### 1. SUMMARY

This study explores the serious problem of food insecurity faced by the Kogui community in the Sierra Nevada de Santa Marta. Colombia. lt analyzes the socioeconomic and geographical context and, crucially, the impact of the armed conflict on this situation, including the lack of access to basic services, the distance from urban centers, poverty and the active presence of armed groups. It identifies 163 families as being directly affected by food insecurity and scarcity, leading to a high risk of youth recruitment by armed groups as a desperate way to earn income for their families. The need for a comprehensive that addresses approach both the immediate and structural causes of food insecurity, considering the context of the conflict, is emphasized. The geology, soils and vegetation of the Sierra Nevada are described in detail, which are essential to understand the environmental context. Solutions are proposed such as the implementation of rainwater harvesting systems, solar panels and drip irrigation systems to improve agricultural production, in addition to community strengthening strategies and recovery of ancestral practices.



### 2. INTRODUCTION

The Kogui, heirs of the ancient Tayrona civilization, inhabit the Sierra Nevada de Santa Marta, a territory that transcends mere geography to become a sacred space, the "Heart of the World". This mountain massif, the highest coastal system on the planet, exhibits a complex geology that directly influences the life of this indigenous community. The Sierra Nevada was formed at the end of the Tertiary period. approximately 66 million years ago, from an even older metamorphic basement, about <mark>400</mark> million years ago (Pre-Devonian), composed mainly of igneous rocks such as <mark>g</mark>rani<mark>to</mark>ids, as well as metamorphic rocks such as schists and gneisses. This diverse geological composition, the result of multiple orogenesis and periods of faulting, gives rise to a variety of soils that directly influence the subsistence activities of the Ko<mark>gui.</mark>

From the lowlands and middle areas, with relatively fertile alluvial and volcanic soils, suitable for agriculture, to the highlands, where thin, acidic and unproductive soils predominate, geological diversity shapes the agricultural and subsistence activities of the Kogui. Alluvial soils, formed bv sediments carried by rivers, are rich in nutrients and retain moisture well, ideal for growing various products. Volcanic soils, derived from past volcanic activity, are also fertile due to their mineral content. However, in the highlands, the soils are less developed, with lower organic matter content and higher acidity, which limits their agricultural capacity. In addition, heavy rainfall, characteristic of the region, and

agricultural practices that are not always sustainable exacerbate erosion, further hindering food production and causing the loss of valuable arable layer.

The Sierra Nevada is home to a rich biodiversity, with ecosystems ranging from tropical rainforests in the lower and middle parts, through montane and cloud forests as you ascend in altitude, to the moors in the However, this natural wealth is threatened by multiple factors. Deforestation, driven by the expansion of the agricultural frontier, illegal logging and the conversion of land for grazing, reduces vegetation cover and fragments natural habitats. Climate change, with the increase in global temperature and the alteration of rainfall patterns, affects the distribution of species and the availability of

highest areas. This diversity of thermal floors and ecosystems translates into a great variety of species of flora and fauna. Vegetation plays a fundamental



role in the lives of the Kogui, providing them with essential resources: wood for the construction of their traditional homes, medicinal plants for their ancestral healing practices, and a variety of wild foods, such as fruits, berries and roots.

In the lower areas, tropical rainforests predominate, with tall trees and dense vegetation. As you ascend, the vegetation transforms into montane forests, with smaller trees and a greater presence of mosses and epiphytes. In the highest areas, above the tree line, are the moorlands, high mountain ecosystems characterized by the presence of frailejon, shrubs and grasslands adapted to the extreme conditions of cold, wind and high solar radiation.

water resources. The proliferation of illicit crops, mainly coca, degrades the soil, contaminates water sources with chemicals and contributes to deforestation.

The Kogui community faces a complex web of interrelated issues that put their physical and cultural survival at risk. Lack of access to basic services such as drinking water, electricity and health care; the distance from urban centers, which hinders access to markets and essential services; extreme poverty that affects most families; and armed conflicts due to the Sierra Nevada being used as a cocaine transport route, which generates violence and puts the security of the community at risk. Food security is also a critical challenge, as a total of 163 families suffer from food shortages, which has led many young people to consider joining illegal armed groups to generate income for their families. This context of armed conflict shows how violence, the loss of arable land armed and pressure from actors



particularly affect indigenous communities, aggravating their situation.



To address these complex issues effectively, a comprehensive and multidimensional approach is required that takes into account interdependence between the social, economic. environmental and cultural factors, including a deep understanding of the geology, soils and vegetation of their Actions territory. should fo<mark>cus</mark> on guaranteeing access to basic services, strengthening the local economy in a sustainable manner, protecting the territory and the environment, strengthening security and governance, guaranteeing food security and promoting intercultural dialogue. The protection of the territory and respect for the ancestral knowledge of the Kogui are fundamental for the conservation of this invaluable natural and cultural heritage.

## 3. GENERAL OBJECTIVES

Diagnose the food security situation of the Kogui community in the Sierra Nevada de Santa Marta and propose sustainable solutions to improve it.

- 4. SPECIFIC OBJECTIVES
- Identify factors influencing community food insecurity.

- Evaluate the potential of rainwater and solar energy harvesting systems to improve agricultural production.
- Design a drip irrigation system for 50 hectares of crops.
- Estimate the costs and benefits of implementing the proposed solutions.
- 5. JUSTIFICATION

Food security is an internationally recognized fundamental human right, and it is essential to ensure the quality of life of any community. However, there are groups that face significant challenges in accessing nutritious and sufficient food, such as the Koguis, an indigenous community that lives in the Sierra Nevada de Santa Marta, in Colombia.

The situation of the Kogis is particularly critical due to their geographical isolation and exposure to adverse conditions, such as lack of basic infrastructure, scarcity of economic resources and vulnerability to climate change. This has generated a situation of food insecurity, where the community faces difficulties in accessing nutritious and sufficient food.

In this situation, it is essential to implement immediate and sustainable solutions that respect the culture and traditions of the Koguis. One of the most effective strategies is the implementation of appropriate technologies, such as rainwater systems and solar panels, that allow the community to access basic resources such as water and energy.

The implementation of these systems not only responds to the immediate need of the community, but also fosters sustainable development in a region that is key to biodiversity and environmental conservation. The Sierra Nevada de Santa Marta is a unique and fragile ecosystem, which is home to a wide variety of endemic species and is considered one of the most biodiverse places on the planet.

In addition, the lack of opportunities and food has generated an alarming situation, where some young people in the community consider joining armed groups as a way to obtain economic resources for their families. Not only does this put the safety and well-being of young people at risk, but it also perpetuates a cycle of violence and poverty that is difficult to break.

It is therefore critical to address the basic needs of the community, but it is also important to address the underlying social factors that contribute to food insecurity and poverty. This requires a comprehensive strategy that includes the implementation of appropriate technologies, community training and empowerment, and the promotion of environmental conservation and biodiversity.

Food security is a fundamental human right that must be guaranteed for all, including indigenous communities such as the Kogis. The implementation of appropriate technologies, such as rainwater systems and solar panels, is an effective strategy to address food insecurity and promote sustainable development in the Sierra Nevada de Santa Marta. However, it is critical to also address the underlying social factors that contribute to poverty and food insecurity, and to promote environmental conservation and biodiversity in the region.



#### 6. THEORETICAL FRAMEWORK

This theoretical framework explores key concepts to understand and address the problems that affect rural communities, especially in contexts of geographical isolation and socioeconomic vulnerability, such as the one faced by the Kogui in the Sierra Nevada de Santa Marta. It focuses on three fundamental pillars: food security, agroecology and sustainable technologies.

6.1. Food safety:

The Food and Agriculture Organization of the United Nations (FAO) defines food security as the situation that occurs when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their food needs and preferences in order to lead an active and healthy life. This definition encompasses four interrelated dimensions:

6.1.1. Availability: Refers to the physical existence of food, whether through own production, imports, stockpiles, or food aid. In the context of the



Kogui, availability is affected by factors such as the limited availability of fertile arable land, soil erosion, the effects of climate change and the presence of illicit crops that crowd out food production.

- 6.1.2. Access: It implies that people have the economic and physical resources to acquire food. Geographical isolation, lack of road infrastructure and extreme poverty limit the Kogi's access to markets and available food.
- 6.1.3. Utilization: This refers to how the body uses nutrients from food. This depends on factors such as food quality, preparation and cooking practices, people's health status, and access to safe drinking water and basic sanitation. The lack of access to drinking water and sanitation in Kogui communities has a negative impact on the biological use of food.
- 6.1.4. Stability: Refers to the ability to maintain the other three dimensions over time, even in the face of economic crises, natural disasters, or conflicts. The armed conflict affecting the Sierra Nevada and the vulnerability of traditional production systems to climate change threaten the stability of the Kogui's food security.
- 6.2. Agroecology:



Agroecology is presented as a key approach to achieve food security in a sustainable way. It is defined as an integrated approach that applies ecological principles to the design and management of sustainable agricultural systems. It seeks to optimize the interactions between plants, animals, humans, and the environment, while considering social, economic, and cultural aspects. The fundamental principles of agroecology include:

- Biodiversity: Promote the diversity of crops, animals and microorganisms in agroecosystems to improve resilience, productivity and ecosystem services.
- Local knowledge: Valuing and rescuing the traditional agricultural knowledge and practices of local communities, adapting them to current conditions.
- Ecological soil management: Promote practices that improve soil fertility, prevent erosion and conserve water.
- Reduction of external inputs: Minimize the use of fertilizers, pesticides and other synthetic inputs, prioritizing the use of local resources and agroecological practices.
- Food sovereignty: Promote the right of peoples to define their own policies and strategies for food production and consumption.

In the context of the Kogui, agroecology offers a way to strengthen their traditional

production systems, adapting them to current challenges and promoting food security in a sustainable way.

6.3. Sustainable Technologies:

The implementation of sustainable technologies plays a crucial role in improving living conditions and productivity in isolated rural areas. These technologies are characterized by:

- Low environmental impact: Minimize the consumption of natural resources and the generation of waste and pollutants.
- Adaptability to the local context: Be appropriate to the geographical, climatic and socioeconomic conditions of the region.
- Accessibility and low cost: Be affordable for local communities and easy to maintain.

In the case of the Kogui, th<mark>e use of so</mark>lar panels for electricity generation and rainwater harvesting and storage systems represent viable and sustainable solutions to improve access to these basic resources and support productive activities such as crop irrigation. These technologies can contribute to improving the quality of life of the community and strengthening its resilience to environmental and socioeconomic challenges. The combination of these three elements - food security, agroecology and sustainable technologies offers a solid theoretical framework to address the problems that affect the Kogui and other rural communities in vulnerable

situations, promoting more just, equitable and sustainable development.



## 7. LEGAL FRAMEWORK

This legal framework addresses the main norms and agreements that underpin the protection of the rights of indigenous communities in Colombia, with a particular focus on the right to food and sustainable development. It focuses on the Political Constitution of Colombia, Law 21 of 1991 (ILO Convention 169) and Sustainable Development Goal (SDG) 2 (Zero Hunger).

7.1. Political Constitution of Colombia (1991):

The Political Constitution of Colombia of 1991 represents a fundamental milestone in the recognition of the rights of indigenous communities. Unlike previous constitutions, the 1991 Magna Carta recognizes the ethnic and cultural diversity of the Colombian nation, granting special status to indigenous



peoples. The most relevant articles for this analysis are:

- $\triangleright$ Article 1: Recognizes Colombia as a social State governed by the rule of law, organized in the form of a unitary, decentralized, democratic, participatory, and pluralistic republic with autonomy of its territorial entities, based on respect for human dignity, on the work and solidarity of the persons who make it up, and on prevalence of the general the interest. This article lays the groundwork for the recognition of cultural diversity and the autonomy of indigenous communities.
- Article 7: Recognizes and protects the ethnic and cultural diversity of the Colombian Nation. This article is crucial for the protection of indigenous cultures and their ways of life.
- Article 63: The territories of ethnic groups are inalienable, imprescriptible and unseizable. This article guarantees the collective ownership of indigenous communities over their ancestral territories, which is essential for their physical and cultural survival, as well as for the development of their traditional productive activities.
- Article 246: The authorities of the indigenous peoples may exercise jurisdictional functions within their territorial scope, in accordance with their own rules and procedures, provided that they are not contrary to

the Constitution and laws of the Republic. The law shall establish the forms of coordination of this special jurisdiction with the national judicial system. This article recognizes the jurisdictional autonomy of indigenous communities, allowing them to resolve their internal conflicts in accordance with their own customs and traditions.

 $\triangleright$ Article 330: In accordance with the Constitution, the indigenous territorial entities shall be governed by councils formed and regulated in accordance with the uses and customs of their communities and exercise shall the following functions: 1. To ensure the application of the legal norms on land use and settlement of their territories. 2. To design economic and social development policies and programs within its territory, in coordination with the competent national and territorial entities. 3. To promote public investments in their territories and ensure their proper execution. 4. To receive and distribute their resources, in accordance with their customs. 5. То ensure the preservation of natural resources. 6. To coordinate the programs and projects promoted by the different entities of the State in its territory. 7. To collaborate with the maintenance of public order within its territory, in accordance with the instructions of the National Government. 8. To represent the territories before the



National Government and the other territorial entities. 9. Any other duties indicated by law. This article establishes the functions of indigenous councils, including the management of their territories, the design of development programs, and the preservation of natural resources.

7.2. Law 21 of 1991 (ILO Convention 169):

Law 21 of 1991 ratifies ILO Convention 169 on Indigenous and Tribal Peoples in Independent Countries. This international convention establishes important rights for indigenous peoples, including:

- Right to free, prior and informed consultation: Indigenous peoples have the right to be consulted on any legislative or administrative measure that may affect them directly.
- Right to participation in decisionmaking: Indigenous peoples have the right to participate in the formulation, implementation and evaluation of development plans and programmes that concern them.
- Right to collective ownership of their lands and territories: The right of indigenous peoples to collective ownership of the lands they traditionally occupy is recognized.
- Right to development with identity: The right of indigenous peoples to economic, social and cultural development that respects their own cultures, values and forms of social organization is recognized.

## 7.3. SDG 2 (Zero Hunger):

Sustainable Development Goal 2 (Zero Hunger) seeks to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture." This goal recognizes the importance of ensuring access to nutritious food for all, especially the most vulnerable populations. Specific targets for SDG 2 include:

- End hunger and ensure access for all people, in particular the poor and vulnerable people, including infants, to healthy, nutritious and sufficient food throughout the year.
- End all forms of malnutrition, including by achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutrition needs of adolescent girls, pregnant and lactating women and older persons.
- Double the agricultural productivity and incomes of small-scale food producers, including women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equitable access to land, other productive resources and inputs, knowledge, financial services, value-added markets and opportunities, and non-farm jobs.
- Ensure the sustainability of food production systems and implement resilient agricultural practices that increase productivity and production, contribute to the maintenance of

ecosystems, strengthen the capacity to adapt to climate change, extreme weather events, droughts, floods and other disasters, and progressively improve soil and soil quality.

This legal framework provides strong support for the protection of the rights of indigenous communities in Colombia, including the right to food, sustainable development, and the protection of their territories and natural resources. The effective implementation of these norms and agreements is essential to guarantee the well-being and survival of indigenous peoples.

### 8. METHODOLOGY

### 8.1. Community Diagnosis

The first stage consists holding of participatory workshops with local communities to identify the main food needs and define priorities in terms of access to and use of water for agricultural production. These workshops will gather information on major crops, current agricultural practices irrigation-related challenges. and In addition, a mapping of the areas suitable for the implementation of irrigation systems will be carried out, considering the topography, the availability of water resources and the capacity of the communities to maintain the system.



Participatory tools such as community maps, surveys, and focus groups will be used to ensure the inclusion of all sectors of the community, including women and youth. Likewise, a technical diagnosis will be developed that will analyze soil quality, infiltration index, and rainfall patterns in the region, using historical climate data and GIS (Geographic Information Systems) tools.

8.2. Design and Implementation

8.<mark>2.1. Rain</mark>water Systems



Rainwater harvesting systems will be installed using existing community infrastructure roofs. The collected water will be conveyed to 10,000-liter storage tanks, made of weather-resistant materials and equipped with multi-stage filtration systems to ensure water purification. In an average year, considering a rainfall index of 1,200 mm per year in the region and a catchment area of 150 m<sup>2</sup> per roof, it is expected to collect up to 180,000 liters of water per installed unit.



Each tank will have a pre-filtration system to remove large particles, followed by activated carbon filters and ultrafiltration membranes to ensure clean water suitable for agricultural irrigation. In addition, control valves and flow meters will be integrated to monitor water use in real time.



8.2.2. Solar Panels

The energy required to operate the drip irrigation system will come from solar panels. A photovoltaic system with a generation capacity of 5 kW will be installed, consisting of 15 solar panels of 335 W each. These panels will be oriented to the optimal angle of inclination to maximize energy capture during peak sun hours (5 average peak hours per day). The system will also include a battery bank with a storage capacity of 10 kWh to ensure the continuous operation of the electric pump even on cloudy days.

The solar inverter will be of the hybrid type, allowing the integration of additional energy sources if necessary. In addition, MPPT (Maximum Power Point Tracking) charge controllers will be installed to optimize the efficiency of the system. 8.2.3. Electric Pump and Drip Irrigation System



A 7 HP electric pump will be used to drive water from the storage tanks into the drip irrigation system, designed to cover 50 hectares. This system will include primary and secondary distribution pipes, as well as em<mark>itters c</mark>alibrated to deliver a uniform flow of water directly to the roots of the plants. Drip irrigation is especially efficient, as it minimizes losses due to evaporation and runoff, allowing water savings of up to 40% compared to traditional irrigation systems. Each hectare will require approximately 6,000 liters of water per week on average, which equates to a total consumption of 1,200,000 liters of water per month for the total area.



In addition, a system of soil moisture sensors connected to an automated



controller will be implemented, which will allow irrigation to be adjusted according to the specific needs of each crop. This not only optimizes water use, but also increases agricultural productivity.





### 8.3. Training

The sustainability of the system will be guaranteed through a comprehensive training program. Monthly workshops will be held for community members, covering the following topics:

- 8.3.1. Harvesting and Irrigation System Management: Participants will learn how to operate and maintain storage tanks, solar panels, and electric pump, including activities such as filter cleaning, periodic review of system components, and technical troubleshooting.
- 8.3.2. Sustainable Farming Techniques: Workshops will address agricultural practices that optimize water use and increase productivity, such as crop rotation, the use of organic

fertilizers, and the implementation of cover crops to improve soil moisture retention.

- 8.3.3. Monitoring and Evaluation: Community leaders will be trained in monitoring irrigation system performance and collecting data on its impact on agricultural production. This will allow necessary adjustments to be made to optimize its operation and ensure its longterm sustainability.
- 8.3.4. Renewable Energy: Participants will receive training on PV system maintenance, including cleaning panels and monitoring system efficiency.

## 9. EXPECTED RESULTS

This comprehensive project seeks to generate a positive and sustainable impact on the Kogui community, addressing the problem of food security through the of efficient implementation irrigation sustainable systems and training in technologies. The expected results focus on four main areas: increased production of local crops, reduction of external food dependence, improvement in the availability of water for agricultural uses, and strengthening community autonomy.

9.1.1. 80% increase in the production of local crops in the first year:

A significant increase in local crop production is expected during the first year of project implementation, specifically an increase of 80%. This increase is based on



the improvement in access to water for irrigation, which will allow:

- 9.1.2. Expand the cultivated area: By having an efficient irrigation system, it will be possible to cultivate areas that were previously unproductive due to lack of water, expanding the available agricultural area.
- 9.1.3. Increase yields per hectare: Drip irrigation optimizes the use of water, providing the necessary amount to each plant and reducing water stress, which translates into higher yields per unit area.

By increasing local food production, it is hoped that the Kogui community's dependence on external sources of food will be reduced. This involves:

9.2.1. Reducing the need to buy food outside the community: By producing more food locally, the need to purchase products in foreign markets will be reduced, reducing economic costs and vulnerability to price fluctuations.

9.2.2. Strengthen the local economy: Increasing local food production and

> consumption will strengthen the community's economy, generating income and employment opportunities. 9.2.3. Promoting

> 9.2.3. Promoting food sovereignty:

Reducing external dependence will contribute to the food sovereignty of the community, allowing them to have greater control over their food production and consumption.

This reduction in external dependence will strengthen the autonomy and resilience of the Kogui community.

9.3. Improvement in the availability of water for agricultural uses:

The implementation of rainwater harvesting and drip irrigation systems will significantly





of weather conditions, increasing the number of harvests and total production.

9.1.5. Diversify crops: The availability of water will allow diversifying production, including crops with higher water requirements and improving the diet of the community.

This increase in local production will have a direct impact on the availability of food for the Kogui community, improving their food and nutrition security.

9.2. Reduction of external food dependence:

improve the availability of water for agricultural uses. This will be achieved by:

- 9.3.1. Harnessing a local and renewable resource: Rainwater harvesting will make it possible to take advantage of an abundant natural resource in the region, reducing pressure on other water sources.
- 9.3.2. Optimization of water use: The drip irrigation system, by directing water directly to the roots of the plants, minimizes losses due to evaporation and runoff, optimizing the use of water resources.
- 9.3.3. Greater availability of water in times of drought: Rainwater storage tanks

will allow water reserves to be available during periods of drought, ensuring th



ensuring the continuity of agricultural production.

This improvement in water availability will not only benefit agricultural production, but will also contribute to the environmental sustainability of the territory.

9.3.4. Strengthening community autonomy through training in sustainable technologies:

The project includes a fundamental component of training and technical assistance, which seeks to strengthen the capacities of the Kogui community to manage and maintain the systems in place and adopt sustainable agricultural practices. This will result in:

- 9.3.5. Technical knowledge transfer: Workshops and technical assistance will provide the community with the necessary knowledge to operate and maintain irrigation systems, solar panels and rainwater harvesting systems.
- 9.3.6. Local capacity building: The training will strengthen local capacities for water resources management, sustainable agricultural production and the use of appropriate technologies.
- 9.3.7. Community

empowerment: By acquiring new knowledge and skills, the Kogui community will be empowered to manage their own resources and

improve their living conditions autonomously.

This strengthening of community autonomy will ensure the long-term sustainability of the project and promote the holistic development of the Kogui community. Together, these expected results contribute to improving the quality of life of the Kogui community, strengthening their food security, autonomy and resilience in the face of environmental and socio-economic challenges.

### 10. PROJECT MAP





## 11. CONCLUSIONS

The food security of the Koguis can be significantly improved through sustainable technological solutions that take advantage of local resources such as rainwater and solar energy. These strategies will not only ensure a steady supply of food, but will also contribute to the cultural and environmental preservation of the Sierra Nevada de Santa Marta. It then delves into the key aspects that demonstrate how these initiatives can transform the quality of life of this indigenous community.

# 11.1. Technological and Environmental Sustainability

The use of rainwater and solar energy represents a unique opportunity to address the historical challenges of access to basic resources in the Sierra Nevada de Santa Marta. With the installation of rainwater harvesting systems, storage tanks with the capacity to purify and maintain water, and solar panels designed to perform optimally under local weather conditions, a significant impact is made on the availability of water and sustainable energy.

Implementing these technologies not only offers an immediate solution to the lack of water and energy resources, but also minimizes dependence on fossil fuels and reduces carbon emissions. This approach is particularly relevant in an ecosystem as fragile as the Sierra Nevada, where the preservation of biodiversity is essential both for the environmental balance and for the worldview of the Koguis, who see their

territory as a sacred and interconnected space.

## 11.2. Food Supply Assurance

Access to efficient irrigation systems such as drip irrigation will allow Kogis to sow and harvest more consistently and productively. By reducing dependence on seasonal rainfall, the community will be able to diversify its agricultural production and ensure year-round food. In addition, adopting sustainable practices such as the use of organic fertilizers and cover crops will improve soil fertility and help retain moisture, thus maximizing agricultural yield with minimal water use.

The positive impact of these measures is not limited to the availability of food. It also has a significant impact on community nutrition and health, especially children and women, who are often the most affected by food insecurity. With a greater variety of crops and continued access to clean water, the Koguis will have the opportunity to strengthen their overall well-being and ability to face future challenges.

### 11.3. Respect for Ancestral Knowledge

A fundamental element for the success of any technological intervention in indigenous communities is the respect and integration of their ancestral knowledge. Kogis possess deep connection to their natural а environment and a holistic understanding of the earth's cycles. Incorporating this knowledge the in design and implementation of technological systems not only ensures their acceptance, but also enriches the proposed solutions.

For example, Kogis have a unique way of interpreting the seasons and water cycles, which can complement irrigation system usage planning. Likewise, their knowledge of native crops and local biodiversity can be key to deciding what to plant and how to do it sustainably. This integration not only reinforces the cultural identity of the community, but also ensures that the technologies introduced are adapted to their specific needs and context.

### 11.4. Active Community Engagement

The involvement of the Koguis in all stages of the project, from initial diagnosis to implementation and monitoring, is essential to ensure its long-term sustainability. Training workshops not only empower the community with technical and maintenance skills, but also foster a sense of belonging and responsibility towards the systems implemented. Training in renewable energy, irrigation system management and sustainable agricultural practices will strengthen the autonomy of the Koguis, allowing them to manage their resources independently. This participatory approach also creates opportunities for women and youth to take on leadership roles within the community, gender promoting equity and social cohesion.

11.5. Cultural and Environmental Preservation

In addition to the tangible benefits in food security and sustainability, these initiatives have a profound impact on the cultural and environmental preservation of the Sierra Nevada de Santa Marta. By reducing pressures on natural resources and promoting agricultural practices that respect ecological balance, the habitat of many species is protected and the cultural heritage of the Kogis is preserved.

The Sierra Nevada is much more than a physical space for the Koguis; it is the heart of their worldview and spirituality. By implementing solutions that strengthen this connection while improving their quality of life, a development model is created that respects both people and the environment in which they live. This approach not only benefits the Koguis, but also offers valuable lessons for other sustainable development projects in indigenous territories.

### 11.6. Final Recommendations

To maximize the impact of these strategies, it is crucial to ensure continuous monitoring and the availability of resources for the



maintenance of the implemented systems. This includes the provision of spare parts, the regular updating of the community's technical capacities, and the creation of support networks with other organizations and institutions. In addition, it would be ideal to establish monitoring and evaluation mechanisms that allow measuring the impact of the project in terms of food security, health and environmental sustainability.

conclusion, the combination In of sustainable technological solutions with the active participation of the Koguis and respect for their ancestral knowledge has the potential to transform their food security and resilience in the face of the challenges of climate change. This development model represents not only a short-term solution, but a long-term investment in the wellthe community being of and the preservation of one of the most valuable ecosystems in Colombia.

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