 routes	4 routes	>4 routes

(A) Farm profitability. (B) Net monthly income. (C) Economic risks. Source: Sarandón

Table 4. Sub-indicators and standardized values for assessing social sustainability

Code Sub-indicators	Standardization Scale				
Indicador Social	0	1	2	3	4
A1 Housing	Does not own a house	Cane house/ Bamboo house	Wooden house	Mixed-material house	Concrete house
A2 Access to education	No access	Access to kindergarten	Access to primary school	Access to secondary school	Access to university
A3 Access to health services	>10 km	From 5 to 10 km	From 3 to 5 km	From 1 to 3 km	<1 km
A4 Basic services	No electricity or water	No electricity, with water	With electricity, no water	With water and electricity	Water, electricity, sewage system
B1 Social integration	No integration	Low	Medium	High	Very high
C1 Environmental knowledge	No knowledge	Low	Medium	High	Very high

(A) Satisfaction of basic needs. (B) Social integration. (C) Ecological knowledge and awareness. Source: Sarandón. 2002


Figure 1. Multivariable environmental sustainability

The economic analysis in the Cañales area showed medium sustainability (2.37 points). The farms present acceptable productivity (1.5-2 t ha), but with intermediate incidence of pests and diseases. Monthly incomes are low (\$100-\$150), there is little productive diversification, high dependence on external inputs, and only one marketing channel, which limits profitability and highlights the need to improve efficiency and diversify income (Figure 2).

The social analysis of the cocoa farms in the Cañales area revealed a medium level of social sustainability (2.84 points). Cement houses predominate and there is high community integration, although limitations exist in access to education, healthcare, and sewage systems. Additionally, a low level

of knowledge in environmental and agricultural practices was identified, highlighting the need to strengthen training and improve basic services to enhance social well-being (Figure 3).

Establishment of the general sustainability index of the cocoa farms in the Cañales area

The analysis of 60 cocoa farms in the Cañales area determined an average General Sustainability Index of 2.27, corresponding to a medium level. Although positive practices are evident in the environmental, social, and economic spheres,

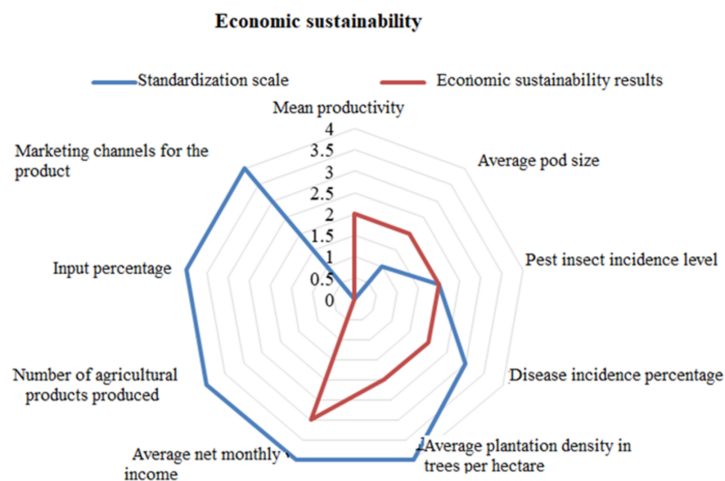


Figure 2. Multivariable economic sustainability

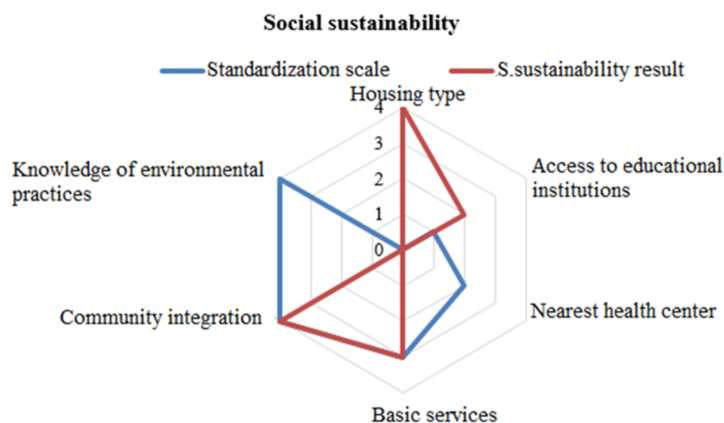


Figure 3. Multivariable social sustainability

weaknesses persist such as limited productive diversification and poor access to technical assistance. These results show the need and opportunity to implement strategies that strengthen the comprehensive sustainability of the cocoa farming system, improving profitability, environmental conservation, and community well-being (Figure 4).

Proposal for agroecological management in cocoa farming in Cañales area

As part of the fulfillment of the third specific objective of the research, a comprehensive agroecological management proposal for cocoa cultivation in the Cañales area is presented. This proposal aims to promote a sustainable, resilient production system compatible with the conservation of the cocoa agroecosystem (Table 5).

The results obtained from the cocoa farms in the Cañales area show that the production system has structural limitations in the environmental, economic, and social dimensions, which condition its sustainability level. In the environmental component, the average value of 1.60 reflects predominantly conventional management, characterized by monoculture, the absence of conservation areas, and inadequate soil management practices, consistent with reports by some authors (5) on the negative impact of low adoption of agroecological practices on biodiversity and ecosystem services.

In the economic dimension, although the recorded productivity (1.5-2 t·ha⁻¹) is technically acceptable, the high dependence on external inputs, limited productive diversification, and low monthly incomes (USD 100-150)

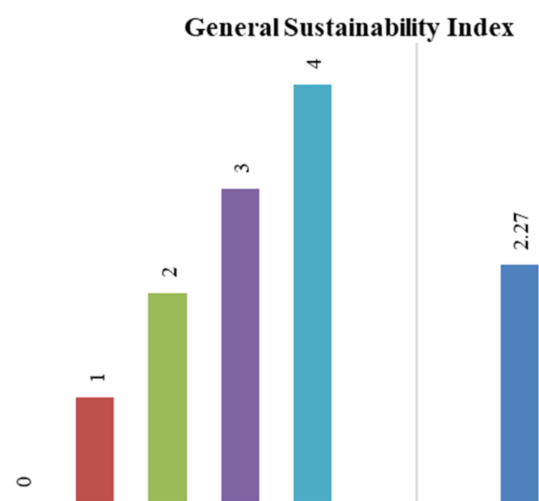


Figure 4. General sustainability index

Table 5. Agroecological management implementation schedule

Activity	Stage	Estimated period	Remarks
Site selection and soil analysis	Pre-sowing	Month 1	Assessment of shade, soil, and drainage
Land preparation and incorporation of organic matter	Pre-sowing	Month 2	Use of compost and manual clearing
Establishment of temporary shade and planting	Planting	Month 3	Planting at the beginning of the rainy season
Initial application of compost and mycorrhizae	Planting	Month 3	During planting
Shade management and training pruning	Establishment	Months 4-12	Adjustments according to growth
Agroecological control of pests and diseases	Maintenance	Monthly	Application of extracts and monitoring
Application of green manures and organic fertilizers	Maintenance	Every 3-6 months	Canavalia, bocashi, bioles (fermented organic fertilizers)
Harvest and postharvest management	Production	Month 12 onwards	2 harvests per year
System evaluation and adjustments	Monitoring	Annually	Participatory technical review

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increase the vulnerability of producers, coinciding with observations by (6) regarding the lower resilience of poorly diversified systems. At the social level, while there are strengths associated with housing quality and community integration, gaps persist in access to basic services and technical training, which restricts the adoption of agroecological practices, as indicated by previous studies on agroecological transition processes (8).

The average General Sustainability Index of 2.27 places the production system at a medium sustainability level, with partial progress and persistent weaknesses, especially in productive diversification and access to specialized technical assistance, results similar to those reported by some authors (7,8). In this context, the agroecological management proposal for cocoa cultivation in Cañales area is presented as a viable alternative; however, its implementation faces challenges related to limited technical assistance and restrictions in marketing channels (9), can limit the adoption of agroecological approaches. Nevertheless, experiences documented show that participatory and territorial approaches strengthen the sustainability of production systems (10).

CONCLUSIONS

The analysis of the cocoa farms in Cañales area revealed a medium level of sustainability, with strengths and limitations in the environmental, economic, and social components. In the environmental aspect, low to medium sustainability was observed due to limited diversification, absence of conservation areas, and partial soil management, despite adequate vegetation cover. In the economic sphere, productivity was acceptable, but dependence on external inputs and low diversification limit financial resilience. Socially, there are good housing conditions and community integration, although gaps persist in access to healthcare and technical training.

The average General Sustainability Index of 2.27 confirms partial adoption of sustainable practices and highlights the need to strengthen productive diversification and technical assistance. In this context, the agroecological management proposal is presented as a comprehensive and participatory alternative to improve the sustainability of the cocoa farming system, reduce dependence on chemical inputs, and promote a more resilient production model in harmony with the environment.

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