



Evaluation and Proposal for an Environmental Management System in a Mango Plantation

Evaluación y Propuesta de un Sistema de Gestión Ambiental en una Plantación de Mango

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Abstract.

A mango farm in Los Ríos province, Ecuador, lacked an Environmental Management System (EMS) and had rudimentary management of fertilizers, pesticides and waste. The objective of the research was to design an EMS based on ISO 14001:2015 for the farm in order to improve its environmental performance and facilitate compliance with environmental regulations. For the development of the research, surveys were applied to workers to assess their knowledge of environmental management and a tour of the hacienda's facilities was conducted to observe its processes. The results were analyzed and an EMS based on ISO 14001:2015 was proposed. As a result, it was found that most of the workers had no knowledge of environmental management. The farm did not have an EMS in place and faced challenges in water management and waste management. The proposal to implement an EMS based on ISO 14001:2015 would allow the farm to improve its environmental performance and meet its certification objectives in the medium term. Therefore, it can be concluded that the proposal to implement an EMS based on ISO 14001:2015 would allow the farm to improve its environmental performance and meet its certification objectives in the medium term.

Keywords.

Environmental Management System (EMS), ISO 14001:2015 Standard, Mango farm, Sustainable agriculture, Good agricultural practices, Corporate Social Responsibility.

Resumen.

Una hacienda productora de mangos en la provincia de Los Ríos, Ecuador, carecía de un Sistema de Gestión Ambiental (SGA) y presentaba un manejo rudimentario de fertilizantes, pesticidas y residuos. La investigación tuvo como objetivo el diseñar un SGA basado en la norma ISO 14001:2015 para la hacienda, con el fin de mejorar su desempeño ambiental y facilitar el cumplimiento de las regulaciones ambientales. Para el desarrollo de la investigación se aplicaron encuestas a los trabajadores para evaluar su conocimiento sobre gestión ambiental y se realizó un recorrido por las instalaciones de la hacienda para observar sus procesos. Se analizaron los resultados y se propuso un SGA basado en la norma ISO 14001:2015. Como resultado se obtuvo que la mayoría de los trabajadores no poseían conocimientos sobre gestión ambiental. La hacienda no contaba con un SGA implementado y enfrentaba desafíos en la gestión del agua y en el manejo de residuos. La propuesta de implementar un SGA basado en la norma ISO 14001:2015 permitiría a la hacienda mejorar su desempeño ambiental y cumplir con sus objetivos de certificación a mediano plazo. Por lo que se puede concluir que la propuesta de implementar un SGA basado en la norma ISO 14001:2015 permitiría a la hacienda mejorar su desempeño ambiental y cumplir con sus objetivos de certificación a mediano plazo.

Palabras clave.

Sistema de Gestión Ambiental (SGA), Norma ISO 14001:2015, Hacienda productora de mangos, Agricultura sostenible, Buenas prácticas agrícolas, Responsabilidad social empresarial.

1.- Introduction

In the current context, environmental management has become increasingly important for many companies, due to the benefits it brings both economically and in the conservation of natural resources. Environmental management systems (EMS) provide a structured framework for companies to identify, evaluate and control the environmental impacts of their activities, facilitating a more sustainable operation and compliance with environmental regulations.

This study focuses on a mango farm located in the province of Los Ríos, canton Palenque, Ecuador, which faces significant environmental challenges. The farm, which covers 16.13 hectares (of which 15.82 hectares are dedicated to mango cultivation), does not have a formal environmental management system, which has led to inadequate waste management and problems related to fertilizer use and noise pollution. Currently, waste accumulates without classification, which complicates its management and can generate pollution problems [1].

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In the absence of an EMS, farm management has difficulty making informed decisions and effectively addressing environmental risks. In addition, the lack of knowledge of the ISO 14001:2015 standard, both on the part of the manager and staff. The environmental management system, however, limits the farm's ability to implement effective environmental controls and mitigation measures. These challenges highlight the need to develop an appropriate environmental management system that will enable the farm to improve its environmental performance, comply with regulations and lay the groundwork for environmental certification in the medium term.

The objective of this study is to design an Environmental Management System (EMS) based on ISO 14001:2015 for the mango farm in the Palenque canton. The purpose of this EMS is to improve the environmental performance of the farm, promote sustainable practices among its workers, and facilitate compliance with current environmental regulations.

The implementation of an EMS at this farm will not only help mitigate the environmental impacts of its agricultural activities, but will also optimize the use of resources such as water and energy, reducing costs and improving its competitiveness in the market. This approach is in line with the current demands of consumers and regulators who favor products from companies with environmentally responsible practices.

1.1 The importance of environmental management on mango farms.

Environmental management is fundamental in the agricultural industry, especially on mango farms, as it allows the identification, evaluation and control of the environmental impacts generated by their production activities. The implementation of an Environmental Management System (EMS) facilitates the adoption of sustainable practices and the efficient use of resources, helping companies to reduce their negative effects on the environment and comply with current regulations. In a context where sustainability and social responsibility are increasingly valued, environmental management becomes a key component for the competitiveness and longevity of farms, particularly those facing the challenges of intensive agriculture [2].

The environmental risks on these farms are multiple and are largely related to the intensive use of fertilizers and pesticides, which can lead to contamination of water sources and soil degradation. In addition, practices such as agricultural expansion without adequate planning can contribute to soil erosion and deforestation, threatening the biodiversity of rural areas. These factors not only affect crop productivity, but also impose environmental risks to surrounding communities and ecosystems. Thus, a well-structured EMS not only has the potential to mitigate these

impacts, but also favors a more sustainable agriculture that respects the natural environment [3].

Likewise, adopting an environmental management approach to mango production brings economic benefits by optimizing the use of inputs such as water and energy, which reduces operating costs and improves long-term profitability. In addition, an EMS can improve the company's image, since today's consumers prefer products from environmentally responsible companies, which helps attract new customers and consolidate the loyalty of current ones. In this sense, environmental management not only responds to a regulatory obligation, but also to a market demand that values sustainability as a differentiating attribute [4].

The implementation of a well-structured EMS enables farms not only to meet their environmental responsibilities, but also to generate a positive impact on their environment and establish a sustainable production model. Aligning operations with environmental standards, such as ISO 14001:2015, encourages the adoption of good agricultural practices that protect natural resources and contribute to the sustainable development of the mango industry in the region.

1.1.1. Benefits of environmental management on mango farms.

The implementation of an Environmental Management System (EMS) in mango farms brings multiple benefits that go beyond regulatory compliance, optimizing internal processes and contributing to environmental well-being. One of the main benefits is the reduction of operating costs. By improving efficiency in the use of critical resources such as water and energy, farms can reduce significant expenses in these areas. For example, by employing efficient irrigation systems, water consumption is optimized, resulting in lower costs and improved crop sustainability [5].

In addition, the adoption of an EMS can improve the company's public image. In a context where consumers are increasingly informed and concerned about the environmental impact of the products they purchase, companies that demonstrate environmental responsibility are often preferred. This represents a competitive advantage in the marketplace, allowing mango farms to attract and retain customers who value environmental commitment and sustainable practices.

An EMS also facilitates compliance with environmental regulations, both nationally and internationally, which is essential to avoid penalties and ensure business continuity. In many countries, environmental regulations for the agricultural sector are becoming increasingly stringent, and an EMS provides a structure that enables companies to remain in compliance with these requirements on an



ongoing basis. This compliance not only reduces the risk of sanctions, but also reinforces the farm's reputation as a reliable and ethical operator.

These benefits reflect how environmental management can transform the production approach of mango farms, promoting practices that not only reduce their ecological impact, but also strengthen their market position and improve their economic performance. A well-implemented EMS enables farms to respond to both regulatory demands and consumer expectations, strengthening their competitiveness and long-term sustainability.

1.1.2. Environmental impacts of agricultural activities in mango farms

Intensive agricultural activities on mango farms can generate significant environmental impacts if not properly managed. One of the main problems is water pollution, caused mainly by the excessive use of agrochemicals such as fertilizers and pesticides. These products, when applied in an uncontrolled manner, can leach into nearby bodies of water, affecting both surface sources and subway aquifers. This water pollution represents a risk to aquatic ecosystems and to the communities that depend on these resources for their basic needs [6].

In addition to water pollution, the improper application of fertilizers and pesticides can lead to soil degradation, reducing its fertility and impacting the long-term productivity of crops. The accumulation of chemicals in the soil alters its natural properties, making it less suitable for agriculture and limiting its ability to support plant and microbial life. This phenomenon also contributes to soil erosion, as degraded soil is more susceptible to nutrient loss and erosion caused by wind and water.

Another significant impact is deforestation and biodiversity loss, which often occur when agricultural areas expand without proper management. Agricultural expansion can fragment essential natural habitats, leading to the extinction of native species and disrupting the balance of local ecosystems. Furthermore, deforestation for intensive agriculture contributes to climate change by increasing greenhouse gas emissions due to the loss of vegetation that normally acts as a carbon sink.

These environmental impacts are particularly concerning in the context of sustainable agriculture, where the goal is to minimize disruptions to the natural environment. The implementation of a well-designed and managed Environmental Management System (EMS) can help mango-producing farms mitigate these negative effects by promoting responsible agricultural practices that contribute to the protection of water, soil, and biodiversity. With an appropriate environmental management approach, it is possible to reduce the ecological footprint of agricultural production while ensuring the sustainability and resilience

of mango cultivation in the face of current environmental challenges [7] [8].

1.2 Benefits of implementing an Environmental Management System (EMS) based on the ISO 14001:2015 standard.

The implementation of an Environmental Management System (EMS) in accordance with the ISO 14001:2015 standard provides significant benefits to mango-producing farms, both in terms of environmental sustainability and operational efficiency. The ISO 14001:2015 standard offers a systematic framework that enables organizations to identify, manage, and mitigate the environmental risks associated with their activities, while promoting continuous improvement and compliance with applicable environmental regulations. In the context of a mango farm, a well-implemented EMS facilitates the reduction of operational costs through efficient resource use, waste recycling, and process optimization [9] [10].

One of the key benefits of an EMS based on the ISO 14001:2015 standard is cost reduction, as efficiency in water and energy consumption significantly lowers operating expenses. For instance, by implementing energy-saving practices and efficient irrigation techniques, the farm can optimize its resources and reduce costs for essential inputs. Additionally, waste recycling and proper waste disposal help decrease management costs while simultaneously preventing pollution and resource waste [11].

Another important benefit is the improvement of the farm's public image, as consumers and business partners increasingly value sustainably sourced products and environmentally responsible business practices. An EMS based on the ISO 14001:2015 standard strengthens the farm's competitiveness in the market by highlighting its commitment to environmental stewardship and aligning with the expectations of environmentally conscious consumers. This positive image not only attracts new customers but also enhances the loyalty of existing ones, demonstrating that the company upholds high sustainability standards.

Compliance with environmental regulations is another fundamental benefit provided by an ISO 14001:2015 EMS, as it ensures that the farm's operations comply with both local and international environmental laws. This helps avoid penalties and legal issues arising from non-compliance, providing the farm with operational stability and a reputation as a responsible organization.

The ability to comply with regulations also facilitates the acquisition of environmental certifications, which can open doors to markets that require high sustainability standards [12].



Additionally, the ISO 14001:2015 standard promotes operational efficiency by helping farms identify and manage environmental risks, set clear objectives, and conduct periodic audits to assess progress and ensure continuous improvement. This structured approach not only enhances environmental performance but also increases employee engagement and satisfaction, as they can actively contribute to an important cause. Job satisfaction is enhanced when staff members are part of a sustainability effort that benefits both the environment and the community [13].

1.3. Practices and Technologies to Improve Water Management in Mango-Producing Farms

Efficient water management is one of the most significant challenges for mango-producing farms, especially in regions experiencing significant climate variability or where water availability is limited. The responsible and sustainable use of this resource is essential to ensure the continuity of agricultural activities and environmental protection. Implementing innovative technologies and practices allows farms to optimize water use, reduce consumption, and mitigate the negative effects of water scarcity [14] [15].

One key practice is the use of efficient irrigation systems, such as drip irrigation and sprinkler irrigation. These systems deliver water directly to the plant roots, minimizing evaporation and runoff, thereby enabling more effective resource use. Drip irrigation, in particular, is highly efficient in water delivery and can be controlled based on the specific needs of the plant, reducing waste and improving crop productivity. Installing efficient irrigation systems is an investment justified by savings in water consumption and improvements in crop quality.

Furthermore, rainwater harvesting is an effective strategy for farms, especially in areas where the rainy season is limited. By collecting rainwater, farms can accumulate reserves that can be used during dry periods. To implement this practice, farms can install gutter systems and storage tanks that capture water directly from rooftops or catchment areas, allowing for its subsequent use in irrigation activities. Green roofs, which also facilitate rainwater harvesting, provide the additional benefit of improving air quality and reducing the temperature within the facilities [16].

Another relevant practice is the reuse of greywater, which involves treating water from domestic or agricultural activities for use in irrigation. By using filtration and disinfection systems, farms can safely utilize this water and reduce the demand for potable water. This technique, in addition to being a sustainable alternative, helps conserve water resources and minimize environmental impact.

Proper management of fertilizers and pesticides is also essential for protecting nearby water sources. The controlled and efficient application of these inputs reduces the risk of water contamination, which is crucial for preserving biodiversity and the health of local ecosystems. Planning fertilizer and pesticide applications based on the actual needs of the crop and prevailing climatic conditions can minimize runoff into nearby water bodies and prevent soil degradation [17].

These practices, combined with the implementation of appropriate technologies, enable mango-producing farms to manage water efficiently, minimize environmental impact, and promote sustainable production. The adoption of these strategies not only contributes to the conservation of water resources but also enhances the farm's resilience to water scarcity, thus ensuring the long-term sustainability and competitiveness of mango cultivation [18].

1.4. Environmental Impacts of Agricultural Activities on Mango-Producing Farms

Intensive agricultural activities, such as those carried out on mango-producing farms, can have significant environmental impacts if not properly managed. Among the most important effects are water and soil pollution due to the excessive use of agrochemicals. Fertilizers and pesticides applied indiscriminately can leach into both surface and groundwater sources, altering their composition and negatively affecting aquatic ecosystems. This contamination poses risks not only to local biodiversity but also to the health of communities that rely on these water sources for drinking and irrigation.

Soil degradation is another critical environmental impact associated with intensive agriculture. The excessive use of chemicals and the lack of soil conservation techniques can lead to a decline in soil fertility, reducing its productivity over time. Moreover, degraded soils are more susceptible to erosion, which can result in the loss of fertile layers and, consequently, a diminished capacity of the land to sustain plant life. This degradation affects both the sustainability of the crop and the ecological structure of the area by eliminating habitats and reducing biodiversity.

Another relevant impact is deforestation and biodiversity loss, which often accompany the expansion of cultivated areas. The expansion of agricultural land to meet the growing demand for agricultural products frequently leads to the removal of native vegetation and the fragmentation of natural habitats, thereby compromising the survival of local species. The reduction of forest cover also contributes to climate change, as trees play a crucial role in carbon sequestration. The loss of these vegetative areas results in increased greenhouse gas emissions, thereby accelerating global warming [19].



Climate change, in itself, is an environmental impact stemming from conventional agricultural practices that generate significant emissions of greenhouse gases. From the use of agricultural machinery to the emissions from fertilizers, intensive agricultural activities contribute to the accumulation of gases in the atmosphere. This exacerbates climate variations, negatively affecting crop productivity and food security.

To address these impacts, mango-producing farms can implement an Environmental Management System (EMS) that integrates sustainable practices, such as the controlled use of agrochemicals, reforestation, and the conservation of water and soil resources. By doing so, it is possible to mitigate the negative effects of agriculture on the environment, promoting a more sustainable production model that does not compromise biodiversity or the availability of natural resources for future generations. The adoption of a responsible environmental management approach enables farms to operate in a more ethical and resilient manner, contributing to the preservation of the natural environment and reinforcing their commitment to sustainability [20] [21].

2. Materials and Methods

This research adopted a mixed-methods approach, integrating descriptive and analytical methods to thoroughly assess the state of environmental management on a mango-producing farm. The methodological design was structured into five interrelated phases, which allowed for a holistic view of the study subject:

2.1. Documentary Review

A systematic review of specialized literature was conducted, including:

- Indexed academic publications on Environmental Management Systems (EMS)
- Technical documentation of the ISO 14001:2015 standard
- Manuals and guidelines for best agricultural practices
- Applicable environmental legislation relevant to the sector

This phase established the necessary theoretical-conceptual framework for the development of the proposed EMS.

2.2. Primary Data Collection

Semi-structured Surveys

Data collection instruments were implemented targeting two primary groups:

- Administrative personnel: Focused on environmental management policies and strategies
- Operational personnel: Focused on daily practices and field procedures

The instruments assessed:

- Level of knowledge regarding environmental management
- Waste management practices
- Agricultural input usage protocols
- Perceptions of environmental impacts

Direct Observation

A systematic data collection process was conducted through:

- Detailed inspection of facilities
- On-site verification of operational procedures
- Identification of critical points in resource management [22].

2.3. Data Analysis and Interpretation

The collected data was processed using:

- Descriptive statistical analysis of quantitative data
- Content analysis for qualitative data
- Source triangulation to validate findings
- Identification of significant patterns and trends

This process enabled:

- Diagnosis of the current state of environmental management
- Identification of strengths and areas for improvement
- Establishment of intervention priorities
- Validation of the feasibility of the proposals

2.4. Development of the Proposal

Based on the comprehensive analysis of the data, a proposal for an Environmental Management System (EMS) aligned with ISO 14001:2015 was designed, which includes:

- Customized environmental policy
- Measurable strategic objectives
- Specific action programs
- Environmental performance indicators
- Monitoring and control procedures
- Phase-based implementation plan

The applied methodology ensured a comprehensive diagnosis of the current situation and facilitated the design of a proposal tailored to the specific needs of the organization.

3.- Analysis and Interpretation of Results

This section presents the main findings and results obtained from the surveys conducted with the workers of the mango-producing farm, aiming to diagnose the knowledge and perceptions of the staff regarding environmental management issues. The contributions of the personnel constitute a valuable source of primary data for identifying strengths and areas for improvement related to waste management, production practices, and input management.

Below, the quantitative and qualitative results derived from the responses provided by the consulted staff are detailed, allowing for the establishment of baseline data on their environmental awareness and the required capabilities.

3.1. Analysis of the Survey Conducted with the Farm Workers

Table 1. How much do you know about what an EMS ("Environmental Management System") is?

Responses	Number of people	Percentage
Nothing	15	75%
Little	5	25%
Quite	0	0
TOTAL	20	100%

Table 1 shows that 75% of employees have no knowledge of what an Environmental Management System (EMS) is, while only 25% possess basic understanding. This result reveals a significant lack of training on environmental topics, highlighting the need to implement a structured training program that covers the principles of environmental management. This training should be ongoing and tailored to the farm's context to ensure that all staff acquire the necessary knowledge for the proper implementation of an EMS.

Table 2. Have you received training on environmental topics?

Responses	Number of people	Percentage
YES	13	65%
NO	7	35%
TOTAL	20	100%

Table 2 indicates that **65% of employees** have received some form of environmental training, while **35%** have not been trained in these topics. Although the farm has made some efforts, it is clear that the scope and content of the training programs need to be expanded. It is essential to develop a comprehensive training plan that not only covers basic aspects but also addresses advanced topics such as waste management, energy conservation, and the ISO 14001:2015 standard. This program should include in-person workshops, seminars, and online training options to effectively reach all employees.

Table 3. What environmental training topics have you received?

Responses	Number of people	Percentage
Environmental laws	1	5%
ISO 14001:2015 Standards	0	0%
Waste handling	1	5%

None	12	60%
Others	6	30%
Total	20	100%

Regarding the topics covered in the training, Table 3 shows that most employees have received training in waste handling (60%), but critical topics such as ISO 14001:2015 standards (0%) and energy conservation have not been addressed. This gap indicates that the training has been partial and does not cover key areas of environmental management. To improve, it is necessary to include topics that promote the efficient use of resources and compliance with international standards, which will not only benefit the environment but also reduce operational costs.

Table 4. Are you aware if the estate cares about protecting and preserving the environment by developing and implementing an Environmental Management System?

Responses	Number of people	Percentage
YES	0	0%
NO	19	95%
Unaware	1	5%
TOTAL	20	100%

According to Table 4, 95% of employees are unaware if the estate has implemented an Environmental Management System (EMS), highlighting a lack of internal communication. This suggests that, although the estate may have some environmental initiatives, employees are neither involved in nor informed about these actions. To address this, the estate should establish more effective communication channels, such as publishing environmental reports, internal newsletters, and creating an environmental committee with employees from all levels.

Table 5. Based on the previous question, if you answered YES, please specify how it is carried out. If you answered NO, please indicate "none."

Responses	Number of people	Percentage
Recycles	0	0%
Saves energy	0	0%
There is separation according to the type of waste ("organic or inorganic")	0	0%
Follows the principle of paper conservation	0	0%
None	20	100%
Total	20	100%

In Table 5, the results show that none of the employees were able to identify specific environmental practices such as recycling or energy conservation. This confirms the absence of structured environmental management measures at the estate. It is essential to establish clear procedures for waste classification and energy use optimization. Additionally, the implementation of collection points is recommended to facilitate proper waste disposal.

Table 6. Does the estate have environmental regulations and measures?

Responses	Number of people	Percentage
YES	0	0%
NO	11	55%
Unaware	9	45%
TOTAL	20	100%

Table 6 reveals that 55% of employees believe the estate does not have environmental regulations, while 45% are unaware if such regulations exist. This high level of ignorance reflects a lack of transparency in communicating the company's environmental policies. It is crucial for the estate to implement clear policies and communicate them effectively to all staff. This can be achieved through informational sessions and the publication of easily accessible internal regulations.

Table 7. Does the estate have collection points ("sets of bins placed in a specific location for disposing of waste") to store waste during harvesting and packing?

Responses	Number of people	Percentage
SI	2	10%
NO	10	90%
TOTAL	20	100%

According to Table 7, 90% of employees state that there are no collection points for waste management during harvesting. This is concerning, as proper waste management is key to reducing the environmental impact of agricultural operations. The estate should install collection points in strategic locations and ensure that all employees know how to use them correctly. This, along with hiring a company specialized in waste management, will ensure more efficient and sustainable waste handling.

Table 8. Knowing that environmental pollution is increasing every day due to various agricultural, industrial, and service processes, how important do you think it is to care for the environment?

Responses	Number of people	Percentage
Not important	0	0%
Slightly important	0	0%

Important	9	45%
Very important	11	55%
TOTAL	20	100%

Table 8 shows that **55% of employees** consider protecting the environment to be "very important," and **45%** consider it "important." Although there is a general environmental awareness, it is necessary to reinforce this through training that provides practical tools to enable employees to contribute effectively to the sustainability of the estate.

Table 9. Would you be willing to change your way of working in order to protect the environment?

Respuestas	Número de personas	Porcentaje
YES	20	100%
NO	0	0%
TOTAL	20	100%

100% of the employees surveyed are willing to modify their work practices to protect the environment. This is a positive indicator that the estate should leverage to implement an Environmental Management System (EMS) that has the support of the staff. The formation of an environmental committee made up of employees who act as change agents within their work areas could be an effective strategy.

Table 10. Knowing that an EMS ("Environmental Management System") allows an organization to control all its activities, services, and products that may cause an environmental impact, how do you think an EMS would benefit the organization?

Responses	Number of people	Percentage
Reduction of costs in waste management	0	0%
Facilitates compliance with environmental legislation	2	10%
Reduction of pollution	9	45%
Increases customer trust	1	5%
All of the above	8	40%
TOTAL	20	100%

According to Table 10, 45% of employees identify the reduction of pollution as the main benefit of an EMS, while 40% believe it facilitates compliance with legislation. However, only 10% mention cost reduction in waste management. This highlights the need to educate staff on the economic benefits that a well-implemented EMS can bring, such as resource optimization and reduced fines for non-compliance with regulations.



3.2. Employee Training on Environmental Management.

A training plan is essential to increase employees' knowledge and skills on environmental issues. Given the low level of knowledge detected in the surveys, it is a priority to design a training program that is accessible, practical, and low-cost. The estate can choose to develop an internal program using existing materials and resources or hire an external consultant specialized in environmental management to provide more structured training.

The objective of the plan is that the staff will be able to:

- **Identify the environmental impacts** of their daily activities.
- **Implement best practices** for waste management and efficient use of resources.
- **Actively contribute** to the proposed Environmental Management System (EMS).

Priority topics for training:

To ensure that workers acquire the necessary knowledge, the training will be structured into thematic modules delivered in one-hour weekly theoretical sessions, complemented by practical activities on the estate. The main topics include:

1. **Introduction to Environmental Management:** Key concepts, importance, and benefits of an Environmental Management System (EMS).
2. **Waste Management:** Classification and proper management of waste in the field.
3. **Efficient Resource Use:** Methods to reduce water and energy consumption on the estate.
4. **Pollution Prevention:** Measures to prevent soil and water pollution.
5. **Regulatory Compliance:** Relevant environmental legislation and principles of ISO 14001:2015.
6. **Audits and Continuous Improvement:** Procedures for internal audits and environmental performance monitoring.
7. **Biodiversity Conservation:** The importance of preserving local ecosystems.

These sessions should be adapted to the staff's educational level and the demands of their daily tasks, allowing for easy integration of daily work with new environmental practices.

Implementation of the Plan:

It is crucial that the training sessions be interactive and include practical field demonstrations. Additionally, periodic assessments are recommended to measure the effectiveness of the program and adjust content based on the results. The success of the training plan should be measured not only by the level of knowledge gained but also by the effective application of environmental practices in the estate's daily operations.

3.3. Development of a Recycling and Composting Program:

The development of a recycling and composting program on the estate is an effective and relatively accessible measure to reduce environmental impact. Although this initiative would not require large initial investments, its implementation needs to be planned in a structured way to ensure long-term sustainability.

The first step involves separating the waste into recyclable (plastics, metals, paper) and compostable (food and vegetable scraps) categories. The estate can set up collection points in strategic locations and later collaborate with a specialized waste management company to process these materials.

Components of the Recycling and Composting Program:

• Clear and Measurable Objectives:

- Define specific targets, such as recycling 50% of the waste generated within one year or composting 25% of organic waste. These goals should be aligned with the overall objectives of the EMS.

• Scope of Application:

- Include all sectors of the estate, from production areas to offices, covering waste types such as plastics, paper, organic waste, and hazardous waste.

• Responsibility and Role Assignment:

- Appoint an environmental coordinator to oversee the implementation of the program and assign specific tasks to employees. For example, the field manager may be responsible for waste separation, while the logistics manager may coordinate the transportation of waste to recycling and composting facilities.

• Operational Procedures:

- Develop detailed procedures specifying how waste should be separated, how containers should be used, and how safety should be ensured during the handling of hazardous waste. These procedures should be clearly documented and reviewed periodically to ensure their effectiveness.

• Continuing education program:

- Train staff on the proper separation and handling of waste. It is essential that employees understand which types of waste can be recycled or composted, how to use the assigned containers, and how to follow safety procedures.

• Monitoring and Evaluation:

- Implement a tracking system to measure the quantity of waste recycled and composted on a monthly basis. Key Performance Indicators (KPIs) would include the reduction of waste sent to landfills, waste management costs, and benefits



derived from compost production. This data should be analyzed quarterly to evaluate progress and make adjustments as needed.

Program implementation and follow-up:

Once the plan is developed, it is crucial to continuously monitor its implementation to ensure that objectives are met. This may include regular inspections of recycling points, waste audits, and periodic meetings with staff to discuss potential improvements. The success of the program will be measured in terms of waste reduction, savings in disposal costs, and the production of quality compost that can be reused in the estate's agricultural operations.

Timeline for Developing a Recycling and Composting Plan

Below is a proposed detailed timeline for the development and implementation of a recycling and composting plan on the estate, with specific timeframes for each stage.

Month 1: Evaluation and Planning

- Evaluate generated waste: Conduct an initial assessment of the types and quantities of waste generated on the farm, classifying them as recyclable and compostable.
- Set objectives: Define clear and measurable goals, such as reducing landfill waste by 50% and composting at least 25% of the generated organic waste.

Month 2: Plan Design and Training

- Develop the recycling and composting plan: Include clear procedures for waste separation, container placement, and waste transport routes to processing facilities.
- Train staff: Provide practical workshops on how to properly separate and manage waste, using demonstrations with the equipment and containers that will be implemented.

Month 3: Equipment Acquisition and Program Implementation

- Acquire necessary equipment: Purchase recycling bins, composters, and other equipment. If possible, consider reusable bins or those made from recycled materials.
- Initiate program implementation: Place containers in strategic locations on the farm and begin waste separation at the source.

Month 4: Initial Monitoring

- Monitor and evaluate the program: Conduct an internal audit to ensure staff is complying with the plan and evaluate the amount of waste recycled and composted against established goals.

Subsequent Months: Evaluation and Continuous Improvement

- **Continue monitoring:** Review performance indicators monthly, such as tons of waste processed and cost savings in disposal.
- Promote the program: Strengthen staff commitment through educational campaigns and encourage farm visitors to participate in the recycling and composting program.

Tips for Effective Implementation:

- **Assign specific roles:** Designate employees responsible for overseeing waste separation and coordinating logistics with waste management providers.
- **Use incentives:** Implement a recognition system for employees who stand out in their commitment to recycling and composting.
- **Engage the community:** Collaborate with local recycling and composting companies and promote public-private partnerships to ensure the program's sustainability.

3.4. Improving Water Management in a Mango Plantation in Los Ríos Province, Ecuador

Los Ríos Province, one of Ecuador's main mango-producing regions, faces significant water management challenges due to climatic variability, including recurrent droughts and floods. Improving water management in mango plantations is essential not only for the sustainability of production but also for adapting to climate change in the region.

Recommended Practices for Improving Water Management:

1. Efficient Irrigation:

- Drip irrigation system: This system delivers water directly to the roots of the trees, significantly reducing evaporation and ensuring optimal water use during drought periods.
- **Irrigation automation:** Use humidity sensors and weather stations to automate irrigation based on specific crop needs and climatic conditions.

2. Rainwater Harvesting and Storage:

- Build reservoirs or implement rainwater harvesting systems on the farm to capture this resource during the rainy season and use it in dry periods.

3. Graywater Reuse:

- Install graywater treatment systems from farm facilities to reuse it for crop irrigation or other agricultural activities. This method reduces potable water use for irrigation, maximizing water efficiency.

4. Fertilizer and Pesticide Management:

- Apply fertilizers and pesticides efficiently to minimize the risk of runoff and ensure that these substances are used in appropriate quantities and at the right time to reduce environmental impact.

5. Water Source Contamination:



- Implement soil conservation measures, such as the construction of terraces and contour ditches, to prevent erosion and protect nearby water bodies. Planting vegetative barriers along the banks of rivers and streams will also contribute to the protection of the resource.

Benefits of Efficient Water Management:

- **Cost Reduction:** The implementation of efficient irrigation systems and rainwater harvesting decreases the use of potable water, thus reducing operational costs.
- **Increased Productivity:** A constant water supply during drought periods improves both the quality and quantity of mango production.
- **Long-Term Sustainability:** Protecting water sources and reusing water resources enhances the farm's resilience to climate change, ensuring the long-term viability of the business.
- **Regulatory Compliance:** Implementing good water management practices ensures compliance with both local and international environmental regulations.

Monitoring and Evaluation of the Water Management Program:

Continuous monitoring of the implemented improvements is key. The use of humidity sensors, measuring the volume of recycled water, and analyzing crop productivity will help assess the success of the measures. Periodic adjustments to irrigation techniques and water reuse will ensure that optimal water balance is maintained in the plantation.

4. Discussion

One of the key findings of this study is that the majority of workers on the mango-producing estate lack knowledge about environmental management, which aligns with previous research conducted in other agricultural contexts in Ecuador [14]. The lack of training in environmental management not only limits the adoption of sustainable practices but also hinders compliance with current environmental regulations. This deficiency is especially concerning in a sector where sustainability is increasingly demanded by consumers and international regulations [9].

Another relevant finding is that the estate lacks a formally implemented Environmental Management System (EMS). This situation reflects a common pattern in small and medium-sized agricultural operations in Ecuador, as documented in previous studies [23]. The absence of an EMS hinders the organization's ability to identify, manage, and mitigate the environmental impacts generated by its operations, such as inefficient resource use and poor waste management [5], [8].

Regarding specific challenges related to water and waste management, similar issues to those reported in fruit farms in other Latin American countries were identified. When not properly managed, these areas tend to generate significant environmental impacts, such as contamination of water sources and soil degradation. The implementation of an EMS could address these problems by providing a clear framework for the efficient management of these resources [16], [17].

Finally, the hypothesis that implementing an EMS based on the ISO 14001:2015 standard would improve the estate's environmental performance was supported by the results obtained. Existing literature shows that agricultural organizations adopting this standard not only improve their environmental performance but also enhance their competitiveness in international markets and ensure regulatory compliance [10], [20].

The findings of this study not only partially validate the proposed hypotheses but also highlight the urgent need to strengthen environmental management capabilities within the agricultural sector. This study can serve as a basis for future research on the actual impacts of implementing EMSs in the region.

5. Conclusions

Based on the analysis of the results obtained, the following key conclusions can be drawn regarding the proposed implementation of an Environmental Management System (EMS) based on the ISO 14001:2015 standard on the mango-producing estate:

Lack of an EMS: The estate currently lacks a formal environmental management system, which has led to inadequate management of critical resources such as fertilizers, pesticides, and waste. This deficiency increases the environmental risks associated with its operations and reduces its ability to comply with current regulations.

Deficiencies in training: Most workers on the estate lack the necessary knowledge about the benefits and importance of implementing an EMS. This lack of training is a significant barrier to adopting sustainable practices and improving environmental performance.

Potential benefits of implementing an EMS: The proposal for an EMS based on ISO 14001:2015 will enable the estate to achieve its medium-term environmental certification goals, with benefits such as reducing operational costs, ensuring regulatory compliance, and improving its public image.

Relevance of the Study for the Agricultural Sector:

This study not only has implications for the estate analyzed, but it can also serve as a model for other agricultural operations seeking to improve their environmental



performance. The adoption of Environmental Management Systems (EMS) in the agricultural sector will significantly contribute to reducing the country's ecological footprint.

Future Research:

Future studies should be conducted to measure the actual impacts of EMS implementation, using performance indicators such as the reduction in agrochemical use and the improvement of water and soil quality. These studies will help validate the long-term benefits of these systems in similar contexts.

The implementation of an EMS on the studied estate is not only feasible but also necessary to ensure the sustainability of its operations in the long term and to improve its competitiveness in demanding markets.

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