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ORIGINAL

Analysis of green innovation for cocoa growers in the municipality of Roberto Payán

Análisis de la innovación verde para los cultivadores de cacao en el municipio de Roberto Payán

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ABSTRACT

Introduction: this project focused on the application of green innovation to cocoa cultivation in the municipality of Roberto Payán, Nariño, with the purpose of improving agricultural productivity and promoting environmental sustainability in the region. Roberto Payán has large tracts of land suitable for large-scale cocoa production, which represents a key opportunity to transform its rural economy. The study focused on identifying the problems and opportunities associated with the crop, such as lack of technical support, inadequate land use and competition with illicit crops. It also proposed solutions focused on reducing environmental impact, improving product quality and increasing the income of small producers through sustainable and innovative practices.
Method: the research adopted a positivist paradigm, also known as quantitative, which relied on the collection and analysis of numerical data to test hypotheses and answer research questions. An empirical-analytical approach was used to study causes and effects of low cocoa yields and propose alternative solutions. The study was descriptive, aimed at characterizing the current conditions and practices of growers during the year 2024. The population consisted of 30 cocoa producers, randomly selected, including relatives of the researcher and inhabitants of the Loma Linda village.
Results: the data obtained showed that Roberto Payán has a high potential to develop a competitive cocoa industry, thanks to its geographical and climatic conditions. However, producers face barriers such as lack of technification, training and access to markets. Surveys revealed a low use of sustainable practices and a high dependence on traditional methods, which limits product quality and profitability. However, farmers expressed interest in adopting technological improvements if provided with the necessary means and accompaniment.
Conclusions: the research led to the conclusion that Roberto Payán has the necessary conditions to position itself as a sustainable and high quality cocoa producing area. The implementation of sustainable agricultural practices such as agroforestry, the use of organic fertilizers and crop diversification can increase productivity, protect the environment and ensure long-term sustainability. It is recommended to strengthen innovation in cocoa production and processing, take advantage of fair trade certifications and orient producers towards value-added markets. This will improve income, competitiveness and the quality of life of rural communities.

Keywords: Green Innovation; Cocoa; Producers.

RESUMEN

Introducción: el presente proyecto se centró en la aplicación de la innovación verde al cultivo de cacao en el municipio de Roberto Payán, Nariño, con el propósito de mejorar la productividad agrícola y promover la

sostenibilidad ambiental en la región. Roberto Payán cuenta con amplias extensiones de tierra aptas para la producción a gran escala de cacao, lo que representa una oportunidad clave para transformar su economía rural. El estudio se enfocó en identificar las problemáticas y oportunidades asociadas al cultivo, tales como la falta de apoyo técnico, el uso inadecuado del suelo y la competencia con cultivos ilícitos. Asimismo, se plantearon soluciones enfocadas en reducir el impacto ambiental, mejorar la calidad del producto y aumentar los ingresos de los pequeños productores mediante prácticas sostenibles e innovadoras.
Método: la investigación adoptó un paradigma positivista, también conocido como cuantitativo, que se apoyó en la recolección y análisis de datos numéricos para probar hipótesis y responder a las preguntas de investigación. Se utilizó un enfoque empírico-analítico para estudiar causas y efectos del bajo rendimiento cacaotero y proponer alternativas de solución. El estudio fue de tipo descriptivo, orientado a caracterizar las condiciones y prácticas actuales de los cultivadores durante el año 2024. La población estuvo conformada por 30 productores de cacao, seleccionados aleatoriamente, incluyendo familiares del investigador y habitantes de la vereda Loma Linda.
Resultados: los datos obtenidos mostraron que Roberto Payán posee un alto potencial para desarrollar una industria cacaotera competitiva, gracias a sus condiciones geográficas y climáticas. Sin embargo, los productores enfrentan barreras como la falta de tecnificación, capacitación y acceso a mercados. Las encuestas revelaron un bajo uso de prácticas sostenibles y una alta dependencia de métodos tradicionales, lo cual limita la calidad del producto y la rentabilidad. No obstante, los agricultores manifestaron interés en adoptar mejoras tecnológicas si se les brindan los medios y el acompañamiento necesario.
Conclusiones: la investigación permitió concluir que Roberto Payán cuenta con las condiciones necesarias para posicionarse como una zona productora de cacao sostenible y de alta calidad. La implementación de prácticas agrícolas sostenibles como la agroforestería, el uso de fertilizantes orgánicos y la diversificación de cultivos, puede aumentar la productividad, proteger el medio ambiente y garantizar la sostenibilidad a largo plazo. Se recomienda fortalecer la innovación en la producción y transformación del cacao, aprovechar las certificaciones de comercio justo y orientar a los productores hacia mercados de valor agregado. Esto mejorará los ingresos, la competitividad y la calidad de vida de las comunidades rurales.

Palabras clave: Innovación Verde; Cacao; Productores.

INTRODUCTION

Cocoa, Theobroma cacao, is one of the most traditional products of Mesoamerica.[1,2,3,4]

Since pre-Columbian times, cacao has been present in American cultures.[5,6,7,8] It is native to the Amazon and was consumed by the Toltecs, Aztecs, and Incas.[9,10,11,12] In the early 17th century, cacao was introduced by Spanish conquistadors to Europe, where its consumption began to spread.[13,14,15,16]

The project focuses on green innovation among cocoa harvesters in Roberto Payán.[17,18,19,20] It also seeks to analyse the problems and opportunities for improvement in environmental care, proposing alternative solutions for farmers to use to make their product more productive and of higher quality,[21,22,23,24] given that the municipality has large areas of land suitable for large-scale cocoa production.[25,26]

The research will focus on green innovation for cocoa cultivation, aiming to replace chemical fertilisers with natural fertilisers, reduce water and air pollution in the fumigation process, and use renewable energies such as solar and wind power. It also aims to create and develop green awareness by generating cocoa production as a profitable and environmentally sustainable business and encouraging cocoa collectors to use green innovations to enhance their crops.

How does green innovation contribute to the growth and development of cocoa farmers in the municipality of Roberto Payán?

Objective

To conduct an analysis of green innovation for cocoa farmers in the municipality of Roberto Payán.

METHOD

Paradigm

The paradigm is positivist, referred to by other authors as quantitative. It uses data collection and analysis to answer research questions and test previously established hypotheses, relying on numerical measurement, counting, and, frequently, statistics to establish patterns of behaviour in a population accurately.

It is based on a type of deductive thinking that goes from the general to the particular. From extensive knowledge of a generality, it then deduces the limited behaviour of an individual particularity. It is based on modelling that defines how each thing is done, transforming it into a more rigid approach framed within a

certain way of doing things.

It is based on the probabilistic induction of logical positivism because it emphasises proven or verified sensory experience.

Research on green innovation among cocoa producers belongs to the positivist paradigm as it uses data collection and analysis through the application of surveys, where a numerical measurement is made to tabulate and interpret the information obtained.

Approach

Quantitative research consists of collecting and analysing numerical data. This method is ideal for identifying trends and averages, making predictions, testing relationships, and obtaining general results from large populations.

The research approach is quantitative because surveys will be conducted to collect and analyse numerical data.

Method

The method is empirical-analytical, in which studies are carried out with numerical or statistical data to respond to specific causes and effects.

The research on cocoa farmers uses an empirical-analytical method because the causes and effects of the problem will be studied, and alternative solutions will be provided.

Type of research

Descriptive research identifies the characteristics of the population being studied. This methodology focuses more on the 'what' rather than the 'why' of the research subject.

The ongoing research is descriptive as it will reveal the characteristics of the population under study during 2024.

Population and sample

Population

The population will be estimated through direct observation in an area affected by the presence of illegal groups and the absence of formal records in databases. Thirty cocoa producers will be randomly selected, including family members and some from the village of Loma Linda, as the only data available for the study.

Sample

As this is an environment where illegal groups and the lack of formal records make it difficult to access reliable data, a convenience sampling method will be used to estimate the population. Thirty cocoa producers will be selected, including both family members and some from the village of Loma Linda, which, according to a study:

Convenience sampling is a non-probabilistic and non-random sampling technique used to create samples based on ease of access, the willingness of individuals to participate in the sample within a given time frame, or any other practical specification of a particular element.

The researcher selects members solely based on their proximity and does not consider whether or not they actually represent a representative sample of the entire population. This technique makes it easier to observe habits, opinions, and points of view.

The researcher chooses members solely based on their proximity and does not consider whether or not they are truly representative of the entire population. This technique makes it easier to observe habits, opinions, and points of view.

Researchers use sampling techniques in situations where large populations need to be evaluated, since it is almost impossible to test an entire population.

Convenience sampling is the most commonly used sampling technique, as it is extremely fast, simple, inexpensive, and members are usually accessible to participate in the sample.

This technique is used when no criteria must be considered for a person to be part of the sample. Every member of the population can be a participant and is eligible to be part of the sample. These participants usually depend on their proximity to the researcher.

Information collection techniques

Primary sources: a survey will be conducted among cocoa farmers in the village of Loma Linda (Roberto Payán).

Secondary sources: books and university theses from Pasto will be consulted.

Tertiary sources: websites, blogs, digital books, and digital articles will be consulted.

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RESULTS

Diagnosis based on green innovation among cocoa harvesters in the village of Loma Linda in the municipality of Roberto Payán.

The results of the surveys are presented below

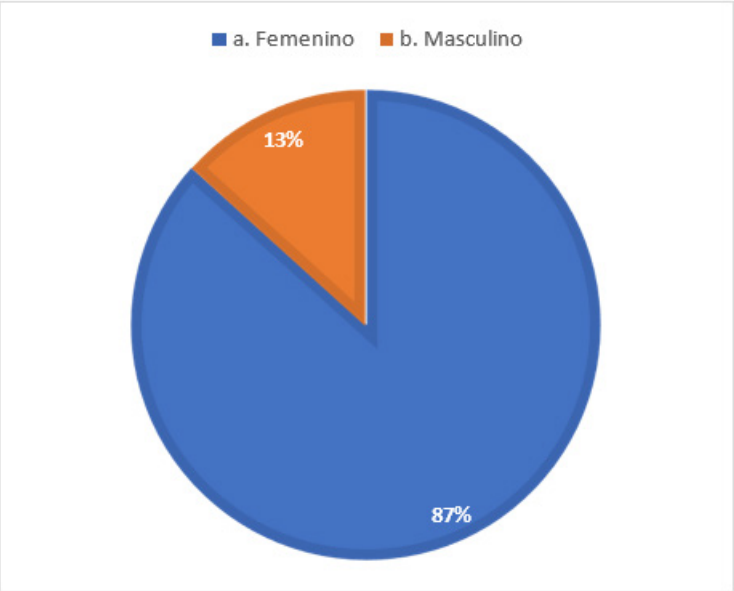

Figure 1. Gender

The figure shows the gender distribution of cocoa farmers, highlighting that 87 % are men, while the remaining 13 % are women. This notable difference reflects the predominance of men in agricultural activity in the region, where men are mainly engaged in cocoa farming. Women, on the other hand, tend to participate in different activities, such as domestic work.

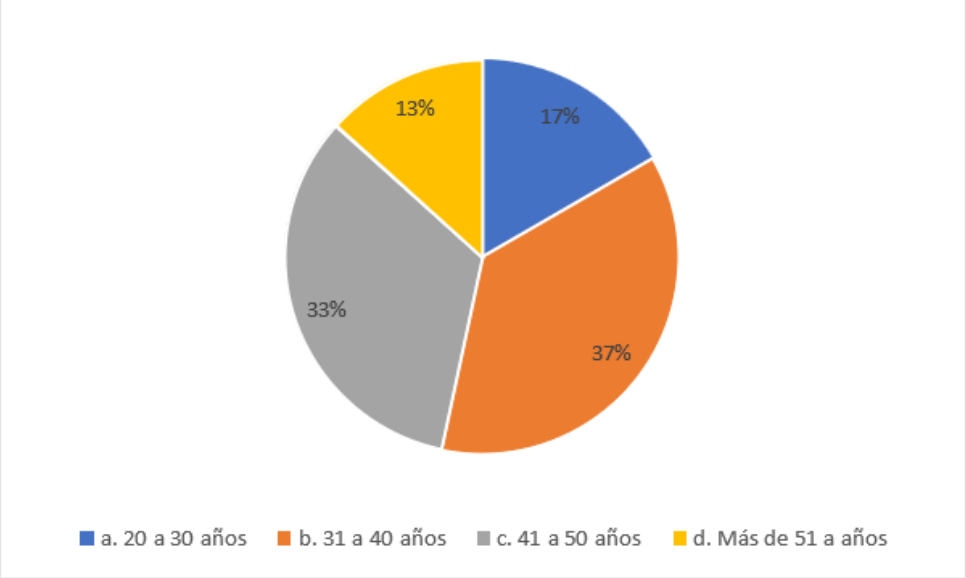

Figure 2. Age

The figure above shows that 37 % of growers are between 31 and 40 years old, making them the largest group. This suggests that most of those involved are in their prime productive years. Meanwhile, 33 % are in the 41 to 50 age range, indicating that middle-aged adults also play an essential role in this activity.

Young people aged 20 to 30 account for 17 %, who are less represented, reflecting low participation among younger generations. On the other hand, 13 % are over 51 years old, representing the smallest group, probably due to the physical demands of cultivation. Therefore, most cocoa farmers (70 %) are between 31 and 50. In

contrast, young people and older people participate to a lesser extent, which could indicate challenges for generational renewal and the long-term sustainability of the crop.

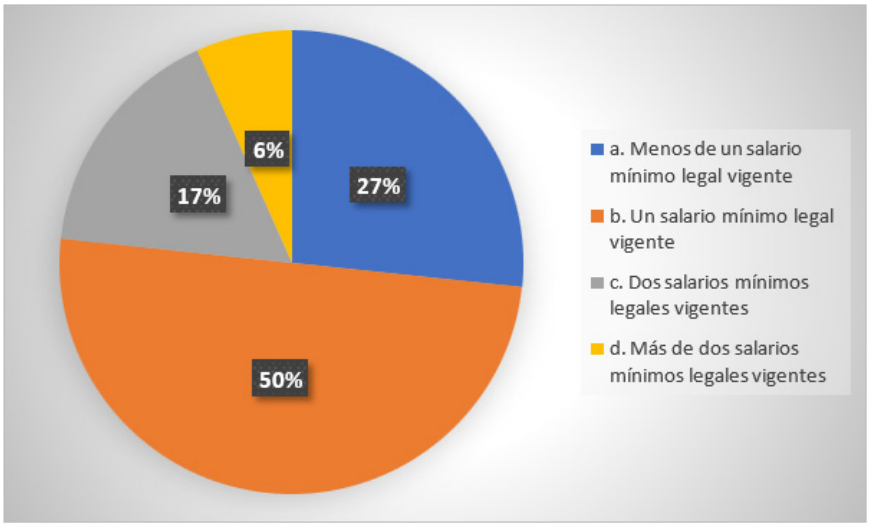

Figure 3. Monthly income

Fifty percent of farmers earn the current legal minimum wage, indicating that half of them are at the bottom of the wage scale. This group probably faces significant economic constraints. Meanwhile, 27 percent earn less than the minimum wage, showing that a considerable group of producers are below the minimum income standard, possibly reflecting low levels of productivity or profitability in their crops.

Seventeen per cent earn two times the minimum wage, representing an economic improvement compared to the previous groups, although they remain a minority. This group may be better positioned due to access to better technologies or markets. However, 6 % of farmers earn more than two times the minimum wage, making them the smallest group. These few producers will likely be more successful in their crops, achieving higher profitability.

This analysis shows an unequal income structure in the cocoa sector, where most producers are at the lowest wage levels. This could suggest the need for policies or programmes that promote greater productivity, access to better markets, and financial support for small farmers.

It should be noted that the highest-earning farmers are people who not only have income from crops but also have other jobs or are state employees (teachers, social leaders, self-employed workers), so as not to depend on a single source of income.

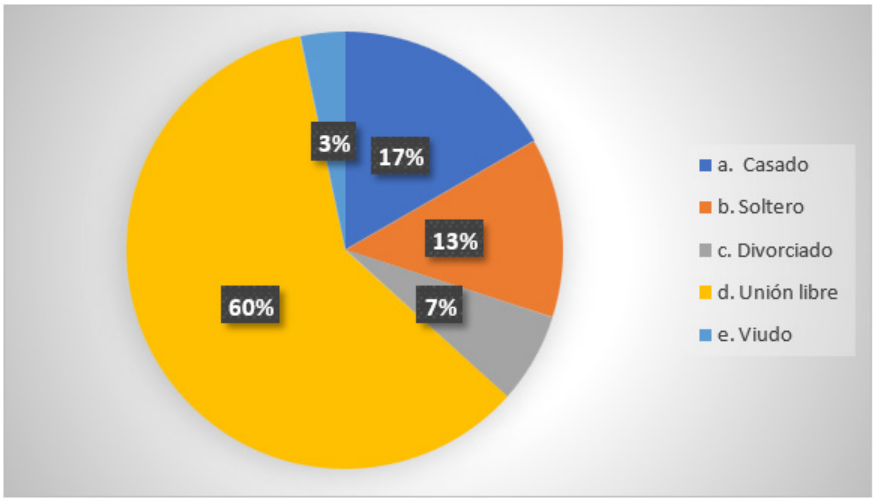

Figure 4. Marital status

According to the figure, 60 % of respondents live in common-law unions, which could indicate a change in social norms or preferences regarding traditional marriage. This trend may be due to greater social acceptance of unions without legal formalisation, economic difficulties, or a greater search for relationship flexibility.

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Twenty percent of respondents still opt for formal marriage, an important option, although not the most common in this sample. This could be related to cultural, religious, or legal factors.

A significant percentage of respondents (17 %) are single, which may reflect a desire for independence or a postponement of forming a couple due to professional or personal goals.

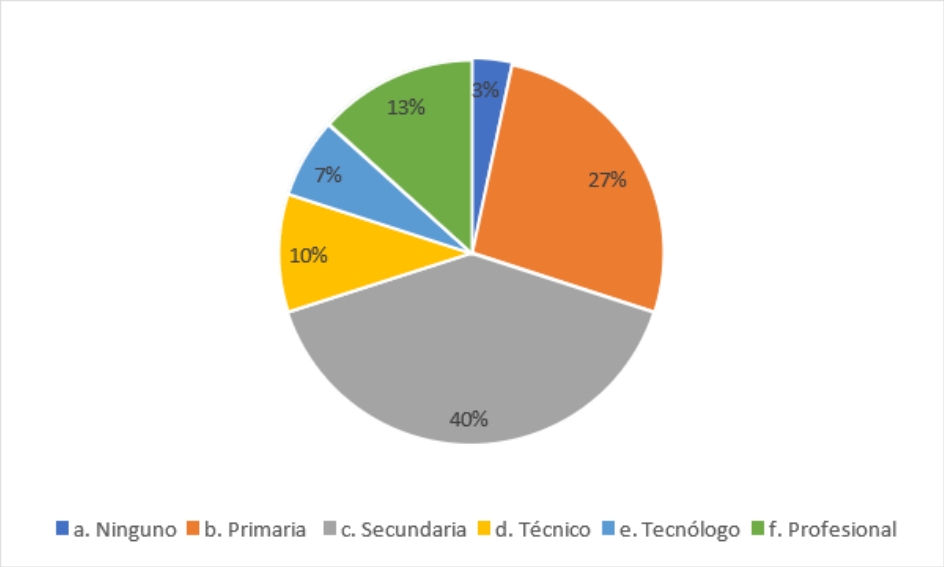

Figure 5. Level of education

The survey shows that 40 % of cocoa farmers have secondary education, representing the most significant proportion. This indicates that many farmers have attained a medium level of education, which could influence their technical knowledge and farming skills. However, 27 % of farmers completed primary education, showing that a significant proportion of the population has a basic level of education.

After that, 13 % of farmers have professional qualifications, representing a smaller group with more advanced academic training. This could imply greater access to specialised knowledge in agriculture or crop management. Meanwhile, 10 % have technical qualifications. This group has training focused on practical skills, which could help implement improvements in cocoa production processes.

Finally, 7 % of farmers have technologist studies, an intermediate level between technical and professional, which could give them an advantage in using more advanced technologies and production methods. Only 3 % of farmers have no formal education. This group is the smallest, suggesting that most cocoa farmers have at least some formal education.

This analysis reflects the diversity of educational levels among cocoa farmers, where secondary education predominates, but with a significant presence of people with higher education who could help drive improvements in the industry.

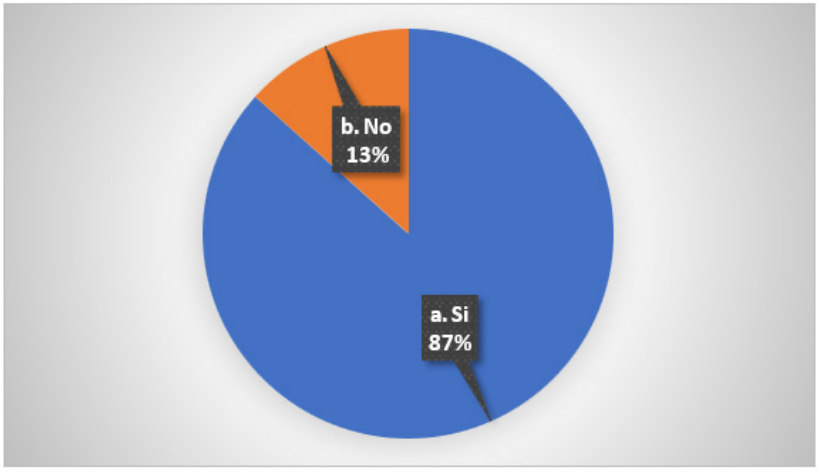

Figure 6. Delivers their production to a raw material collection centre

The figure shows that 87 % of respondents indicate that they do deliver their production to a collection centre. This is a majority percentage, suggesting that most producers prefer to centralise the delivery of their

cocoa in collection centres. This may be due to logistical facilities, commercial agreements, or the possibility of accessing broader markets.

Only 13 % of producers do not use collection centres to deliver their production. This minority group may be marketing directly or using other distribution mechanisms, which could suggest greater autonomy or a different approach to selling their cocoa.

This analysis suggests that collection centres are essential for the vast majority of producers. They facilitate their access to markets and provide an efficient channel for marketing cocoa.

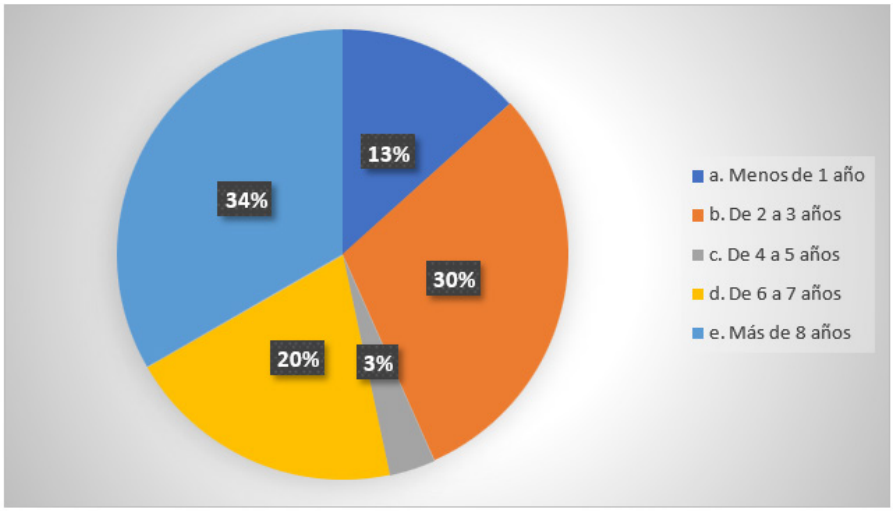

Figure 7. Years as a cocoa farmer

It can be analysed that 34 % of farmers have been growing cocoa for more than 8 years. This group represents the largest proportion, indicating that a significant proportion of producers have extensive experience in the sector, which may positively influence their knowledge and cultivation practices. On the other hand, 30 % of respondents have been growing cocoa for between 2 and 3 years. This is a considerable group, suggesting that there are a large number of relatively new producers, possibly driving the growth of the sector.

However, 20 % of farmers have been in this activity for between 6 and 7 years. This group is also significant and reflects a mix of intermediate experience that may be at a stage of consolidation as producers. Meanwhile, 13 % of producers have been growing cocoa for less than 1 year, indicating that this percentage corresponds to new entrants beginning to establish themselves.

Finally, 3 % of respondents have been growing cocoa for between 4 and 5 years, making this the least represented group. This suggests that fewer producers are in this time frame.

This analysis shows a combination of consolidated experience and the entry of new growers, which may contribute to the long-term sustainability of the cocoa sector.

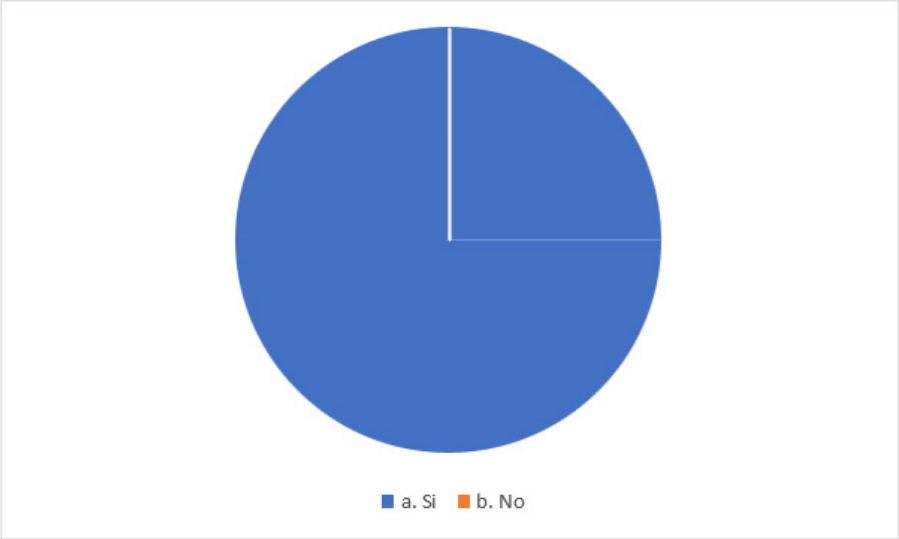

Figure 8. Own cocoa plantation

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100 % of participants responded 'yes,' suggesting that no farmers work on leased land, under third-party contracts, or on land owned by others.

This result highlights producers' autonomy and total control over their agricultural activity, which can influence their decision-making, management practices, and the profitability of their cocoa business.

This data suggests a high degree of independence among producers, which could translate into a greater commitment to product quality and an ability to implement improvements in their cultivation. In addition, full ownership of the land indicates stability and deep roots in the cocoa industry.

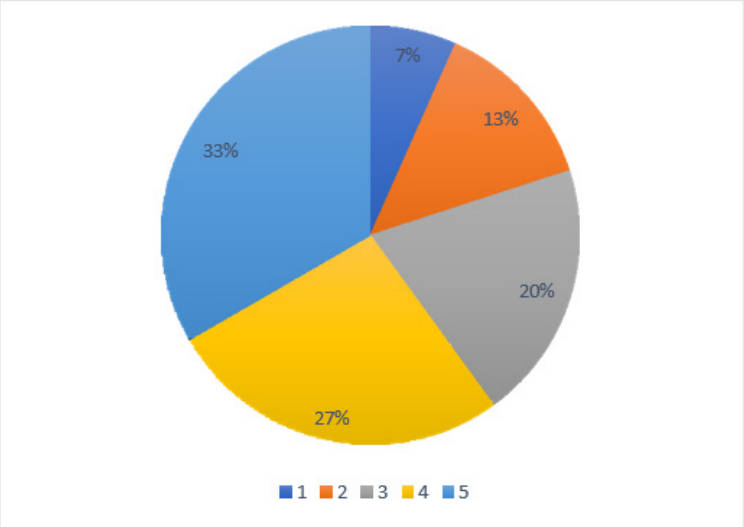

Figure 9. Hectares owned

The figure shows that 33 % is the largest category, indicating that most respondents or cocoa producers own only one hectare. This could suggest that many small farmers are involved in cocoa cultivation. Twenty-seven percent show that many farmers have a little more space to cultivate (2 hectares), which could be related to increased investment and resources.

Meanwhile, 20 % of farmers own 3 hectares. Although the percentage has decreased, it is still a considerable portion representing producers with moderate capacity to grow cocoa. However, 13 % own 4 hectares. This group is significantly smaller, which could indicate that as the area under cultivation increases, the number of producers decreases. This could reflect barriers such as costs, access to land, or the management of larger crops.

Finally, 7 % is the smallest proportion, suggesting that few farmers own 5 hectares of land. This could indicate that cocoa cultivation in larger areas is less common, possibly due to economic or market constraints.

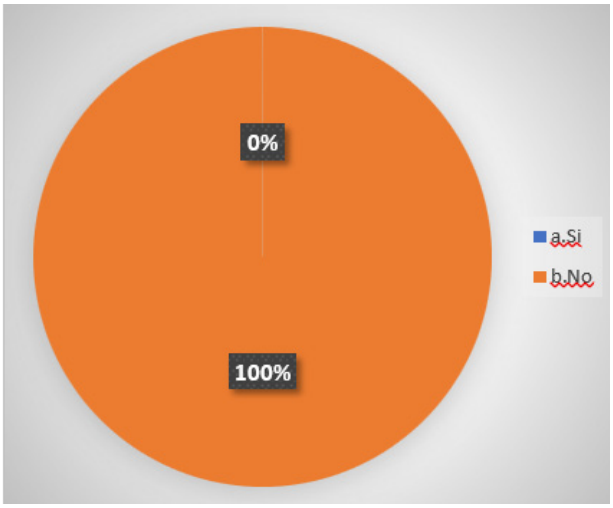

Figure 10. Produces under some national and/or international quality standard and/or certification

The figure suggests that most cocoa producers are small farmers with less than 3 hectares. This phenomenon may imply challenges regarding economies of scale, resource access, and the potential for sustainable

development within the cocoa industry. It could also open up opportunities for policies that support these farmers and facilitate the expansion of their crops.

This should be reflected in the fact that farmers use their land for other crops such as banana plantations, sugar cane, etc., or even large-scale coca plantations of more than 10 hectares.

The fact that 100 % of respondents do not produce under quality standards or certifications indicates a lack of alignment with modern market trends, where sustainability and quality are increasingly valued. Cocoa producers in Roberto Payán should consider implementing standards and certifications, which could open new doors and improve their economic situation.

This is because the population is unaware of standards that could benefit them.

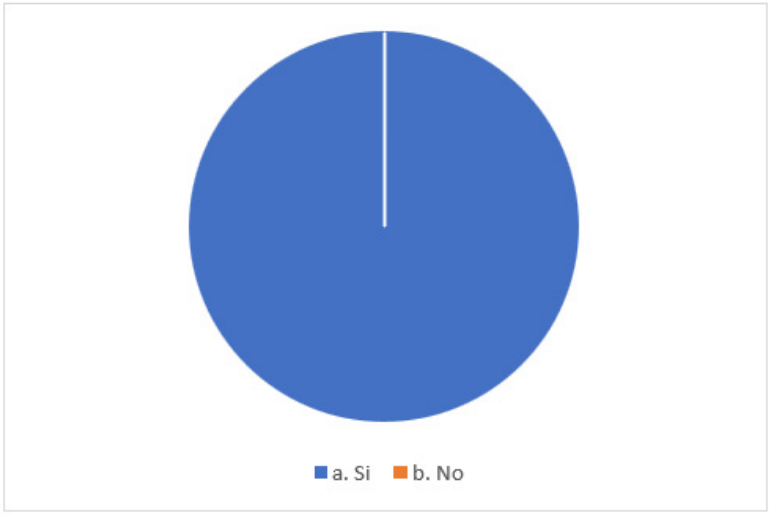

Figure 11. Changes in the environment, such as climatic factors and soil quality, have a positive influence on cocoa cultivation and harvest

100 % of respondents agree that environmental factors, such as climate change and soil quality, positively influence cocoa cultivation and harvest. This means everyone recognises that the natural environment plays a fundamental role in successful cocoa production. This finding is crucial, as it reflects a widespread understanding of the importance of optimal environmental conditions for maximising productivity and quality in cocoa cultivation.

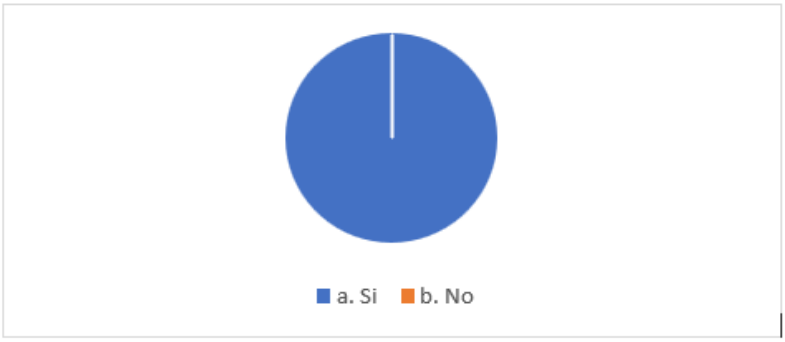

Figure 12. The quality of the environment: climate, temperature, humidity, and soil fertility are suitable for cocoa production

The figure indicates that 100 % of respondents consider the quality of the environment, including factors such as climate, temperature, humidity, and soil fertility, suitable for cocoa production. No respondents expressed the opposite view.

This result suggests that cocoa producers perceive current environmental conditions as favourable for cultivation, a positive indicator of productivity and production sustainability in the areas analysed.

Seventy-three percent of cocoa producers have not received technical advice or innovation from government agencies. This high percentage suggests that most producers have access to some form of institutional support to improve their production. This could imply exemplary implementation of state agricultural support programmes in the region, aiming to enhance the quality of cocoa, increase productivity, or introduce new technologies or farming practices.

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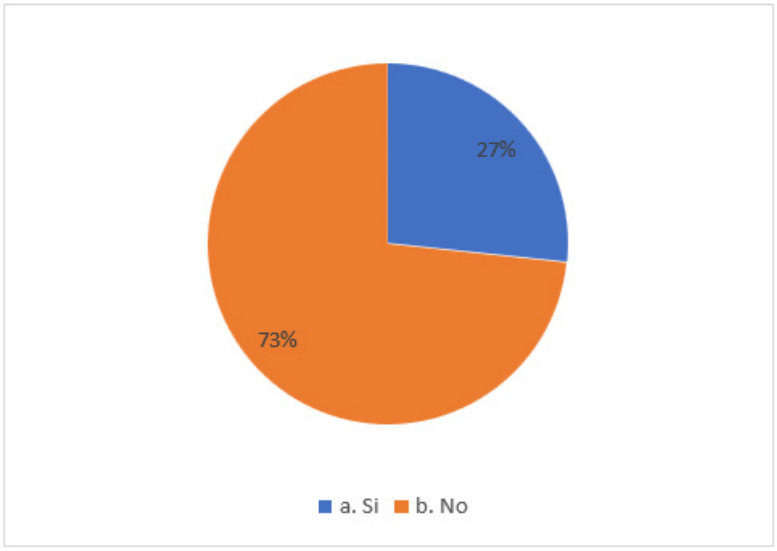

Figure 13. He has received technical advice and innovation from state agencies for cocoa production

27 % of respondents have received technical advice or innovation from state agencies. Although a minority, this percentage is not negligible, indicating that many producers may be working without adequate technical support, which could limit their modernisation or efficiency in their crops. This group could benefit from more outreach efforts and access to innovation and technical advisory programmes so as not to be left behind in the sector's development.

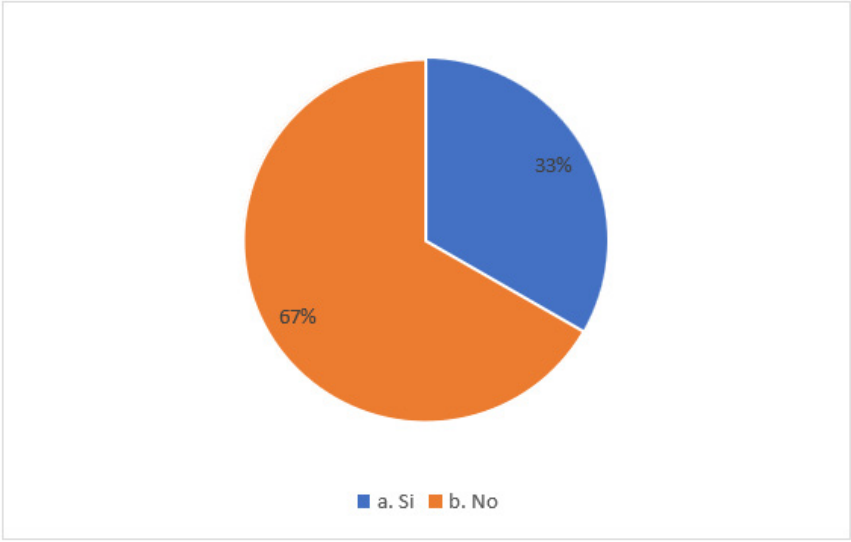

Figure 14. He has received technical advice and innovation (seeds for cultivation) from non-governmental organisations for cocoa production

Sixty-seven percent of respondents stated that they had not received technical advice or innovation support from non-governmental organisations for cocoa production. On the other hand, 33 % had received support because they attended a course run by SENA, where they were given guidance on how to grow cocoa and seeds to help them start growing cocoa.

The high proportion of 'no' responses indicates an opportunity to improve the reach of support programmes to promote greater adoption of innovative techniques and resources to enhance cocoa cultivation's productivity and sustainability.

Most respondents (53 %) indicated that wastewater from cocoa cultivation is treated through a filtration process. This suggests that filtration is the primary method used to manage wastewater on these plantations.

More than half of the respondents use filtration, suggesting awareness of the need to treat wastewater in cocoa farming, although this process could be improved by adding disinfection.

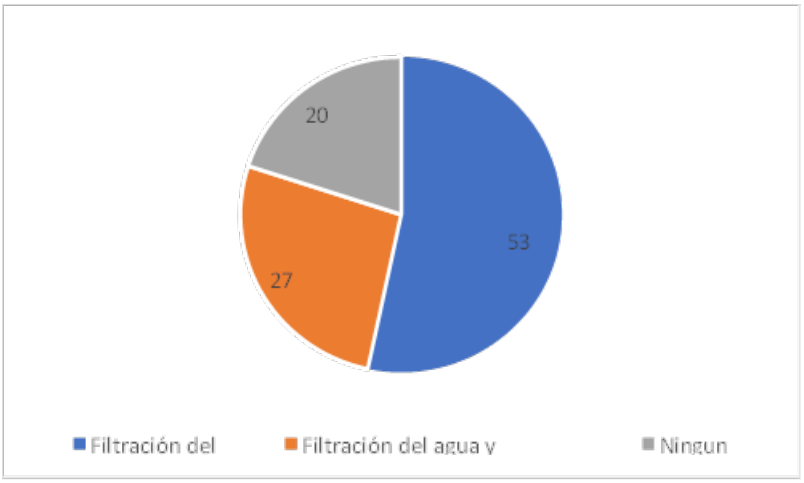

Figure 15. Wastewater treatment in cocoa cultivation

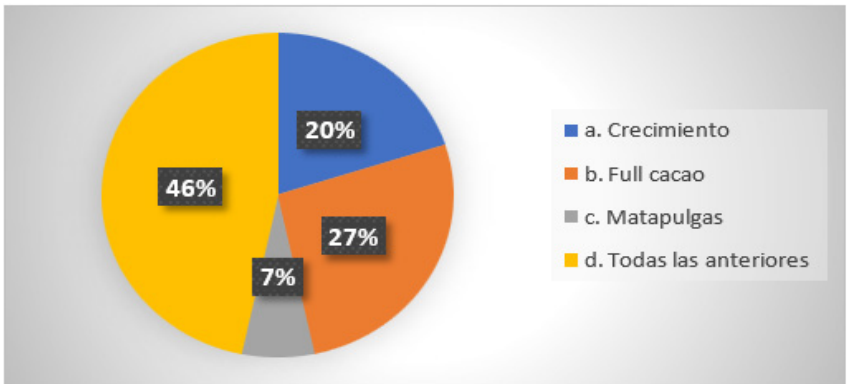

Figure 16. Type of fertiliser used to grow cocoa

Forty-six percent of respondents use various fertilisers, suggesting that almost half of the respondents do not limit themselves to a single type of fertiliser but prefer to combine different options to achieve better results. This trend may indicate greater awareness of the need to balance nutrients and control pests simultaneously. This variation could be related to ensuring healthy crop growth, protecting against pests, and improving cocoa quality.

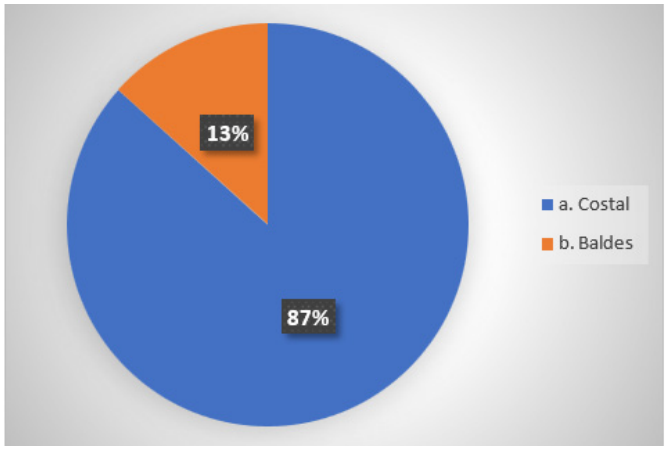

Figure 17. Types of packaging used to sell cocoa

87 % of producers choose sacks as their primary packaging for selling cocoa. This may be due to several reasons. Sacks are usually cheaper and widely available, making them accessible to most producers. They are also easier to carry, as this packaging makes transport less laborious in rural areas.

The predominant use of sacks reflects a clear trend towards a more traditional, economical, and effective packaging method for cocoa producers. Although buckets offer advantages in terms of reusability, their low adoption suggests that they are not as well suited to most respondents' logistical or economic needs.

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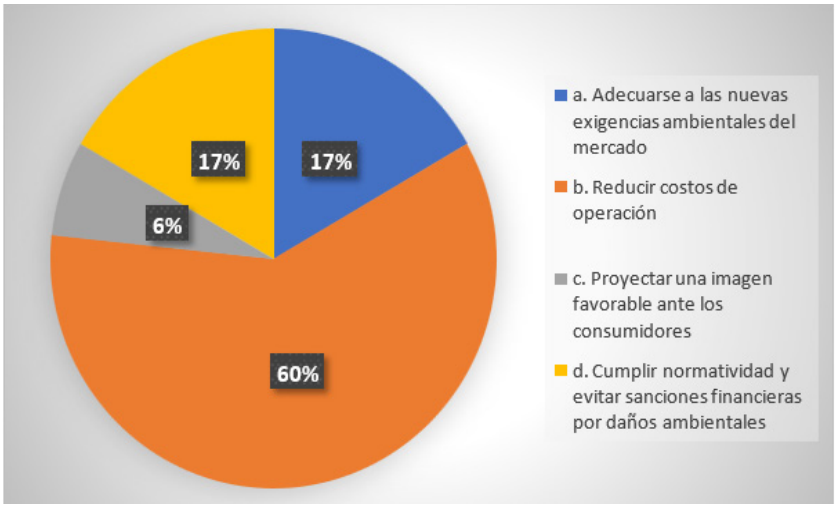

Figure 18. Reasons for implementing green practices in cocoa cultivation

Sixty percent of respondents believe that the main reason for implementing green practices in cocoa farming is to reduce operating costs. This suggests that most farmers see green practices as an efficient way to make their processes more economical in the long term, by optimising the use of resources such as water, energy, or fertilisers, or by improving production efficiency.

Analysis of this survey shows that most cocoa producers are primarily motivated by the operating cost savings that can be derived from green practices.

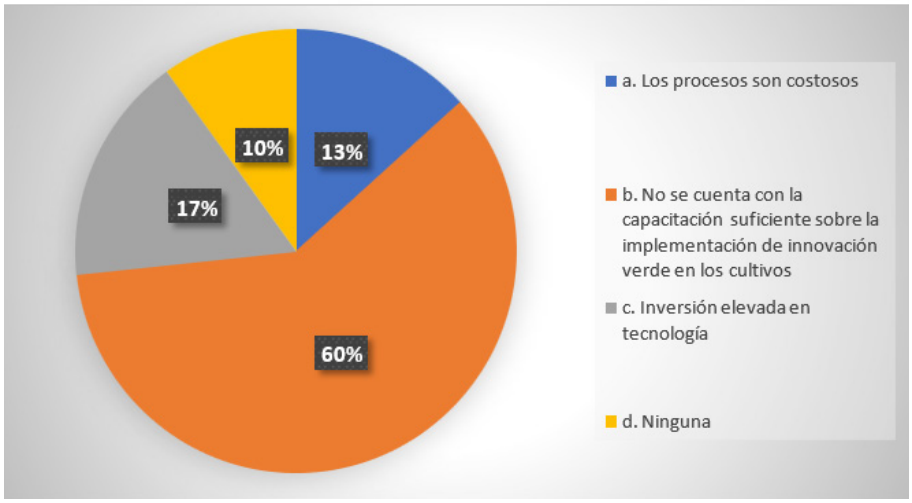

Figure 19. Difficulties in implementing green practices

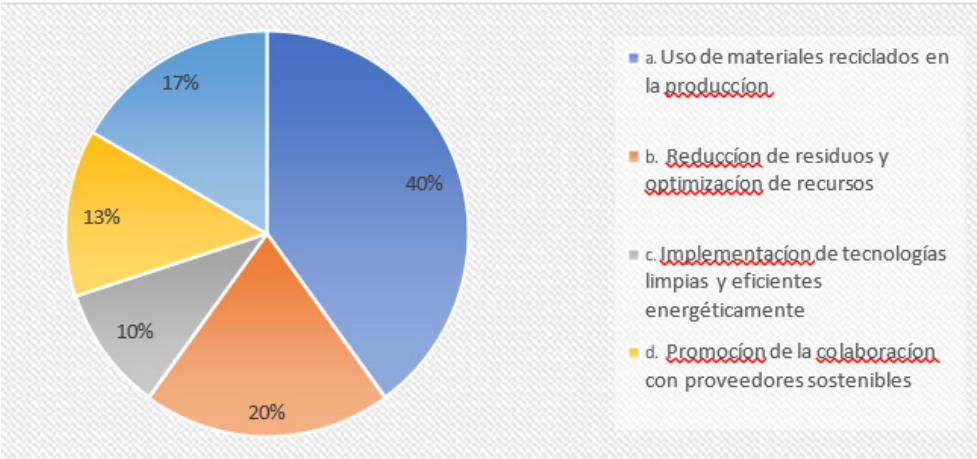

Figure 20. Measures implemented in your crop to reduce its environmental impact

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60 % of respondents cited inadequate training as the main obstacle to adopting green practices, suggesting a strong need for training programmes.

Farmers lack access to necessary information on sustainable agricultural practices. These include techniques such as agroforestry, crop rotation, and shade crop implementation, which are essential for conserving soils and increasing biodiversity.

The fact that 40 % of cocoa producers choose to reuse materials to mitigate environmental impact is a positive indicator of ecological awareness in the sector. This practice can include the reuse of agricultural materials, such as tree pruning waste, cocoa shells, or compost, which helps reduce waste and improve the sustainability of operations.

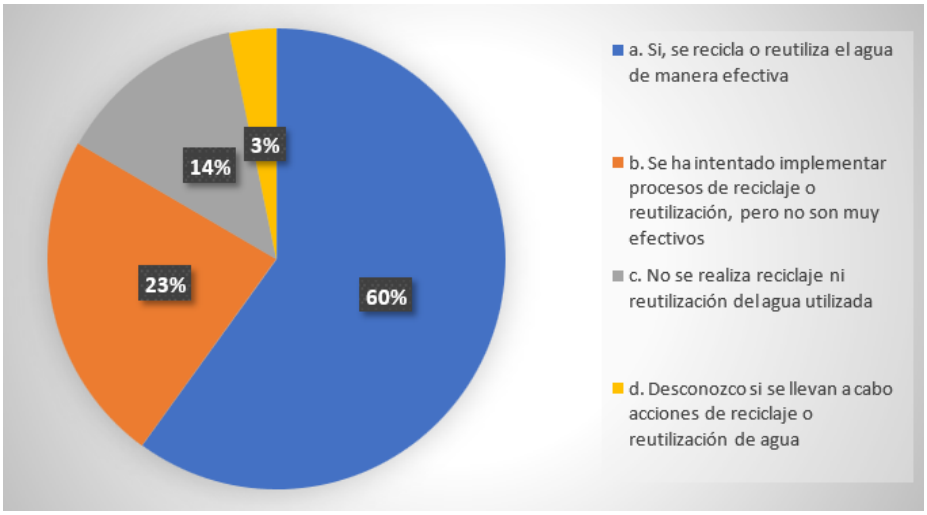

Figure 21. Management of technology or processes that enable the recycling or reuse of water used in operations

Sixty percent of respondents indicate that more than half of producers have effectively implemented processes to recycle or reuse water, which could be driven by the need to conserve resources and reduce costs in areas where water may be scarce or expensive.

Most producers (60 %) have successfully established effective processes for recycling or reusing water, suggesting that there is awareness and commitment to the responsible use of this resource.

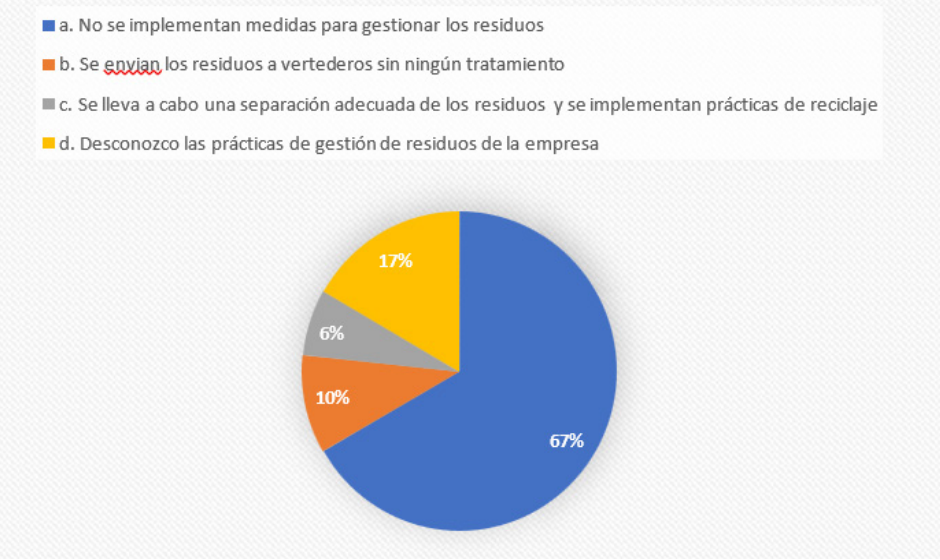

Figure 22. Management of waste generated in production processes

60 % of respondents indicate that no measures are implemented to manage waste in the cocoa production process.

This could reflect a lack of awareness or resources to establish sustainable waste management practices. This high percentage suggests that farmers in the area are not yet trained to take action to reduce or properly manage waste.

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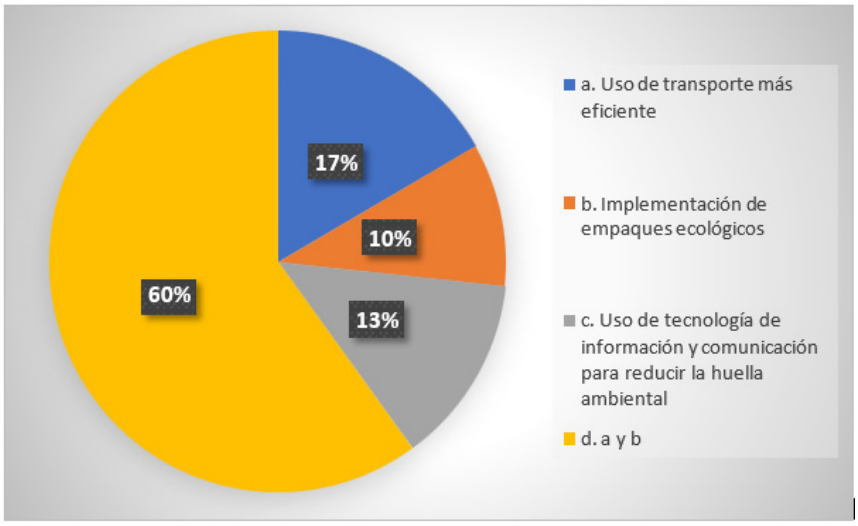

Figure 23. In which area do you think distribution and marketing processes should be improved from a green innovation perspective?

The analysis of the survey results shows that 60 % of respondents identify two key areas for improvement in distribution and marketing processes from a green innovation perspective: efficient use of transport and the implementation of eco-friendly packaging:

1. The use of efficient transport is essential because the region only has the river for transport. It is expensive to get their products out of the area, so they choose to sell them at a low price. With land transport connectivity, the products could be transported, and higher profits could be made, motivating farmers.
2. Implementation of eco-friendly packaging. Promote research into sustainable materials and support the design of modular or collapsible packaging that facilitates recycling.

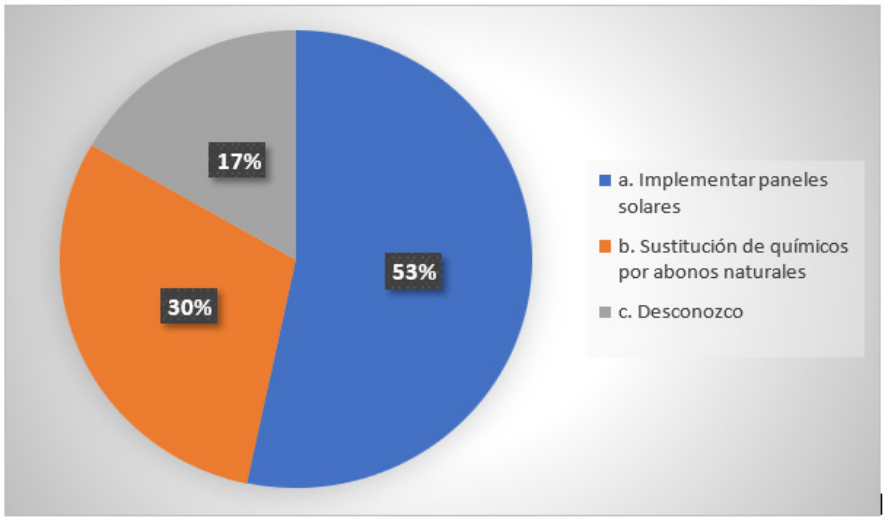

Figure 24. Measures that would be adopted to improve energy efficiency in crop production and marketing processes

53 % of respondents choose to install solar panels as one of the most effective measures to improve energy efficiency. This reflects a clear preference for using renewable energy in agriculture, which reduces energy costs in the long term and minimizes the carbon footprint. Installing solar panels allows clean and stable energy generation, reducing dependence on conventional sources, which are often more expensive and polluting. This measure is not only seen as an economically viable option but also as a strategy to align with global trends towards sustainability.

The survey also shows that most producers like concrete and technologically advanced measures like solar panels. At the same time, many are already open to more sustainable practices, such as using natural fertilisers.

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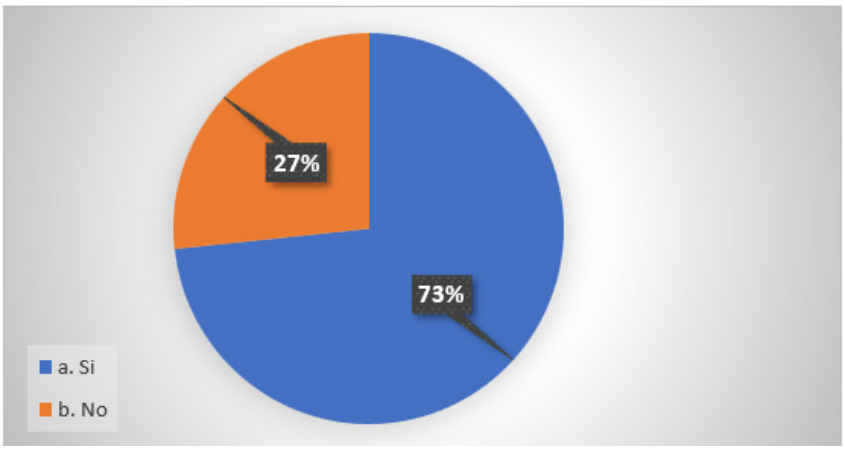

Figure 25. Would you be willing to invest in implementing green practices in your crop in the long term?

73 % of respondents said they would be willing to invest in green practices long-term, reflecting widespread interest and openness towards sustainability in agricultural production. This result suggests that farmers are not only aware of the environmental impact of their activities but also see green practices as a viable and beneficial long-term investment.

This indicates that the agricultural sector is willing to evolve and improve its relationship with the environment.

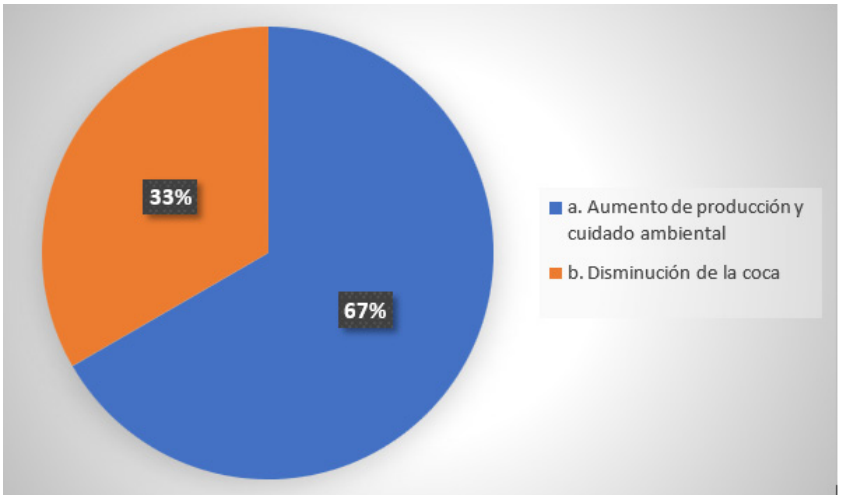

Figure 26. How do you think green innovation could benefit cocoa production in the municipality of Roberto Payán?

Many respondents believe that green innovation can optimise farming methods, using sustainable practices that improve yields and protect the environment. Green innovation would benefit producers in terms of income and foster greater community cohesion by allowing them to collaborate on sustainable agricultural practices. This could lead to the creation of support networks and improved local infrastructure.

Most respondents perceive that green innovation would not only benefit cocoa production by increasing yields and product value, but would also positively impact the community and the environment. This highlights the need to promote policies and programmes that support the transition to more sustainable agricultural practices in the region.

External Factor Evaluation Matrix (EFEM)

An audit of the external environment is carried out to identify threats and opportunities for cocoa crops. The following steps were taken:

- A list of success factors was drawn up, considering first opportunities and threats.
- Each external factor was assigned a weight between 0,0 and 1,0, taking into account the level of impact that this variable has on cocoa farmers, ensuring that the sum of all the weights assigned to the factors added up to 1,0.
- Each external factor was rated between 1 and 4, where 4 = most incredible opportunity, 3 = lesser opportunity, 2 = lesser threat, and 1 = greatest threat.

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- The value was multiplied by the rating of each factor to determine the weighted score.
- As a final step, the total score was obtained by adding the weighted scores.

Table 1. MEFE external factors evaluation matrix

MEFE matrix for cocoa farmers			
Factors	**Value**	**Rating**	**Weighted value**
Opportunities			
Government support	0,08	3	0,24
Favourable climate	0,07	4	0,28
Rural development projects	0,9	4	0,36
Promotion of regional cocoa	0,12	3	0,36
Access to international markets	0,08	4	0,32
Growth in demand	0,10	3	0,30
Total	0,54	21	1,86
Threats			
Armed conflicts	0,08	2	0,16
Crop substitution	0,10	1	0,10
Lack of innovation	0,09	2	0,18
Lack of road infrastructure	0,12	2	0,24
Global competence	0,07	1	0,07
Total	0,46	8	0,75
Total, Overall	1		2,61

The MEFE matrix for cocoa crops in the Loma Linda district of Roberto Payan, Nariño, has 11 external factors, of which 6 are opportunities and 5 are threats, with the following ratings:

Opportunities (Total: 1,86)

1. Government support (0,08; rating 3; weighted value 0,24): the existence of government support indicates that some policies and programmes could facilitate cocoa production and marketing. The moderate rating suggests that, although support exists, it may not be sufficient or fully utilised.
2. Favourable climate (0,07; rating 4; weighted value 0,28): a favourable climate is essential for cocoa cultivation. This high rating highlights the importance of this factor in ensuring successful, high-quality harvests.
3. Rural development projects (0,09; rating 4; weighted value 0,36): ongoing projects are an excellent opportunity to improve infrastructure and production capacities. The high rating suggests that these projects are well-received and effectively implemented.
4. Promotion of regional cocoa (0,12; rating 3; weighted value 0,36): promoting regional products can increase the visibility and demand for local cocoa. This is essential for building a strong brand and differentiating oneself in the market.
5. Access to international markets (0,08; rating 4; weighted value 0,32): the possibility of accessing international markets represents an excellent opportunity to increase sales and recognition of quality cocoa. A high rating suggests that this access is quite effective.
6. Growth in demand (0,10; rating 3; weighted value 0,30): the growing demand for cocoa in the market is a positive indicator. However, the moderate rating suggests that farmers should be prepared to meet this demand consistently.

Threats (Total: 0,75)

1. Armed conflict (0,08; rating 2; weighted value 0,16): the presence of armed conflict can destabilise communities and affect production. This moderate rating indicates a risk that needs to be considered.
2. Crop substitution (0,10; rating 1; weighted value 0,10): crop substitution is a significant threat that can divert farmers' attention and resources to other, more profitable products. The low rating highlights the urgency of addressing this issue.
3. Lack of innovation (0,09; rating 2; weighted value 0,18): lack of innovation can limit the competitiveness of growers. This threat highlights the need to adopt new technologies and agricultural

methods.

4. Lack of road infrastructure (0,12; rating 2; weighted value 0,24): deficiencies in road infrastructure hinder access to markets and product distribution. This is a threat that needs immediate attention.

5. Global competition (0,07; rating 1; weighted value 0,07): competition in the global market is a minor but relevant challenge. The low rating suggests that, although there is competition, it can be managed if local competitive advantages are strengthened.

Overall total (Opportunities and Threats): 2,61

The overall total of 2,61 indicates a positive balance, as opportunities (1,86) significantly outweigh threats (0,75). This suggests that, although challenges exist, cocoa farmers can exploit many more opportunities.

MEFI internal factor assessment matrix

An internal audit is carried out to identify the strengths and weaknesses of cocoa crops. To do this, the following steps were taken:

- A list of key internal factors was drawn up.
- Each factor was assigned a weight between 0,0 and 1,0. The total of all weights added up to 1,0.
- A rating between 1 and 4 was assigned to each factor, where 1 = major weakness, 2 = minor weakness, 3 = minor strength, and 4 = major strength.
- The value was then multiplied by the rating for each factor to determine the weighted score.
- Finally, the weighted scores were added together to obtain the total score for the cocoa crops.

Table 2. MEFI internal factor evaluation matrix

MEFI matrix for cocoa farmers			
Factors	**Value**	**Rating**	**Weighted value**
Strengths			
Availability of land for cocoa cultivation	0,15	4	0,60
Community empowerment	0,10	3	0,30
Fertile soils	0,12	4	0,48
Diversity of cocoa species	0,10	3	0,30
Total	0,47	14	1,68
Weaknesses			
Devaluation of cocoa	0,10	1	0,20
Lack of training in production and marketing	0,12	1	0,12
Devaluation of cocoa	0,15	2	0,30
Crop diseases and pests	0,08	2	0,16
Access to financial resources	0,08	2	0,16
Total	0,53	8	0,94
Total, overall	1		2,62

The MEFI matrix for cocoa crops in the Loma Linda district of Roberto Payan, Nariño, has nine internal factors, four of which are strengths and five weaknesses, with the following ratings:

Strengths

Availability of land for cocoa cultivation (Value: 0,15, Rating: 4, Weighted value: 0,60)

Analysis: the rating of 4 indicates that the land is highly favourable for cocoa cultivation, which is essential for the crop's success.

Implication: this strength should be capitalised to maximise cocoa production and quality.

Community empowerment (Value: 0,10, Rating: 3, Weighted value: 0,30)

Analysis: empowered communities tend to collaborate better, which can create cooperatives or associations that strengthen the cocoa value chain.

Fertile soils (Value: 0,12, Rating: 4, Weighted value: 0,48)

Analysis: fertile soils are a significant advantage, allowing optimal plant growth.

Implication: investing in agricultural practices that maintain soil fertility will be key.

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Cocoa diversity (Value: 0,10, Rating: 3, Weighted value: 0,30)

Analysis: the diversity of cocoa varieties can provide competitive advantages and adaptation to different markets.

Implication: promoting this diversity can help to combat pests and diseases. Obtaining a total rating of 1,68

Weaknesses

Market access (Value: 0,10, Rating: 1, Weighted value: 0,20)

Analysis: a rating of 1 indicates minimal market access, a critical weakness.

Implication: strategies to improve market connections, such as partnerships or marketing networks, should be sought.

Lack of training (Value: 0,12, Rating: 1, Weighted value: 0,12)

Analysis: this weakness suggests that producers may not have the skills necessary to maximise production and quality.

Implication: investing in training programmes to improve agricultural and management skills is essential.

Devaluation of cocoa (Value: 0,15, Rating: 2, Weighted value: 0,30)

Analysis: devaluation indicates a significant problem affecting the crop's profitability.

Implication: marketing and product differentiation strategies are needed to address this situation.

Crop diseases and pests (Value: 0,08, Rating: 2, Weighted value: 0,16)

Analysis: this weakness represents a risk to production, although it is being managed moderately.

Implication: implementing integrated pest and disease management is crucial to protect crops.

Financial access (Value: 0,08, Rating: 2, Weighted value: 0,16)

Analysis: limited financial access may restrict the investments needed to improve production.

Implication: seeking alternative financing and support programmes is essential to ensure financial viability.

With a total weakness score of 0,94.

Achieving a total score of 2,62 on the MEFI matrix, this score indicates that the organisation is in a balanced position, with significant strengths that can be leveraged and weaknesses that need attention.

General recommendations

Strengthening Opportunities: strengths, especially fertile land and soil, should be fully exploited to increase the production of high-quality cocoa.

Improving Market Access: implement strategies to enhance market access, such as establishing relationships with cooperatives and distributors.

Training and Education: invest in training programmes to address skills gaps and improve production.

Differentiation Strategies: develop products that differentiate themselves in the market to counteract the devaluation of cocoa.

Integrated Pest Management: implement sustainable practices to manage diseases and pests, ensuring crop health.

DOFA Matrix

The DOFA analysis studies the company's external and internal factors, facilitates decision-making, and provides a frame of reference when selecting strategies and reviewing the company's position.

Threats and opportunities are represented by external conditions that may influence the company negatively or positively; opportunities are external conditions that could affect the company positively, and threats are external conditions or actions by other parties that could affect it negatively

Table 3. Matrix of weaknesses, opportunities, strengths and threats (SWOT)

	(F)STRENGTHS 1. Land availability for cocoa cultivation 2. Community empowerment 3. Fertile soils Cocoa diversity	(D) WEAKNESSES 1. Market access 2. Lack of training 3. Devaluation of cocoa 4. Crop diseases and pests 5. Financial access
(O) OPPORTUNITIES 1. Government support 2. Rural development projects	Strategies (FO) Contact entities such as the Ministry of Agriculture, Rural Development and SENA	Strategies (FA) Cultivate available land so that armed groups do not take over the land (F1, A1).

3. Promotion of regional cocoa 4. Access to international markets 5. Growth in demand 6. Favourable climate	to access technical assistance and training programmes on cocoa cultivation (F1, O1). Take advantage of the Minagricultora project, which seeks to renew 6500 hectares of cocoa with an investment of 12 billion (F2, O2). Showcase the healthy cocoa cultivation process in the Roberto Payan region on social media platforms such as TikTok, Facebook and Instagram (F3, O3). Create an association to achieve large-scale production and enable imports, taking advantage of the different varieties of cocoa (F4, O4).	Carry out cocoa farming campaigns with assistance from the SENA institution to motivate the community (F2, A2). With the help of the community council, submit a road project to Colombia Transforma demonstrating the benefits that would be achieved if the region had road connectivity (F3, A3). Implement the selection of the type of cocoa and carry out artificial drying to speed up the drying of the cocoa (F4, A4).
(A) THREATS 1. Armed conflicts 2. Crop substitution 3. Lack of road infrastructure 4. Lack of innovation Global competition	Strategy (DO) Access programmes offered by the Fedecacao federation to improve cultivation techniques in order to increase cocoa quality and marketing (D1, O1). Training: Provide training in good agricultural practices, pest management, harvest optimisation and post-harvest (D2, O2). Innovate in presentation, such as eco-friendly packaging, to create a regional image and add value to the product (D3, O3). Use disease- and pest-resistant cocoa varieties. Also carry out biological crop control (D4, O4).	Strategy (DA) Implement dialogue with leaders of armed groups to minimise risk and open access to the cocoa market (D1, A1). Implement crop diversity within cocoa (D2, A2). Due to the lack of roads in the region, agreements will be sought with land transport companies in Barbacoas (D3, A3). Techniques such as using biological products based on bacteria or fungi for pest or disease control, differentiating us from the competition (D4, A4). Access financing from entities such as the agricultural bank to invest and become competitive (D5, A5).

Types of green product and process innovations that can be implemented with cocoa harvesters in the village of Loma Linda (ROBERTO PAYAN).

Table 4. Types of green product and process innovations that can be implemented with cocoa collectors in the village of Loma Linda (ROBERTO PAYAN)

Processes	Details
Production	Integrate cocoa cultivation with other products such as bananas or fruits that grow in the area in order to improve biodiversity, care for the soil and provide shade. The plants will also be fertilised with organic fertilisers such as compost to reduce the use of chemical pesticides that harm the environment.
Distribution	Seek agreements with transport companies that provide the best service in order to distribute cocoa to more profitable markets such as Tumaco.
Marketing and sales	An e-commerce platform that allows farmers to sell and promote cocoa directly to consumers and international markets, eliminating intermediaries and increasing their income. Additionally, the platform can include features such as product reviews, farmer stories, and quality certifications, which build consumer trust. This strategy not only promotes more ethical and sustainable trade but also allows farmers to diversify their markets and reach global audiences, thereby contributing to the economic stability of the community.
Information and communication system	Create a database to access farmers and inform them about training or projects for cocoa cultivation. In addition, the system can incorporate communication channels, such as newsletters, text messages, and online platforms, to ensure that information reaches farmers quickly and effectively. This not only empowers farmers by keeping them informed, but also fosters a more united and collaborative community.
Business process	Partner with companies or entities that allow growers to interact directly with consumers and international markets, eliminating intermediaries and increasing their income. By eliminating intermediaries, growers not only get fairer prices for their product, but also have the opportunity to build stronger relationships with their buyers.

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Compost will also be produced for cocoa cultivation, contributing to the crop's sustainability and improved productivity. Some of the main objectives are detailed below:

Improving soil fertility

Nutrient supply: compost is rich in essential nutrients (nitrogen, phosphorus, potassium) that promote the growth of cocoa plants.

Increase in organic matter: improves soil structure, increasing water and nutrient retention capacity.

Environmental sustainability

Waste recycling: uses organic waste (crop residues, kitchen waste, manure) that would otherwise become waste, contributing to the circular economy.

Reduction of Synthetic Chemicals: reduces dependence on chemical fertilisers, reducing soil and water contamination risk.

Increased productivity

Improved Growth and Yield: more fertile and healthier soil can produce more vigorous plant growth and higher fruit production.

Pest and disease control

Improved Soil Health: healthy soil may be less susceptible to pests and diseases, reducing the need for pesticides.

Erosion Reduction

Better Water Retention: soil rich in organic matter retains water better, which helps prevent erosion and improves drought resistance.

Local Economy

Cost savings: farmers can reduce fertilizer costs and improve crop profitability by producing compost locally.

Environmental education and awareness

Promotion of sustainable practices: encouraging the use of compost can help farmers better understand the importance of sustainability in agriculture.

It is a practice that improves the health and productivity of cocoa crops and contributes to environmental sustainability and the well-being of farming communities.

Compost production

This organic fertilizer is obtained from decomposing plant and animal waste, which is transformed into a homogeneous mass with a lumpy structure rich in humus and microorganisms. This process is aerobic and, therefore, enhanced in the presence of air, as decomposition is carried out by microorganisms such as bacteria and fungi.

Materials

Source: https://repository.agrosavia.co/bitstream/handle/20.500.12324/1195/Ver_Documento_1195.pdf?sequence=1&isAllowed=y

Figure 27. Materials

It is very easy to make, requiring only materials found on cocoa farms, such as soil, plant waste (from bananas, corn, beans, cocoa shells, kitchen waste, and others), animal manure (cattle, chicken, and others), lime or ash, water, and #5 black plastic.

Use of organic fertiliser

Once the organic fertiliser has been obtained, it is recommended that it be used on plantations cultivated within the cocoa agroforestry system to increase the soil's humus content and water retention capacity, improve its structural stability, facilitate soil work, stimulate biological activity, and supply most of the nutrients necessary for plant development.

Source: https://repository.agrosavia.co/bitstream/handle/20.500.12324/1195/Ver_Documento_1195.pdf?sequence=1&isAllowed=y

Figure 28. Use of organic fertilizer in plantations cultivated within the cocoa agroforestry system

Action plan with strategies to implement green innovation among cocoa farmers in Roberto Payán.

Table 5. Action plan with strategies to implement green innovation among cocoa farmers in Roberto Payán

Strategies	Description of strategies	Objective of the strategy	Responsible	Average Time	I
Create an association of cocoa farmers in the village of	The creation of an association strengthens the social fabric and promotes collaboration among community members. In addition, it can generate social welfare projects, such as infrastructure construction, health services, education, and technical training. The association can promote sustainable and environmentally friendly agricultural practices, such as agroforestry (cultivation combined with trees) and the responsible use of chemicals. This not only improves the quality of cocoa, but also protects the natural environment and contributes to climate change. A well-organised association allows small producers to join forces to negotiate fairer prices and access national and international markets. Roberto Payán's cocoa could be valued for its quality and special characteristics, which would allow growers to earn higher incomes. The association can establish links with cocoa processing companies, marketing cooperatives or even high-end chocolate brands, which would facilitate the sale of cocoa at better.	Strengthen the cocoa community in the region	Cultivator	2 months	As con leg Nú
Sustainable	Expanding crops or planting new hectares on land available and suitable for growing cocoa in large quantities, as this can lead to an increase in total income for farmers, who therefore have more cocoa to sell.	Increase production, protect the environment and reduce	Association and Cultivator	From 6 months to	Hec se

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	As production increases, so does sales capacity, which translates into higher profits. A seedbed will be created for each crop with the aim of achieving sustainable agriculture and avoiding the purchase of seeds, thereby reducing costs. On the contrary, income could be generated by selling cocoa seeds to other growers. Promote the implementation of agroforestry systems where cocoa is grown under the shade of native or fruit trees. This approach not only helps protect the soil from erosion, but can also improve biodiversity, protect water sources, and increase income from the sale of additional products such as fruits (soursop, sugar cane, oranges, avocados, and other fruits that grow in the region) or products and wood (plantains and cedar). This can supplement the income of cocoa farmers and reduce the economic risks associated with dependence on a single crop. The use of organic fertilisers and green manure (such as compost or manure) improves soil structure and nutrient retention and is more environmentally friendly than chemical fertilisers. In addition, the use of agricultural waste and local organic matter to produce fertilisers can reduce input costs. Given the waste of banana and cocoa peels and other products, these will be used to create fertilisers for crops. It should be noted that the use of this type of fertiliser helps to control pests and diseases. To implement these strategies, a request will be made to SENA to issue. Training and technical education to ensure that farmers know how to carry out the entire process, from planting, cultivation and harvesting to post-harvesting and sale of the product.				
Marketing		Promote the region's cocoa with the aim of gaining a foothold in the market.	Cultivator - Association	2 months	% inc ve
Cocoa processing.	Social media marketing: Leveraging social media (such as Instagram, Facebook, or TikTok) to tell stories about Roberto Payán's cocoa, highlighting sustainable practices and the work of farmers. This type of marketing, which shows the connection between the product and the people who produce it, can attract consumers interested in ethical and high-quality products. Participating in trade fairs allows Roberto Payán's producers to showcase the quality of their cocoa to international buyers, connect with distributors and access new markets. These events also provide opportunities to obtain feedback on product quality and new market trends.	Create new products	Association	3 to 4 years s	Nú nue pro

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CONCLUSIONS

The cocoa sector in Roberto Payán demonstrates a comprehensive approach that takes advantage of both the region's internal resources and capacities and the opportunities and support available at the national level. The success of this project will depend largely on collaboration between local producers, government institutions, and non-governmental organisations.

By integrating technical training, institutional support, investment in infrastructure, and effective promotion in national markets, it will be possible to boost cocoa production in Roberto Payán, which is facing threats to its resilience, and take advantage of opportunities efficiently. This approach will not only improve the competitiveness of the region's cocoa but also contribute to local communities' economic and social development, ensuring a long-term positive and sustainable impact.

These measures represent a comprehensive vision for the cocoa sector in the Roberto Payán region, seeking to transform internal weaknesses and external threats into opportunities for the sector's sustainable and competitive development. By improving agricultural practices, optimising cocoa quality, implementing innovations in packaging, and diversifying crops, regional producers can increase their yields, access new markets, and improve their economic well-being.

At the same time, addressing security, infrastructure, and pest control threats through adaptive strategies, such as dialogue with local actors, transport agreements, and biological control, will ensure that cocoa production is profitable, resilient, and sustainable. Access to financing and collaboration with government and private entities will be key to implementing these strategies and ensuring that Roberto Payán's cocoa is recognised nationally and internationally for its quality and sustainability.

RECOMMENDATIONS

It is recommended that cocoa producers form a legal association based on a solidarity economy model. The main contribution of the members will be their work in cultivation, which is key to improving the production of high-quality cocoa and obtaining good yields. Through this association, technical assistance should be requested from Fedecacao to optimise and strengthen crops, as well as access to credit from the Agrarian Bank to ensure the necessary resources to restart production appropriately.

Implementing organic fertilisers and green manure, such as composting, is crucial as a strategy for agricultural sustainability. It improves soil health and water quality and contributes to a more resilient farming system that is less dependent on chemical inputs that negatively affect the environment.

Innovation in cocoa production and processing, and the exploitation of opportunities for certification, fair trade, and differentiation in high-value-added markets, can be key to improving their income and competitiveness in the global market. Implementing sustainable agricultural practices, investing in processing technology, and diversifying cocoa products will allow them to access premium markets and ensure the long-term sustainability of their crops and communities.

Creating a cocoa producers' association in Roberto Payán represents a transformative opportunity beyond improving agricultural productivity. This association would strengthen the social fabric, enable the implementation of sustainable farming practices, and open the door for producers to access broader markets and fairer negotiations. In addition, through crop diversification, generating additional income, and access to financing and infrastructure, cocoa producers in the region will achieve greater economic stability and resilience to the risks associated with agriculture.

By adopting a holistic approach that combines collective work, environmental sustainability, cocoa quality improvement, and technical training, the Roberto Payán association can become a model of success that not only improves cocoa competitiveness but also promotes the region's social, economic, and environmental well-being. With the support of local authorities, educational institutions, and companies in the sector, this project can transform agriculture in the region, improving the living conditions of producers and positioning Roberto Payán's cocoa as a benchmark for quality and sustainability in the global market.

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FINANCING

None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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