Environmental Research and Ecotoxicity. 2026; 5:300
doi: 10.56294/ere2026300

REVIEW

Green innovation as a sustainable alternative to strengthen cocoa cultivation

Innovación verde como alternativa sostenible para el fortalecimiento del cultivo de cacao

Sergio Oleider Angulo Rincón[1], Claudia Magali Solarte Solarte[1]

[1]Universidad CESMAG, Facultad de Ciencias Administrativas y Contables Administración de Empresas. San Juan de Pasto, Colombia.

Cite as: Angulo Rincón SO, Solarte Solarte CM. Green innovation as a sustainable alternative to strengthen cocoa cultivation. Environmental Research and Ecotoxicity. 2026; 5:300. https://doi.org/10.56294/ere2026300

Submitted: 07-02-2025 **Revised:** 20-05-2025 **Accepted:** 20-12-2025 **Published:** 01-01-2026

Editor: Manickam Sivakumar

Corresponding Author: Claudia Magali Solarte Solarte

ABSTRACT

Introduction: the purpose of the research was to identify viable alternatives to strengthen cocoa production and marketing in the municipality of Roberto Payán, department of Nariño. It was proposed as a solution to the devaluation of the crop and the high presence of illicit crops, phenomena that have limited agricultural development in the region. The study focused on the implementation of green innovation as a strategy to promote sustainability, productivity and competitiveness of cocoa in the area.
Development: during the study, the national and international context of cocoa production was analyzed, as well as successful experiences of cooperatives that applied organizational and environmental innovation practices. It was observed that in Peru, for example, community organization significantly boosted the export of organic cocoa. In Colombia, the need to improve processing processes, train farmers and protect the characteristics of fine aroma cocoa was discussed. In the case of Roberto Payán, obstacles such as the presence of armed groups, state neglect, and the lack of adequate technology and infrastructure were identified.
Conclusions: it was concluded that cocoa represents an opportunity for economic, social and environmental development for Roberto Payán, provided that the production chain is strengthened with green innovation, institutional support and community empowerment. The progressive replacement of illicit crops with cocoa is feasible if sustained investment and technical training are guaranteed, which would allow the municipality to become a regional reference in cocoa production.

Keywords: Cocoa; Green Innovation; Illicit Crops; Rural Development; Sustainability; Green Innovation; Rural Development.

RESUMEN

Introducción: la investigación tuvo como propósito identificar alternativas viables para fortalecer la producción y comercialización del cacao en el municipio de Roberto Payán, departamento de Nariño. Se planteó como solución frente a la desvalorización del cultivo y la alta presencia de cultivos ilícitos, fenómenos que han limitado el desarrollo agropecuario de la región. El estudio se centró en la implementación de innovación verde como estrategia para fomentar la sostenibilidad, productividad y competitividad del cacao en la zona.
Desarrollo: durante el estudio, se analizó el contexto nacional e internacional de la producción de cacao, así como experiencias exitosas de cooperativas que aplicaron prácticas de innovación organizacional y ambiental. Se observó que en Perú, por ejemplo, la organización comunitaria impulsó significativamente la exportación de cacao orgánico. En Colombia, se examinó la necesidad de mejorar procesos de beneficio, capacitar a los agricultores y proteger las características del cacao fino de aroma. En el caso de Roberto Payán, se identificaron obstáculos como la presencia de grupos armados, el abandono estatal, y la falta de

tecnología e infraestructura adecuada.
Conclusiones: se concluyó que el cacao representa una oportunidad de desarrollo económico, social y ambiental para Roberto Payán, siempre que se fortalezca la cadena productiva con innovación verde, apoyo institucional y empoderamiento comunitario. El reemplazo progresivo de cultivos ilícitos por cacao es viable si se garantiza una inversión sostenida y formación técnica, lo que permitiría al municipio convertirse en referente regional de producción cacaotera.

Palabras clave: Cacao; Innovación Verde; Cultivos Ilícitos; Desarrollo Rural; Sostenibilidad.

INTRODUCTION

This research aims to propose ideas to help cocoa farmers in the municipality of Roberto Payán grow and market their product more easily and make it much more profitable than illegal activities and crops in the region. It also seeks to strengthen agricultural development and growth in the municipality.

Cocoa harvesters in the municipality of Roberto Payán are not at a level where their product is viable. They face many discouraging factors, such as the devaluation of cocoa crops and competition from illicit crops, which is the activity most commonly practised by farmers in the municipality. We are aware that the Nariño coast has a high percentage of hectares devoted to illicit crops due to armed groups and drug trafficking, which means that farmers do not value crops other than coca. This is the most serious problem facing cocoa harvesters.

This study aims to help cocoa harvesters, with the help of green innovation, to ensure that their product is valued, so that those who are engaged in illegal activities or trades that damage and harm the soil can turn to farming and empower themselves with the wealth that exists in the municipality, which illicit crops and activities have overshadowed due to armed groups and the lack of government support to invest in training and guiding farmers to seethe great potential that cocoa cultivation could have in the municipality of Roberto Payán.

Some cocoa harvesters know and have experienced firsthand how to deal with the crops. These people will be very helpful in carrying out and developing excellent, highly reliable research.

On the social side, assessing cocoa harvesters and their perception of green innovations, such as good land use and caring for the environment by working responsibly, seeks to improve the quality of cocoa production and cultivation. The study is focused on farmers and aims to help them obtain better profits.

The intention of this research is personal, as there are cocoa harvesters in my family. I see that they cultivate this product with the aim of changing the region, but the obstacles, difficulties, devaluation of cocoa, and the lack of machinery, fertilisers, and labour mean that they do not give 100 % to their crops, which is secondary to their work activities.

It should be noted that this will also be a professional endeavour, as the research will uncover new alternatives and solutions that will benefit the farmers. Eventually, they will come to see this activity as their main source of income. The goal is to make them realise the productive viability of dedicating themselves 100 % to cocoa cultivation so that there are no longer just a few hectares of cocoa.

New investments and green innovation applications will help replace coca crops with cocoa. The project focuses on training farmers and changing their mindsets towards cocoa, promoting its economic viability and sustainability. The aim is to make the region a leader in the cocoa market through collaboration between farmers and the government.

DEVELOPMENT

Reference framework

Background International background

Title: Organisational innovation in organic cocoa production in Peru.
Author: Julio Santiago Chumacero Acosta.
Year: 2020.
Institution: University of Buenos Aires.

General objective

To study organisational innovation as a facilitator of technological and commercial evolution for organic cocoa producers in the San Martín Region, based on the Oro Verde Agricultural Cooperative.

Specific objectives

Describe the Peruvian organic cocoa agribusiness subsystem, within which the development of the Oro Verde Agricultural Cooperative is framed.

Describe the case under study, focusing on developing the cooperative's organisational environment and level of coordination.

Conclusions

Faced with a turbulent global scenario in terms of agri-food systems, with significant changes in terms of growing and increasingly demanding demand in general, and for differentiated products in particular, there are commercial opportunities for small producers organised into cooperatives or associations, which develop strictly coordinated subsystems and have access to technological and commercial improvements. Peru has established itself as a major producer of organic cocoa globally, supplying 33 % of global production. Its exports are growing at an annual rate of 19 %, and many cooperatives and associations are dedicated to this business. Oro Verde is one such cooperative, developed in the San Martín region. Despite its small market share, it is growing at an annual rate of 48 % in exports.

Contribution: this research seeks to use green innovation to make it easier for Peru to continue growing in green cultivation, producing more green gold by using technology that helps development and cares for the environment in a way acceptable to environmentalists.

National background

Title: Strengthening green businesses in the Amazonas, Caquetá, and Putumayo departments.

Author: Meyli Yojhana Enríquez.

Year: 2019.

Institution: Technological University of Pereira.

General objective

To study organisational innovation as a facilitator of technological and commercial evolution for organic cocoa producers in the San Martín Region, based on the Oro Verde Agricultural Cooperative.

Specific objectives

Describe the Peruvian organic cocoa agribusiness subsystem, within which the development of the Oro Verde Agricultural Cooperative is framed.

Describe the case under study, focusing on developing the cooperative's organisational environment and level of coordination.

Conclusions

Faced with a turbulent global scenario in terms of agri-food systems, with significant changes in terms of growing and increasingly demanding demand in general, and for differentiated products in particular, there are commercial opportunities for small producers organised into cooperatives or associations, which develop strictly coordinated subsystems and have access to technological and commercial improvements. Peru has established itself as a major producer of organic cocoa globally, supplying 33 % of global production. Its exports are growing at an annual rate of 19 %, and many cooperatives and associations are dedicated to this business. Oro Verde is one such cooperative, developed in the San Martín region. Despite its small market share, it has been growing at an annual rate of 48 % in exports.

Contribution: this research will serve as a reference for analysing the theory of green innovation in the present study.

This research contributes to the present study by describing ways to strengthen regional economic growth so that companies fulfil their role of being environmentally responsible for the present and future inhabitants of the region.

Regional background

Title: Evaluation of the benefits of the agroforestry system of cacao (Theobroma cacao L.) and tangare (Carapa guianensis Aulb) in Tumaco, Nariño.

Author: Jenifer Ortiz Dajome and Diógenes Bernardo Batioja Estupiñan.

Year: 2023.

Institution: University of Nariño.

General objective

To evaluate the benefits in productivity and environmental services of the agroforestry association of cacao (Theobroma cacao L.) with tangare (Carapa guianensis Aulb) on the La Lomita farm, Km 31, municipality of Tumaco, Department of Nariño.

https://doi.org/10.56294/ere2026300

Specific objectives

Identify the physiological variables, grain index, pod index, and phytosanitary status in the T. cacao and C. guianensis agroforestry arrangement.

Shade analysis of the agroforestry association of T. cacao and C. guianensis.

Conclusions

The shade canopy, in association with cocoa cultivation, provides benefits that improve the quality and productivity of the system. However, excessive shade does not allow for adequate production, making it essential to have a farm management plan that provides for managing the tangaré tree canopy over time, as well as its thinning and utilisation.

Contribution: poor phytosanitary management can lead to negative crop behaviour, which means that production risks are incurred, putting the crop at a disadvantage in regional competition. Good crop use and care are required, with the help of green innovation.

Macro context

According to a study, the department of Nariño is Colombia's fifth-largest cocoa producer, with the municipality of Tumaco accounting for more than 70 % of cocoa production in the department. The location of the city and its agroecological conditions mean that more than 95 % of the cocoa produced can be classified as fine aroma cocoa. Still, its characteristics are affected by poor processing practices applied by producers, i.e., the physical and organoleptic qualities of the cocoa are lost during the fermentation and drying processes. This research, therefore, aims to formulate strategies to improve the quality and sustainability of cocoa. The fieldwork was carried out with the support of the Association of Cocoa Producers of Tumaco, whose members identified that most producers are unaware or unconcerned about the importance of a proper cocoa processing process that preserves the qualities of the cocoa. The lack of processing centres and instruments for measuring fermentation and drying variables is other factors that prevent producers in this region from obtaining high-quality cocoa.

Chocolate is one of the most widely used ingredients in gastronomy. Thanks to its versatility, although it has traditionally been used in confectionery, it also perfectly complements savoury dishes. To celebrate the existence of this food, at least two days a year are dedicated to this irresistible sweet treat: 13 September is International Chocolate Day, and 7 July is World Cocoa and Chocolate Day.

Figure 1. Countries that export and import the most chocolate

https://doi.org/10.56294/ere2026300

Most of the leading countries in the global trade of this product are European, as shown in the following graph from Statista, based on data from UN Comtrade. Germany is the world's leading exporter of chocolate and other food preparations containing cocoa, with nearly 916 million kilos exported in 2020. Spain ranks tenth among the largest exporters of chocolate, with almost 117 million kilos exported. About the central importing countries, the United States ranks first, with 638 million kilos. Spain also figures in the list of the ten leading countries in chocolate imports, with approximately 141 million kilos imported last year.

Colombia is one of the world's leading cocoa producers. Cocoa has been recognised for its excellent qualities, earning it the "Fine Aroma Cocoa" title, which has given this product a high standing and increased international demand. This product is a benchmark within the country, grown in 29 of the 32 departments. However, 77 % of production is concentrated mainly in six departments: Santander (42,1 %), Antioquia (8,8 %), Arauca (7,6 %), Huila (6,8 %), Tolima (6,6 %) and Nariño (5,5 %).[1]

Locally adapted agricultural materials are being replaced by universal materials, resulting in the loss of native varieties that are superior in quality and organoleptic attributes.

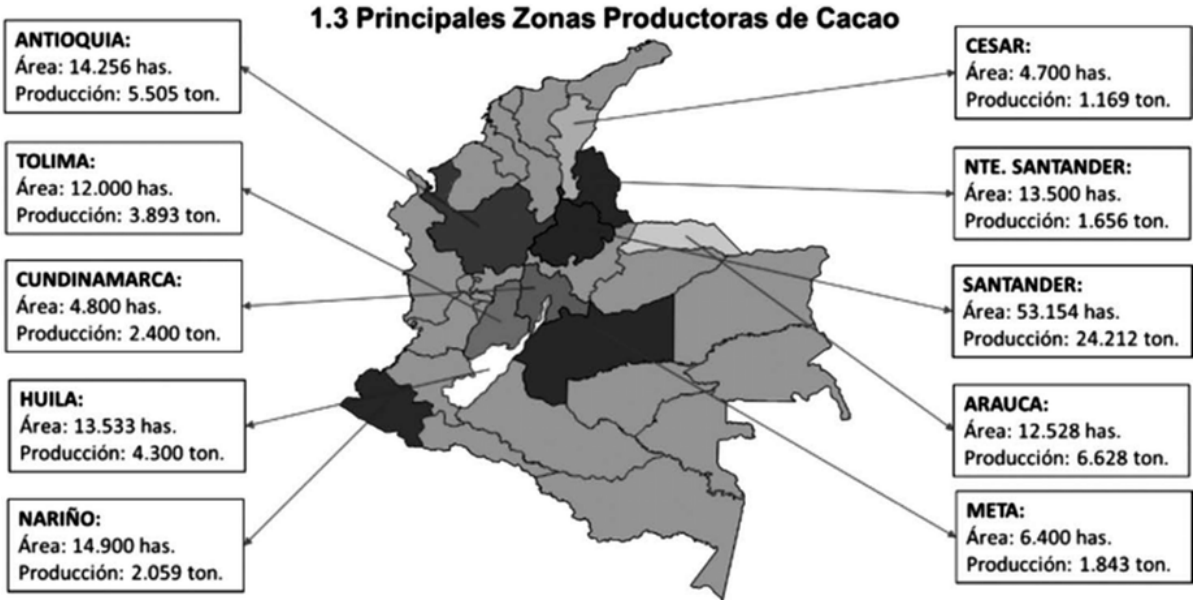

Figure 2. Distribution by department of areas planted with cocoa in Colombia

Resolution 329 of 2009 of the Ministry of Agriculture and Rural Development recognised the Cocoa Chain Organisation, the agro-industry, and the National Cocoa Council and its members as an advisory body to the National Government on policy for the cocoa subsector. It highlighted producers, academia and research, the national government, marketers, and industrialists.

Microcontext

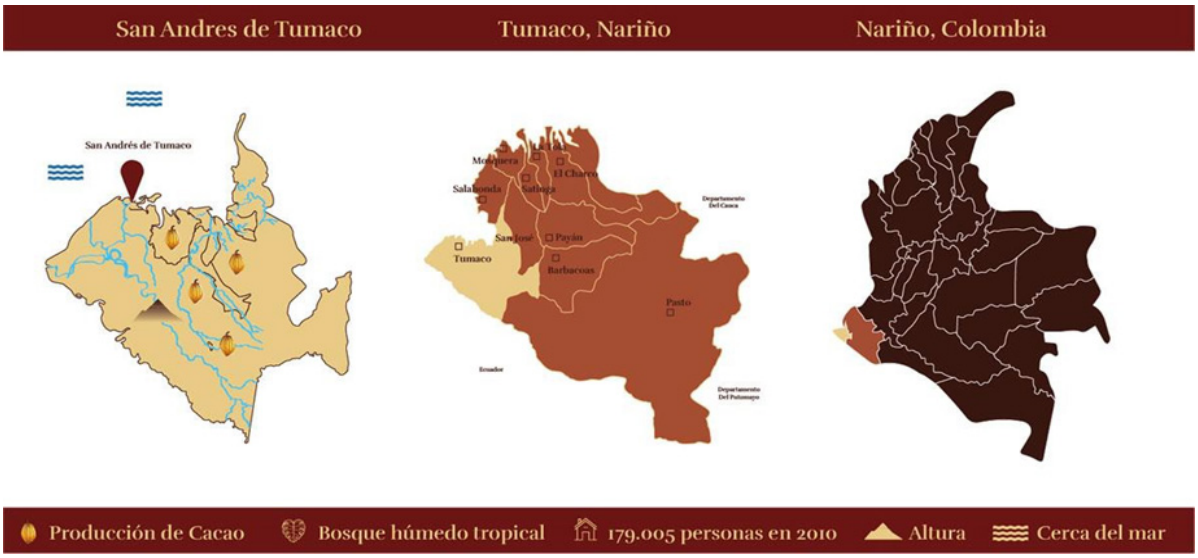

Figure 3. Tumaco chocolate

https://doi.org/10.56294/ere2026300

Cocoa cultivation covers an area of 355 hectares, with an average dry production of 87,6 tonnes. The municipality of Roberto Payán has cocoa collectors who need green innovation to increase their productivity. This research will focus on this area's key strengths to ensure that the Tumaco region is not the only powerhouse of cocoa production in Nariño (2012-2015 Development Plan for the Municipality of Roberto Payán).

This research seeks to strengthen the growth and development of cocoa farming in the municipality of Roberto Payán, where green innovation will facilitate and increase farmers' productivity. The department of Nariño has highly efficient municipalities for cocoa cultivation, such as Tumaco, which has 70 % productivity, as the city values the product the most.

The research aims to increase cocoa production in the municipality of Roberto Payán and use the large hectares of land planted with illicit crops. Due to the actions of various armed groups, these lands are invaded and misused.

It will also seek to make cocoa harvesting more profitable so that it is not seen as a less profitable job than other activities in the municipality.

Historical overview

The municipality of Roberto Payan is located 254 kilometres northwest of the city of San Juan de Pasto. It borders Francisco Pizarro, Mosquera, and Olaya Herrera to the north, Barbacoas and Tumaco to the south, Olaya Herrera and Magüi to the east, and Tumaco to the west.[2]

It is located 24 metres above sea level, with an average temperature of 26,9 degrees Celsius, an average annual rainfall of 720 millimetres, and a municipal area of 1342 square kilometres. This territory is flat to slightly undulating, characteristic of the Pacific region, and has a warm climate. It is irrigated by the Alcalbi, Iguambi, Ispi, Patía, Patía el Viejo, Piri, Sande, and Telembi rivers, and also has the Albino, Chimbusa, Piri, Popa, Puérpera, Tamaje, and Pangüi lagoons. The municipality of Roberto Payan is located 254 kilometres northwest of the city of San Juan de Pasto.[2]

This municipality has more than 10 473 inhabitants and 60 villages dedicated to fishing, agriculture, livestock, and mining. It should be noted that mining and agriculture are the two most common activities in the territory.[3]

Mining gained momentum with the advent of machines that increased mineral productivity. Knowing the profitability and potential of the region's gold, farmers saw this work as very profitable, regardless of the environmental damage it caused.

On the other hand, agriculture had strong potential, as there were massive hectares of banana plantations on the Patía River. It is also worth mentioning the number of families dedicated to planting rice, corn, yucca, and different fruits that can be grown in the municipality, such as cacao.

Cocoa has always been present in the municipality's history, as families grew it for their own consumption. It was harvested, tasted, and used, and the seeds were placed in the sun to dry for several days, then ground in small mills to make chocolate.

The evaluation of the cocoa sector in Roberto Payán has not been very positive. Since its inception, many people have grown this product. However, they do not do so for commercial purposes, thus preventing the product from developing as it has in other municipalities such as Tumaco, which today contributes more than 70 % of the cocoa in the department of Nariño.

By 1997, small cocoa collectors began to emerge as small buyers appeared in the municipality of Barbacoas. With a buyer nearby, the farmers planted and cultivated this product. Not many opted for this product, and with armed groups' arrival in the area in 2003, illicit crops with higher profitability appeared, causing the inhabitants to opt for planting coca instead of other products.

Legal framework

Table 1. Legal framework

Law 1562 of 2012	It explains how the basic contribution income is calculated, along with the coverage provided to self-employed, informal and dependent workers. This new law is supported by three bills that emerged in the Congress of the Republic, which define what constitutes a work accident or occupational disease. Currently, in Colombia, there are a large number of independent, dependent, and informal workers who are not affiliated with the occupational risk system. That is why the Ministry has designed a work plan that seeks to correct these shortcomings through the efficient implementation of the SGSST in companies. This law is very important for cocoa harvesters, as they are independent workers. It provides them with security from the national government in the event of a work-related accident.
Decree 1485 of 2008	Article 1. Organisation. The Cocoa Export Price Stabilisation Fund, whose operation was authorised by Decree 1226 of 1989, regulated by Resolution No. 0529 of 1989 and Resolution No. 053 of 1990 of the Ministry of Agriculture and Rural Development, into the Cocoa Price Stabilisation Fund, which shall operate in accordance with the terms established in Chapter VI of Law 101 of 1993.

	Article 2.- Legal Nature. The Cocoa Price Stabilisation Fund shall operate as a special account, without legal personality legal, in accordance with the provisions of Article 37 of Law 101 of 1993. Article 3.- Purpose. The purpose of the Cocoa Price Stabilisation Fund shall be to ensure a remunerative income for producers, regulate domestic production and increase exports by financing the stabilisation of the prices of the product referred to in Article 4 of this Decree. Article 4.- Product subject to stabilisation. For the purposes of this Decree, the agricultural products subject to stabilisation shall be those classified under tariff heading 18,01, in accordance with Decree 4589 of 2006, and which are obtained from the seed of the cacao tree (Theobroma2020). Article 5.- Administration. The Cocoa Price Stabilisation Fund shall be administered by the entity designated by the Ministry of Agriculture and Development. These articles are favourable to cocoa collectors as they provide them with remuneration in the event of imports of their product and also offer them price fixing when entering international markets.
NTC 1252	This standard aims to establish the classification and requirements that cocoa beans intended for industrial processing for human consumption must meet. Well-fermented beans. Cocoa beans that have undergone a complete fermentation process and have the following characteristics: brown, reddish or reddish-brown husk or tegument that is easily removed from the kernel. The kernels are brown or dark reddish-brown (chocolate colour) with well-defined kidney-shaped cells and a chocolate smell. Insufficiently fermented beans. Cocoa beans with incomplete fermentation, whose cotyledons (kernels) are violet or purple in colour. Violet brown, semi-compact structure, with a shell that is difficult to separate. Slate-like grain. Unfermented cocoa bean, which has a blackish-grey interior colour and a completely compact structure.

Theoretical framework

Green innovation: innovation is associated with creating new or improved products, processes, and methodologies, essential for a better quality of life in the transition towards a cleaner global environment.

It is important to note that the term innovation refers not only to technological innovation, but can also be present in economic, financial, and social systems and in lifestyle changes. Innovation is now an indispensable aspect of all sectors of society. The need to improve production and consumption methods, make institutional and organisational changes, and develop new services and new ways of consuming, living, and moving drives human beings to constantly innovate in order to improve consumption habits, production and organisational processes, and, in general, quality of life.[4]

Likewise, green innovation is associated with the product of research and development or initiatives aimed at sustainable and environmentally friendly solutions.

This type of innovation has boomed in recent years, especially since the last decade of the 21st century, due to the need for organisations and countries to comply with the Sustainable Development Goals agreed in 2015 by the Member States of the United Nations.[5]

On the other hand, a study explain that the literature mainly uses ‘four terms related to innovation, whose objective is to reduce environmental damage, namely: green innovation, environmental innovation, sustainable innovation, and eco-innovation.

However, a study present a difference from the above, as they explicitly add the need to consider the life cycle approach in the environmental impact analysis.

The European Union’s Eco-Innovation Observatory also defines eco-innovation as ‘the introduction of any new or significantly improved product (good or service), process, organisational change or marketing solution that reduces resource use and decreases the release of harmful substances throughout the entire life cycle’.

Many companies are still not convinced of the benefits of green product development. Similarly, beyond contributing to environmental protection, companies need other motivations to allocate resources and efforts to ecological innovation.

Today’s globalised world demands innovation in all economic sectors, products, and services that align with market demands and meet sustainability and equity criteria. It also demands efficient and clean processes, high-performance equipment, and low energy consumption. The agri-food sector is no exception. It faces the challenge of becoming more competitive by improving and taking advantage of innovations in processes, machinery, tools, methodologies, products, and services for its different production chains.

The agri-food sector is of great importance as it provides daily consumption, therefore, it must have or seek tools and equipment that help to increase production and make it more responsible for the care of the environment. Investments must be made in rural sectors to improve the economy and generate growth.

However, it is important to be aware of the high level of competitiveness in the agri-food sector, which requires field improvements to facilitate and increase farmers’ production.

Today, the role of innovation in increasing a country’s productivity and, therefore, its long-term economic growth is clear.

Promoting innovation is one of the IDB’s key strategies for regional development, and we have produced

numerous publications and blogs on the subject.

A study of 31 countries analyses the relationship between greener start-ups and innovation, confirming that these types of companies are more likely to engage in product and process innovation. This highlights the role of innovation in entrepreneurship and economic value creation, which is why recent literature has delved deeper into the contribution of new companies to environmental challenges.

In this analysis of entrepreneurship and innovation in green companies, Hoogandoorn affirms that in different countries, these organisations seek product innovation, i.e., they launch new competitive and higher-quality products, and therefore implement innovations to achieve these objectives and, in turn, facilitate tasks through the use of technologies within the organisation.

From a business perspective, five thematic categories of green entrepreneurship have been identified: conceptualisation, facilitators, practices, opportunities, and the relationship between this type of entrepreneurship and innovation.

The worrying global environmental situation has led companies in the manufacturing sector and their customers to reflect on the need to develop and acquire an innovative green product (IGP). Consumers' reasons are based on greater environmental awareness, ethical concerns, moral motives, and awareness of what kind of planet will be left for future generations.

Many companies are still unconvinced of the benefits they would gain from green product development. Similarly, besides contributing to environmental protection, companies need other motivations to allocate resources and efforts to ecological innovation.

The aim is to advance companies' and customers' understanding of the need to articulate both their requirements and their desires while also encouraging academics to further research into PIV. Based on the literature, this article explores alternatives for addressing the PIV paradigm at the organisational level and what inspires companies and customers to pursue it.

The study's results identified a series of drivers related to orientations for understanding the needs of the ecological customer, dynamics to be implemented at the organisational level, and motivations of both customers and companies in pursuit of PIV. These drivers presented an association that establishes a proposed framework for achieving and purchasing PIV.[6]

In light of the above, researchers and corporate and operational managers can make important contributions to this topic through their different lines of action in academia and management.

Today's globalised world demands innovation in all economic sectors, products, and services that align with market demands and meet sustainability and equity criteria. It also demands efficient and clean processes, high-performance equipment, and low energy consumption. The agri-food sector is no exception. It faces the challenge of becoming more competitive by improving and taking advantage of innovations in processes, machinery, tools, methodologies, products, and services for its different production chains.

The current worrying global environmental situation has led companies in the manufacturing sector and their customers to reflect on the need to develop and acquire innovative green products (IGPs). Consumers' reasons are based on greater environmental awareness, ethical concerns, moral motives, and awareness of what kind of planet will be left for future generations.

Many companies are still not convinced of the benefits they would gain from venturing into green product development. Similarly, beyond contributing to the care of the environment, companies also need other motivations to drive them to allocate resources and efforts to ecological innovation.

The aim is to advance companies' and customers' understanding of the need to articulate both their requirements and their desires while also encouraging academics to advance PIV research.

Types of green innovation: Green process innovation

The use of certain polluting materials is reduced or eliminated, or alternative energy is used in production processes.

The definition and application of green innovation indicators represent an important step forward for the sustainable development of countries, as they make it possible to monitor the most important variables that need to be controlled and then plan and implement strategies to increasingly reduce the environmental pollution gap and thus improve the quality of life of the population. They also provide crucial information for decision-makers and resource planners to define and establish short-, medium-, and long-term policies aimed at designing the best strategies for the development and implementation of new technologies and technological improvements in order to optimise countries' performance in terms of environmental sustainability.

Agriculture and food are also undergoing green innovations. Sustainable agricultural techniques, such as precision agriculture and permaculture, seek to reduce the use of chemicals, optimise resources, and promote biodiversity. In addition, alternatives to conventional meat, such as lab-grown meat and plant-based foods, are being developed to reduce emissions associated with livestock farming.

Intelligent water management is another important aspect of green innovation. Water recycling and

reuse technology is helping to conserve this vital resource. Intelligent irrigation systems and leak detection technologies also contribute to more efficient water use.

Green management

This involves creating and developing green awareness by creating profitable and environmentally sustainable businesses. It also involves a systematic and complex process based on product design and formulating business strategies that promote environmental care and protection, while generating the expected profits for companies. Conventional management is a thing of the past, and green management is the present and the future. Consumers demand new strategies and innovations in products and services today.

Green accounting

The terms environmental accounting, green accounting, and ecological accounting refer to the inclusion in a company's accounting of elements that refer to the environmental impact of its actions. In this way, the profits or losses referred to in the accounting results will not be strictly.

'monetary', but also environmental. This reflects the increasingly noticeable effort by companies to become more involved in respecting the environment, even in their internal accounts.

To achieve this, it is extremely important for business strategy to be involved in so-called green projects, which involve the company in activities that respect or promote the use of natural resources in society. Green projects also refer to practices that allude to good corporate behaviour towards the environment (such as reducing the use of plastics in their products, not testing on animals, etc.).

Supply chain

More than just a process, the supply chain is an interconnected network of companies, people, activities, information, and resources that work together to bring a product or service from its origin to the end consumer. It ranges from the procurement of raw materials to final delivery, including processing, storage, and distribution.

- Anticipating demand, managing inventories, and optimising resources.
- Select suppliers, negotiate prices, and purchase materials.
- Transform raw materials into finished products.
- Manage product stock efficiently.
- Transport products to the point of sale.
- Deliver the product to the end consumer.
- Respond to customer needs and queries.

Green innovation strategies

Growing concern for the planet's sustainability due to unbalanced economic growth drives demand for a more environmentally friendly growth model. That is why, at an industrial level, green innovation is being discussed as a feasible solution for striking a balance between the economy and environmental responsibility. Several companies have already begun implementing methods and strategies to create new market opportunities. Examples include "cradle to cradle" and the sale of eco-friendly products or services. In particular, green innovation can be applied through incentives and life cycle models.

The effect of eco-efficiency on competitive advantage

Companies will gain social legitimacy if they emphasise their activities by adhering to prevailing social norms and implementing eco-efficiency as a form of sound environmental management. Eco-efficiency is a production strategy to reduce the environmental impacts and risks to human health associated with products. When planning production for the future, today's companies must consider that future generations will have access to the natural resources used today and are moving towards environmentally friendly production activities.

The eco-efficiency strategy aims to reduce the use of water, energy, and raw materials during all stages of production. Processes are regularly reviewed to minimise pollution and waste, which helps protect the environment and make companies more competitive. Implementing eco-efficiency as a production strategy can generate additional income and reduce production costs for companies. A company's eco-efficiency strategy reflects good environmental Performance.[7]

When a company practices eco-efficiency and performs well environmentally, it is more appreciated by the public and maintains positive relationships with stakeholders. It can even lead to long-term relationships.[8]

Green human management

This refers to efforts to improve energy efficiency or reduce pollution produced by our homes, businesses, and lifestyles. The main objective of being environmentally friendly is to reduce the potential negative impact of energy consumption and pollution on the environment.[9]

Green finance

Green finance is a broad term that refers to increasing the level of financial flows (from banks, microcredit, insurance, and investment) from the public and private sectors towards sustainable development priorities. Green finance includes climate finance, but is not limited to it.[10]

Components of the financial system that deal specifically with green investments, including their specific legal, economic, and institutional conditions; public and private financing of green investments in different areas, including:

- Provision of environmental goods and services.
- Prevention, minimisation, and compensation for damage to the environment and climate
- Financing public policies that promote implementing environmental projects and initiatives and mitigating or adapting environmental damage.

Business diagnosis

There are different approaches to defining business diagnosis, which is why a study states that 'Business diagnosis is a simple and useful tool for understanding the current situation of an organisation and the problems that prevent its growth, survival or development'. Diagnostics identify symptoms that are causing problems for organisations, to focus efforts and strategies to mitigate negative impacts that may be caused by both controllable and uncontrollable variables that may arise.

Furthermore, a study states that 'Diagnosis allows for the study, analysis and evaluation of the strengths, weaknesses, threats and opportunities of companies, serving as a tool for analysing and evaluating an organisation's environment, its structure, its policies and, in general, its management'. Diagnoses provide a snapshot of the negative aspects that need to be improved and the positive aspects that need to be strengthened to address them and assess the importance and impact of each variable on the particular interests of each company.[11]

Similarly, a study states, ' The main objective of the diagnosis is to quantify the current state of maturity of the organisation against the national or international standards that the company should be managing, quickly, accurately and concisely identifying potential areas for development within it'. It is clear that a diagnosis provides general information about an organisation, and it is up to the organisation to convert this into practical knowledge that can be used to manage, understand, and modify decisions that may be taken for business development, taking into account references provided by successful companies with similar characteristics.[12]

Green Marketing

The objective is to showcase products that are respectful and in harmony with the environment. Green marketing arose from the concerns, worries, and demands of specific movements regarding the consequences of marketing on the environment. Thus, some companies decided to take sides with emerging environmental movements. Businesspeople, in general, have been increasing their environmental awareness. The first actions on this issue took place in the 1970s. At that time, ecological marketing began, although entrepreneurs only became officially aware of it in the 1980s and began implementing ecological marketing strategies in the late 1980s and early 1990s, integrating respect for the environment into their processes.[13,14]

Conceptual framework

Green areas: according to a study, green areas are spaces where vegetation and unpaved natural elements predominate. Another broader definition of green space is provided by Chile's National Environment Commission (CONAMA), which defines green spaces as: "urban or peri-urban spaces predominantly occupied by trees, shrubs or plants, which may have different uses, whether for leisure, recreation, ecological, ornamental, protection, recovery and rehabilitation of the environment or similar". Therefore, green areas refer to all natural open spaces such as beaches, sports fields in educational facilities, and recreational areas.

Cocoa: cocoa is a neotropical crop of global economic importance, used since ancient times in pre-Columbian cultures. It is considered a shade-loving species, although some hybrid genotypes can grow in full sunlight. This ability to tolerate different light levels varies and can be exploited to optimise crop yields. Considering the above, cacao is a key product in Colombia, grown at a temperature that allows for better seed development and higher productivity, as it is currently a commercial product.[15,16]

Consequences of armed groups for cocoa harvesters: in some regions of the country, where the influence of both guerrilla groups and drug traffickers intersect, new conditions and power correlations have been created that make it impossible to envisage a solution to the guerrilla phenomenon by treating it individually and separating it from the effects of the drug industry.[8] Drug trafficking and its possible solutions are even further removed from the realm of internal solutions, as they involve important international actors, and there seems to be no quick fix. Although there is still uncertainty about a peace process with the guerrillas, this paper explores some of their roles in controlling drug-related violence in the department of Guaviare, which they and

some sectors of the population play.

Growers: a farmer or gardener participates in a knitting project as a citizen scientist. Participating growers must be both women and men. The administrator or field agents can recruit growers. To participate, producers only need to allocate a small plot of their farm or garden to cultivating their three technological options.[17]

Growers receive initial training, individual trial kits and assistance during the trial from field agents.

Illicit crops: this is how a comprehensive intervention policy for the reduction of illicit crops was proposed, with a differentiated approach that recognises regional differences and is adapted to the particularities of each territory, as a necessary shift in intervention strategies to respond to new dynamics, challenges and lessons learned in the implementation of programmes to reduce illicit crops in the country.[18]

Eco-innovation: introducing any new or significantly improved product (good or service), process, organisational change, or marketing solution that reduces the use of resources and decreases the release of harmful substances throughout the entire life cycle. A study distinguished green innovation from conventional innovation in that the latter is not developed to address environmental challenges, while the former is developed to meet the ecological requirements of a regulatory body or the ecological concerns of target customers. Similarly, a study define environmental innovation as innovations consisting of new or modified processes, practices, systems, and products that benefit the environment and thus contribute to environmental sustainability.[19]

Environmental innovation: innovations consisting of new or modified processes, practices, systems, and products that benefit the environment and thus contribute to environmental sustainability. For their part, a study explain that green innovation does not have to be developed to reduce the environmental burden, but it must produce significant environmental benefits. A study refer to green innovation as hardware or software innovations related to green products or processes, including energy saving, pollution prevention, waste recycling, green product design, or corporate environmental management.[20,21]

Green innovation: 'Green' innovations are all new ideas that aim to provide us with more options for communication, movement, and even comfort, without harming nature, respecting the environment, and being ecological in their design, construction, use, and disposal.[22] Increasingly, the new brains of innovation are turning to options that emit fewer gases, are environmentally friendly, do not consume fossil fuels, etc. These green innovations are already on the market.

The green economy: a green economy is based on three main strategies: reducing carbon emissions, increasing energy efficiency, using natural resources, and preventing the loss of biodiversity and its ecosystem services.[23]

Illegal mining: exploratory or extractive activity of minerals, whether owned by the nation or by private individuals, carried out without the corresponding valid mining title or without the authorisation of the owner of the private property where the project is located.[24]

Efficient and sustainable use of resources for the production of goods or services: the rational use of inputs used in the manufacture of products, taking into account that the production cycle makes use of natural resources; implementing cleaner technologies that allow for the sustainable use of directly affected ecosystems.[25]

Agri-food system: the Agri-food System (SAA) is "the set of activities that contribute to the formation and distribution of agri-food products and, consequently, to the fulfilment of the function of human nutrition in a given society.[26]

CONCLUSIONS

This research showed that cocoa cultivation in Roberto Payán, despite favourable agroecological conditions, lags behind other municipalities in the department of Nariño, such as Tumaco. This is mainly due to factors such as a lack of institutional support, competition with illicit crops, farmer demotivation, and the absence of adequate infrastructure and technical tools for the sustainable development of the crop.

The analysis reaffirms the urgent need to implement green innovation strategies as a transformative force for the local cocoa sector. This will not only improve the crop's profitability but also mitigate its environmental impact. Green innovation practices can offer viable and sustainable alternatives to illicit crops that negatively affect the social and environmental fabric of the municipality.

Through farmer training, implementing clean technologies, and promoting productive cooperatives, the perception of cocoa as a secondary activity can be transformed into a real economic and social development opportunity. In addition, technical support, organisational strengthening, and coordination with government and private entities are essential to achieve this goal.

The value of cocoa as a product with the potential to enter international markets is highlighted, provided quality standards such as those established by NTC 1252 are met. Research has shown that proper land use, phytosanitary management, and agroforestry planning are key to improving cocoa production and quality. This translates not only into economic benefits but also a greater appreciation of the agricultural identity of the territory.

This study concludes that with political will, investment in innovation, and community commitment, it is possible to reorient the productive path of the municipality of Roberto Payán towards a green, resilient, and sustainable economy. This transition represents not only economic change but also progress in building territorial peace, social inclusion, and environmental care. Cocoa can become a symbol of hope and development, capable of replacing cycles of violence with cycles of prosperity.

BIBLIOGRAPHIC REFERENCES

1. ProColombia. Colombia hace parte de los países productores de cacao en el mundo, logrando así llegar a diferentes lugares con este producto [cited 2025 May 15]. 2020. https://www.colombiatrade.com.co/noticias/el-cacao-en-colombia-esta-presente-en-sus-departamentos

2. Escrucería JH, Gil OL, Velasco R. Censo municipal: Roberto Payán [cited 2025 May 15]. 2006. https://www.cctumaco.org/images/Archivos/censo_ROBERTO_PAYAN.pdf

3. Colombia Turismo. Reseña histórica del municipio Roberto Payán [cited 2025 May 15]. s.f. http://www.colombiaturismoweb.com/DEPARTAMENTOS/NARINO/MUNICIPIOS/ROBERTO%20PAYAN/ROBERTO%20PAYAN.htm

4. Organisation for Economic Co-operation and Development (OECD). Oslo Manual 2018: Guidelines for collecting, reporting and using data on innovation [cited 2025 May 15]. 2018. https://www.oecd-ilibrary.org/docserver/9789264304604-en.pdf

5. Organización de las Naciones Unidas (ONU). La Agenda para el Desarrollo Sostenible [cited 2025 May 15]. 2021. https://www.un.org/sustainabledevelopment/es/development-agenda/

6. Serrano J, Bikfalvi A, Llach J, Arbeláez J, García J. Orientaciones, dinámicas y motivaciones para la obtención del producto innovador verde. Rev CEA. 2022 [cited 2025 May 15];8(17):e2138. https://revistas.itm.edu.co/index.php/revista-cea/article/view/2138

7. Ar IM. El impacto de la innovación de productos ecológicos en el desempeño y la competitividad de las empresas. Procedia Soc Behav Sci. 2012;62:854–64. doi:10.1016/j.sbspro.2012.09.144

8. García M. Coca, guerrilla y sociedad civil en el Guaviare: regulación de conflictos y otros controles [cited 2025 May 15]. s.f. file:///C:/Users/LENOVO/Downloads/colombiaint29.1995.02.pdf

9. Driessen PH, Hillebrand B. Innovación verde: procesos, prácticas y productos sostenibles [cited 2025 May 15]. 2002. http://portal.amelica.org/ameli/jatsRepo/134/1342338002/html/index.html#redalyc_1342338002_ref33

10. Agrosavia. Innovación Agropecuaria (SNIA - Ley 1876 de 2017), se crearon las entidades prestadoras de servicios de extensión agropecuarios (EPSAGROS) [cited 2025 May 15]. 2020. https://www.colombiamascompetitiva.com/wp-content/uploads/2021/09/CC_Guia-diagnostico-de-la-cadena-de-cacao-140721.pdf

11. Cooperación Económica y Desarrollo (SECO). Diagnóstico de la cadena de cacao en Colombia, con énfasis en CFA orgánico y sostenible [cited 2025 May 15]. 2019. https://www.colombiamascompetitiva.com/wp-content/uploads/2021/09/CC_Guia-diagnostico-de-la-cadena-de-cacao-140721.pdf

12. Daza Cacao. Historia del cacao en Colombia [cited 2025 May 15]. Federación Nacional de Cacaoteros y Universidad Industrial de Santander; 2023. http://www.dazacacao.com/blog/historia-del-cacao-en-colombia/

13. IMMAP. Roberto Payán [cited 2025 May 15]. 2023. https://colombia.immap.org/evaluacion-necesidades-narino-2022/roberto-payan/

14. Congreso de Colombia. Ley 1562 de 2012. Por la cual se modifica el sistema de riesgos laborales y se dictan otras disposiciones en materia de salud ocupacional [cited 2025 May 15]. 2012 Jul 11. https://steel.net.co/ley-1562-de-2012/#:~:text=La%20Ley%201562%20de%202012%20es%20la%20que%20se%20encarga,al%20sistema%20de%20riesgos%20laborales

15. Congreso de Colombia. Ley 2163 de 2021. Por medio del cual se aprueba el “Convenio Internacional del

Cacao", adoptado en Ginebra el 25 de junio de 2010 [cited 2025 May 15]. 2021 Dec 7. https://vlex.com.co/vid/ley-2163-2021-medio-879132786

16. Morales M. Después de obtener el abono orgánico se recomienda emplearlo en plantaciones [cited 2025 May 15]. 2018. https://repository.agrosavia.co/bitstream/handle/20.500.12324/1195/Ver_Documento_1195.pdf?sequence=1&isAllowed=y

17. Morales M. Es un abono orgánico que se obtiene por descomposición de residuos o desechos de plantas y animales que son transformados en una masa homogénea [cited 2025 May 15]. 2018. https://repository.agrosavia.co/bitstream/handle/20.500.12324/1195/Ver_Documento_1195.pdf?sequence=1&isAllowed=y

18. Mortis S, Rosas R, Chaires E. Paradigma de investigación cuantitativa [cited 2025 May 15]. Instituto Tecnológico de Sonora; s.f. http://biblioteca.itson.mx/oa/educacion/oa3/paradigmas_investigacion_cuantitativa/index.htm

19. Moreno J. El proceso del beneficio en la poscosecha, está compuesto por dos actividades, por las que debe pasar el grano de cacao [cited 2025 May 15]. 2021. https://repository.unimilitar.edu.co/server/api/core/bitstreams/d91ece23-c537-4f3a-a021-5ea37753ea6b/content

20. Ministerio de Agricultura y Desarrollo Rural. Cadena de cacao [cited 2025 May 15]. 2021 Mar 31. https://sioc.minagricultura.gov.co/Cacao/Documentos/2021-03-31%20Cifras%20Sectoriales.pdf

21. Miñarro M. Innovación tecnológica, organización del trabajo y sostenibilidad ambiental: ¿es el teletrabajo una forma de empleo verde? Estud Financ Rev Trab Segur Soc. 2021;(454):5-16. https://repositori.uji.es/xmlui/handle/10234/192859

22. Osorio M, Rodríguez L, Sierra R, Terán W. Curvas de respuesta fotosintética a la luz: elucidando la capacidad fotosintética de plantas de cacao (Theobroma cacao L.) aclimatadas a luz solar plena en Cundinamarca, Colombia. Bot Sci. 2023;101(2):435-48. https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-42982023000200435&lang=es

23. Roa M. Los mayores exportadores e importadores de chocolate del mundo [cited 2025 May 15]. Statista; 2021. https://es.statista.com/grafico/25259/principales-exportadores-e-importadores-de-chocolate-y-alimentos-que-contienen-cacao/

24. Rovira S, Patiño J, Shaper M. Eco-innovación y producción verde: una revisión de las políticas de América Latina y el Caribe [cited 2025 May 15]. CEPAL; 2017. https://repositorio.cepal.org/bitstream/handle/11362/40968/1/S1700072_es.pdf

25. Sáenz S, Helfgott S. Los profesionales del agro en la difusión de innovaciones: acciones agrícolas sustentables en la región oriental de Colombia [cited 2025 May 15]. 2009. https://ciencia.lasalle.edu.co/eq/vol1/iss11/4/

26. Sistema agroalimentario. P1: el conjunto de las actividades que concurren a la formación [cited 2025 May 15]. 2021. https://elenjambresinreina.eu/sites/default/files/2017-06/teoriasa.pdf

FINANCING

None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

Conceptualisation: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Data curation: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Formal analysis: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Research: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Methodology: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Project management: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.

Resources: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Software: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Supervision: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Validation: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Visualisation: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Writing – original draft: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.
Writing – review and editing: Sergio Oleider Angulo Rincón, Claudia Magali Solarte Solarte.

https://doi.org/10.56294/ere2026300