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University, Family Farming and Agroecological Transition: Systematization of an Extension Experience in Conservation Agriculture

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ABSTRACT

Food insecurity in contexts of socio-environmental vulnerability requires strategies that integrate sustainable production with the strengthening of local capacities. This article systematizes the experience of the Universidad de Oriente (Cuba) in supporting Family Farming (FF) systems for the adoption of Conservation Agriculture (CA) principles in the Santiago de Cuba municipality during the period 2010–2025. To critically reconstruct this experience and identify the main facilitators, obstacles, and lessons learned for the agroecological transition, a case study with a mixed approach was carried out, which included: (a) documentary review of 48 project reports, theses and training materials generated by the university; (b) application of a structured survey to farmers of 120 family plots in five localities (2025); and (c) conducting 15 semi-structured interviews with key producers, extension workers and academics (2023–2025). The results show that 65% of the plots adopt practices compatible with CA, mainly motivated by self-sufficiency (48.4%) and soil protection (45.1%). However, structural obstacles persist such as water scarcity (63.3%), lack of seeds (55.6%) and limitations in appropriate mechanization. The analysis reveals that university accompaniment, based on participatory action research approaches and dialogue of knowledge, has contributed to strengthening the self-esteem of producers, collective organization and the generation of contextualized knowledge. It is concluded that the university can play a relevant role in the agroecological transition when it acts as a facilitator of horizontal processes. The study provides lessons for designing university extension strategies aimed at food sovereignty in family farming contexts.

Keywords: Conservation Agriculture; Family Farming; University Extension; Agroecology; Systematization of Experiences

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1. Introduction

The province of Santiago de Cuba is highly vulnerable in the process of food self-sufficiency due to various agro-productive factors such as its topography, soil quality, climatic and hydrological conditions, which result in low yields that do not meet the food needs of the population ^[1]. Today, in the face of the international situation, the global financial economic crisis, from which Cuba is not exempt, the increase in food prices, together with the fierce imperialist blockade against Cuba, the country's leadership has indicated that all peri-urban lands could be used to produce intensively, in a diversified and sustainable manner on agroecological bases ^[2].

The international rise in food prices can open a path of development for family farming if countries provide effective support, within the framework of long-term policies, as various actors suggest. The increase in agricultural product prices, which began in 2002, is explained by various factors. In the first stage, by the demand from countries with large numbers of poor people who began to eat better, such as China and India, and the revision of corn consumption projections to produce ethanol in the United States ^[1].

Although there is no single definition of family farming (FF), three characteristics are associated with it: family labor, absence of permanent employees, and achievement of sufficient income for its reproduction. 80% of all agricultural holdings in the region would be in the hands of family farmers ^[3].

Urban and suburban agriculture, the emerging family farming and local mini-industries show Cuba's progress towards food sovereignty, since increasing food production is a priority for the country. The Cuban government has prioritized food production for several decades in a context marked by rising international prices, in order to reinforce and guarantee one of the essential rights of its people: food security. This national priority aligns with a global recognition of the role of family farms not only in food production but also in the conservation of agrobiodiversity and the maintenance of ecosystem services, particularly within and around protected areas ^[4].

Conservation Agriculture is based on the fundamental concept of integrated management of soil, water and all

agricultural resources. Its main characteristic is that under specific and continuous forms of cultivation, soil regeneration is faster than its degradation, so that the intensification of agricultural production is economically, ecologically and socially sustainable. This is achieved through the simultaneous application of three interlinked principles: continuous minimum mechanical soil disturbance, permanent organic soil cover, and diversification of crop species grown in sequences or associations ^[5].

Traditional soil management is a very old practice based on intensive plowing, harrowing, and soil turnover. Over time, these practices have contributed to destroying soil structure worldwide. However, faced with this situation, researchers and producers have sought alternatives. This is the case of conservationist soil management through minimum soil disturbance and conservation tillage, which mitigates the negative effects on the soil. Conservation Agriculture (CA) began to be used on the American continent in the early 1970s, with demonstrated benefits from its application. Cuba, with its highly degraded soils due to intensive use, decided to implement CA ^[6].

Among the advantages of applying Conservation Agriculture, according to FAO and Cuba Si ^[7,8], are: lower labor needs, less machinery wear, fuel economy, increased long-term productivity, improved surface water quality, reduced erosion, greater moisture retention, increased water infiltration into the soil, reduced soil compaction, improved soil structure, and lower carbon dioxide emissions into the atmosphere.

Conservation Agriculture seeks sustainable and profitable production, based on minimum disturbance and permanent soil cover, characteristics of direct seeding, and crop rotation. Considered a solution to food insecurity and a mechanism for adaptation to climate change, this agricultural practice yields returns for its followers. Although it is considered a practice accepted by farmers, obstacles still remain, such as weed control, lack of draft animals, the requirement for specific agricultural machinery and appropriate tools, and the difficulty of changing certain ways of thinking ^[9]. In a national context where agricultural policies increasingly promote agroecological transitions, as evidenced by the recent approval of a national agroecology policy integrated into Cuba's Food Sovereignty and Nutritional Education Plan, overcoming these obstacles is para-

mount^[8]. Despite the recognition of its advantages, various limitations remain for its implementation.

Context of the Experience: The Universidad de Oriente Responding to Social Demands

The institution's initial involvement in this area began with multiple demands from ACTAF (Cuban Association of Agricultural and Forestry Technicians) and the provincial government, which requested collaboration from the Faculty of Chemical Engineering and Agronomy to create training materials on Family Farming and to teach postgraduate courses on related topics.

A manual and a plan for postgraduate courses were then developed, aimed at agroecology as the basis for the implementation of Conservation Agriculture, to train producers who, without having an explicit definition of agroecology, have a technological proposal for organic production.

The confluence of a series of factors—scarcity of biophysical and economic resources, availability of small spaces and land, food needs of families and associated groups—determined the design of diversified systems, with genetic materials adapted to those conditions, promoting strategies for resistance and self-regulation of pests and diseases, nutrient recycling and composting. Thus, healthy food products were obtained with very few external subsidies to the system. Simultaneously, forms of organization, participation and exchange of knowledge arose around obtaining and exchanging seeds, cultural techniques, land occupation, product sales, among others.

These elements, analyzed from the dimensions of Agroecology, allow identifying a work perspective strongly focused on this approach. From the sociocultural and economic dimension, a strong endogenous content is identified, expressed in the development of productive strategies and development processes together with elements of Participatory Action Research. And the political dimension of Agroecology translates into the construction of alternatives to the problems of the agri-food question, through the support and accompaniment of collective productive and marketing actions^[9]. Furthermore, family farms, when supported by horizontal extension models, can function as “living labs” for agroecological innovation and knowledge transfer, strengthening local capacities and resilience^[10].

This program aims to be a sustainable alternative

based on human development, addressing the problem of food insecurity of the population and developing the capacity of the participating people to organize themselves, appropriate new knowledge and generate their own solutions. Training and dissemination spaces for agroecological technologies were generated, and dissemination materials that are demanded and used today were produced (multimedia, manuals, instructional guides). Research papers were published and curricular internships for students were developed. Finally, coordination with other institutions and social actors related to the theme of Family Farming (FF), food security and sovereignty, and the promotion of Conservation Agriculture (CA) was sought, not without difficulties.

At that time, some aspects were explicitly integrated into the objectives. Among them: care for the environment, the need for articulation between organizations and institutions related to the theme, and interdisciplinary work.

A survey conducted in the Santiago de Cuba municipality showed that 120 family plots brought together about 670 people, who covered part of their food needs with this alternative. More than 40 agronomy students developed curricular work in these learning “classrooms”. From this experience, many lessons and some challenges were extracted. Links were generated with producers, learning from that relationship and contributing university knowledge to food production and people's nutrition. It was possible to work with producers on an equal footing, with the University as one more actor, sharing knowledge and making its resources available.

An interdisciplinary teaching team was strengthened within the Faculty of Chemical Engineering and Agronomy, linked to other Faculties, committed to supporting Family Farming and Conservation Agriculture initiatives, which has grown in experience and recognition. Participation has been ongoing in projects with MINAG (AGROCADENAS, PALMA), as well as the VLIR project in collaboration with the Flemish University Council of Belgium, and with the work of the Faculty's Chairs (Adolfo Rodríguez Rivera Agroecological Chair and the Álvaro Reynoso Chair), as well as the celebration of the Sustainable Agriculture workshops (AGROSOS).

This demonstrated once again that the University can respond to society's demands, particularly in emergen-

cy contexts, through an interdisciplinary task that has allowed, not without difficulties, articulating contents, logics and methodologies, integrating different academic areas that sought to complement each other in addressing the theme.

This article analyzes some experiences developed by university professors and students and multiple institutional actors. Various themes have framed the actions: food security and sovereignty, contribution to population learning, promotion of healthy eating habits, and having as a conceptual and methodological basis Conservation Agriculture within the Family Farming environment. Specifically, it seeks to answer: What CA practices have been adopted by FF systems and with what perceptions by producers? What are the main obstacles they face in their implementation? What role has the university played in this process? The findings provide empirical evidence for the design of public policies and university extension strategies oriented towards food sovereignty in Caribbean family farming contexts.

Some of the actions developed are described and analyzed, a synthesis of them is made, and the projections that are being built from the lessons learned are presented to respond to the objective of critically systematizing the experience of the Universidad de Oriente in supporting Family Farming systems for the adoption of Conservation Agriculture principles in the Santiago de Cuba municipality during the period 2010-2025, in order to identify the main facilitators, obstacles and lessons learned for the agroecological transition.

2. Materials and Methods

A single instrumental case study ^[11] was carried out with a mixed methods approach and a systematization of experiences design ^[12]. This approach allowed us to critically reconstruct the intervention process of the Universidad de Oriente in the promotion of Conservation Agriculture (CA) in Family Farming (FF) systems, interpreting its results and extracting transferable lessons for other contexts. The analysis period comprised the years 2010 to 2025.

The systematization of experiences is a participatory research approach that critically reconstructs a practice

or intervention process to understand it, extract lessons learned, and share them with other contexts. Unlike a traditional case study, systematization explicitly seeks to generate knowledge from practice, involving key actors in the interpretation of the process. This approach follows a structured process that includes: (a) defining the object of systematization (the university's intervention in FF and CA); (b) recovering the historical trajectory of the experience; (c) critically analyzing the factors that facilitated or hindered the process; and (d) formulating conclusions and transferable lessons for other contexts. In this study, this approach allowed us not only to describe the university's intervention but also to analyze its dynamics, identify facilitators and obstacles, and formulate transferable lessons for university extension in family farming contexts.

The unit of analysis was the set of extension, research and training actions developed by the Universidad de Oriente (Faculty of Chemical Engineering and Agronomy) in family plots and farms in the Santiago de Cuba municipality, including the towns of Boniato, El Cobre, El Cristo and El Caney. The study focused on the male and female producers who participated in the university programs linked to CA and FF.

Three main techniques were used to guarantee the triangulation of information:

Exhaustive documentary review: 48 documents generated between 2010 and 2025 were analyzed, including: (a) project reports from international cooperation projects (PALMA, AGROCADENAS, VLIR) developed jointly with the Ministry of Agriculture (MINAG) and the Universidad de Oriente; (b) undergraduate and postgraduate theses prepared by students of the Agronomy program at the Faculty of Agronomy; (c) minutes of workshops and meetings of AGROSOS, an international workshop on sustainable agriculture sponsored by the Universidad de Oriente; (d) training materials produced (manuals, multimedia); and (e) scientific publications derived from the experience. A data extraction matrix was used to identify objectives, actions, actors involved and reported results.

Structured survey: In 2025, a questionnaire was applied to a census sample of 120 family plots identified by the project. The questionnaire included closed and open questions about: (a) sociodemographic characteristics of the families; (b) implemented agricultural practices (tillage,

cover management, rotation); (c) perception of advantages and disadvantages of CA (**Table 1**); and (d) main problems for its implementation (**Table 2**). The instrument was previously piloted with 10 producers to adjust its comprehension.

Table 1. Main advantages and disadvantages of Conservation Agriculture (CA) recognized by producers.

Main Disadvantages	% of Producers	Main Advantages	% of Producers
Rigor of work	38.3	Self-sufficiency and consumption	48.4
No disadvantages	32.3	Soil protection	45.1
Lack of draft animals	16.1	No advantages	12.9
Effect of pests	10.1	Liking the work	12.9
Non-use of chemical products	6.5	Environmental protection	12.9
Insufficient organic matter	3.2	Non-use of chemical products	9.7
Shortage of tools and machinery	3.2	Work style	6.5
		Training	6.5
		Conservation of plant genetic resources	3.2

Table 2. Problems for the implementation of CA.

Main Problems Raised by Producers	% of Producers
Little water and lack of irrigation system	63.3
Lack of seeds	55.6
Poor substrate quality and lack of organic matter	43.3
Lack of draft animals	37.8
Lack of work means (tools, agricultural machinery)	16.7

Semi-structured interviews: Between 2023 and 2025, 15 in-depth interviews were conducted with intentionally selected key informants: 8 male and female producers (with more than 5 years of participation), 3 extension workers from ACTAF, 2 local government officials and 2 academic coordinators of the program. The interviews explored: the history of the relationship with the university, changes in productive practices, dynamics of collective organization, difficulties faced and perception of the university’s role.

The survey data were processed using SPSS v.22 software. A descriptive analysis (frequencies and percentages) was performed to characterize the practices and perceptions of producers (**Tables 1 and 2**).

The interviews were recorded (with consent), transcribed and analyzed using thematic content analysis with the support of ATLAS.ti software. The phases followed were: (a) open coding to identify emerging themes; (b) grouping of codes into analytical categories (e.g., “change of mentality”, “horizontal link with the university”, “structural obstacles”); and (c) interpretation of the categories

in light of the theoretical framework of Agroecology and Critical Extension. The quantitative and qualitative findings were contrasted with each other and with the documentary information to construct a comprehensive and robust interpretation of the process.

Informed consent was obtained from all participants in the interviews, guaranteeing the anonymity of their responses through the use of codes. The research was framed within the principles of collaboration and feedback of results, sharing preliminary findings with producers in validation workshops held in 2025.

3. Results and Discussion

3.1. Implementation of Conservation Agriculture

As a result of the surveys applied to the producers of 120 family plots in the Santiago de Cuba municipality (also including the towns of Boniato, El Cobre, El Cristo and El

Caney), 2 tables were created.

Table 1 presents the main advantages and disadvantages of Conservation Agriculture (CA) recognized by the male and female producers of the 120 family plots surveyed. This perception exercise is key to understanding the factors that facilitate or limit the adoption of conservation practices in Family Farming (FF) contexts.

The aspect most valued by producers is self-sufficiency and family consumption (48.4%). This data is consistent with the logic of FF, where production is not primarily market-oriented, but rather aimed at the social reproduction of the family^[3,13]. In a context of economic crisis and blockade, as described in the introduction, the capacity to produce food for the household becomes a fundamental resilience factor. This aligns with broader discussions in agroecological literature, which emphasize that the primary goal of peasant and family agriculture is often the reproduction of the family unit and the maintenance of autonomous livelihoods rather than pure market integration^[14,15]. A female producer from the town of El Cobre expressed in an interview: “The main thing is that we have something to put in the pot. What is left over, we sell, but the peace of mind comes from knowing that we won’t go hungry.”

Secondly, soil protection (45.1%) is widely recognized. This suggests that, despite the lack of formal academic training in many cases, there is empirical awareness of soil degradation and the need to care for it. This finding aligns with the principles of CA that emphasize permanent cover and minimum disturbance as ways to regenerate the soil^[5]. However, the recognition of this advantage contrasts with the practical difficulties in implementing it, as will be seen in **Table 2**. The fundamental role of soil health as the basis for sustainable food systems is a cornerstone of agroecological thought^[16], and the producers’ intuitive recognition of this principle is a crucial entry point for extension efforts

Other values such as liking for the work (12.9%), environmental protection (12.9%) and the non-use of chemical products (9.7%) reflect a sociocultural and ethical dimension of agricultural work. From the perspective of agroecology, these elements are fundamental to building a peasant identity oriented towards sustainability^[9,17]. Indeed, the agroecological movement recognizes that a

transition to sustainable systems is not just a technical shift but a social and political one that strengthens rural communities and their cultural ties to the land^[18]. However, the relatively low percentage of those who mention “non-use of chemicals” as an advantage suggests that the transition towards fully agroecological production is still incipient and not necessarily an explicit priority for the majority.

A striking fact is that 12.9% of respondents find no advantages in CA. This group could be composed of producers more attached to conventional agriculture, with difficulties perceiving short-term benefits, or those who have had negative experiences with some component of CA (e.g., increased pests when not tilling). This “hard core” of resistance to change is a key challenge for extension programs. For example, a producer of Boniato stated that “At first, I didn’t understand this idea of leaving the land unplowed. My father taught me that you had to turn it over well so it would be clean. But when I saw that on a neighbor’s plot the soil was spongier and didn’t crack as much in the summer, I decided to give it a try. Now I see that the earthworms have returned and the soil doesn’t harden like before.” This testimony illustrates how the direct observation of results in neighboring plots can act as a catalyst to overcome initial resistance. It also confirms that extension programs should prioritize peer-to-peer learning and demonstrative plots managed by local farmers, as a way to engage those who are still reluctant to adopt conservation practices.

3.2. Analysis of Perceived Disadvantages

The main disadvantage noted is the rigor of the work (38.3%). CA, while reducing tasks like plowing, requires finer and more constant management: cover monitoring, manual weed control (in the absence of herbicides), and rotation planning. In a context of an aging rural population and youth migration, the perception that CA is “more laborious” can be a real barrier. This relates to the lack of appropriate mechanization, which appears as a disadvantage (3.2%) and as a problem in **Table 2**.

One-third of respondents (32.3%) stated that they found no disadvantages. This group could be made up of successful adopters who have fully integrated the practices, or by producers with little understanding of the question. It would be relevant to cross-reference this variable with the

actual adoption level to deepen the analysis.

The lack of draft animals (16.1%) and the effect of pests (10.1%) are concrete operational disadvantages. The former points to a structural problem of peasant de-capitalization; the latter, to a temporary technical difficulty during the transition from conventional tillage to direct seeding, where ecological pest management has not yet stabilized.

These results dialogue with the literature on innovation adoption in family farming. The perception of complexity (rigor of work) and compatibility with previous values and experiences are determinants in adoption. In this case, the high valuation of self-sufficiency (compatibility with the family goal) acts as a motor, while the rigor (complexity) acts as a brake^[19].

From a public policy perspective, the data suggest that efforts to promote CA cannot be limited to technical training. They must be accompanied by:

- Solving the lack of draft animals or facilitating access to small machinery adapted to family farming.
- Supporting producers in the first years, when pest and weed control is most critical, and the perceived risk is highest.
- Incorporating local knowledge about soil and crop management to co-design CA practices more adapted to the reality of each plot.

It is important to note that perception data are subjective and may be influenced by the timing of the survey, the wording of questions, or the social desirability of responses. A more robust analysis would require correlating these perceptions with objective variables such as the level of practice adoption (measured through direct observation), crop yields, or family income. Likewise, it would be valuable to conduct focus groups to delve deeper into the causes of “don’t know/no answer” and apparent contradictions (for example, those who value soil protection but see no disadvantages).

Table 2 identifies the main problems that producers face in implementing Conservation Agriculture (CA) practices in their family plots. These data are crucial because, beyond subjective perceptions (**Table 1**), they reveal the concrete bottlenecks that condition the viability and sustainability of CA in Family Farming (FF) contexts.

The most mentioned problem, and by a signifi-

cant margin, is little water and lack of irrigation system (63.3%). This data reflects a critical reality in Santiago de Cuba and in much of the insular Caribbean: water vulnerability. CA, while promising more efficient water use (up to 30% less according to the literature), does not eliminate the need for a minimum and reliable supply, especially in the initial phases of crop establishment and during drought periods^[7,20].

This limitation transcends the scope of individual producer decisions and lies in the realm of public policies and infrastructure. The lack of irrigation systems, whether due to cost, technical complexity to install them in small plots, or the absence of nearby water sources, discourages any investment in productive improvements. A producer from El Caney stated in an interview: “Why am I going to rotate crops or put cover if I don’t have water for what I sow to grow? Water first, everything else later.” This quote illustrates how water scarcity disrupts any technological package, however sustainable. This coincidence between quantitative and qualitative data reinforces the centrality of the water issue, an aspect that was also identified in the reviewed project reports (PALMA and AGROCADENAS). The challenges of water management in small-scale agriculture are a central concern for agroecological transitions, requiring a holistic approach that goes beyond plot-level solutions to encompass watershed management and collective action^[21].

The main obstacle identified, lack of water (63.3%), acquires a more complex dimension when considering the diversity of crops present in family plots. Vegetables, highly sensitive to water fluctuations, require irrigation strategies that guarantee constant humidity during critical periods such as flowering and fruit development. Fruit trees, with deeper root systems, offer greater resilience, but also demand water at specific moments of the productive cycle. Coffee, when present, faces particularly demanding requirements: outside its optimal life zone (1,600–1,800 mm/year), yields drop drastically and vulnerability to pests increases.

Conservation Agriculture offers a framework to address this structural limitation, not by increasing water supply—which is beyond the individual producer’s control—but by maximizing the efficiency of available water use. Permanent soil cover reduces direct evaporation by up

to 30–40%, while minimum soil disturbance improves infiltration and soil water storage capacity. Crop rotation and the incorporation of species with different root systems optimize the exploration of the soil profile and water use at different depths. This integrated approach to resource management is a core element of agroecological practice, which seeks to design farming systems that work with, rather than against, natural ecological processes^[22].

This suggests that, rather than an insurmountable obstacle, water scarcity reinforces the relevance of adopting CA principles in family farming systems. However, the transition requires technical support to design cropping systems adapted to actual water availability and to implement water harvesting and storage techniques at the plot scale, such as rainwater harvesting or efficient use of especially subsurface drip irrigation which is particularly suitable for CA.

In second and third place are the lack of seeds (55.6%) and poor substrate quality and lack of organic matter (43.3%). These problems point to a weakness in the input sovereignty of FF systems. CA, in its agroecological approach, promotes nutrient recycling and local input production (compost, creole seeds). However, the data show that producers depend on external sources that are not always available.

The lack of seeds can be interpreted as the absence of locally adapted varieties, the loss of creole seeds through substitution, or the difficulty in accessing germplasm banks. This finding questions the resilience of the systems and highlights the need to strengthen local networks for seed exchange and conservation, a pillar of peasant autonomy^[9]. This is a challenge that has been documented in other regions of Cuba, where the number of species and varieties maintained by farmers has decreased in recent years due to a combination of market pressures, rural migration, and a consequent erosion of traditional knowledge^[23]. The exchange spaces promoted by the university have begun to generate collaborative dynamics among producers, as recounted by a female farmer from El Cobre: *“The good thing about these workshops is that we started to get to know each other. When someone lacks bean seeds, another says ‘I have some’ and we exchange. That’s how we recovered varieties that were almost no longer seen, like creole corn. The university helped us organize the barter-*

ing.” This testimony shows that, beyond the direct provision of inputs, institutional accompaniment can catalyze processes of peasant self-organization that strengthen seed sovereignty at the local level.

The lack of organic matter is an apparent paradox, since CA should generate its own organic matter through cover and rotation. However, in a context of degraded soils and low initial productivity, producers do not have sufficient biomass to maintain cover and, at the same time, feed animals or generate income. This ecological “poverty trap” requires an initial external input (green manures, external compost) to “jump-start” the cycle. Long-term studies on family farms in Pinar del Río, Cuba, have shown that a system of agroecological practices can increase soil organic matter from 0.97% to 1.96% over two decades, highlighting the potential for regeneration but also the extended timeframe required^[24]. This is further corroborated by research in other regions of Cuba, such as the Sierra del Rosario Biosphere Reserve, where the measurement of farm environmental sustainability has revealed the complex interplay between family management practices and ecosystem health^[25].

The lack of draft animals (37.8%) and the lack of work means (tools, agricultural machinery) (16.7%) are indicators of the de-capitalization of the FF sector. CA, especially in its direct seeding variant, may require specific equipment (manual seeders, rippers) that are not affordable for small producers. The lack of draft animals, in particular, is a serious problem in contexts where motorized mechanization is unfeasible due to plot size or cost.

The literature on technology adoption in agriculture points out that the adoption of emerging technologies in agriculture is strongly conditioned by the availability of assets (physical, financial, and human) in family units^[19]. In this case, the lack of basic assets (water, seeds, traction) acts as an insurmountable entry barrier for many, regardless of their willingness to adopt conservation practices. This is consistent with earlier analyses of the specific challenges facing the implementation of CA in the Caribbean region, which identified similar structural constraints^[26].

The analysis of these problems suggests that the university’s approach, focused on training and knowledge transfer, is necessary but insufficient. If structural obstacles (water, seeds, capital) are not addressed, knowledge cannot

translate into practice.

The university must complement its formative role with political advocacy actions to demand and co-design solutions to infrastructure problems (rainwater harvesting systems at the plot scale). It can also facilitate access to inputs through the creation of community seed banks or the promotion of compost production. A farmer from El Cristo stated: *“At first we thought that the professors came just to teach us, like in school. But then we realized that they also asked questions, they wanted to know how we did things. That changed everything, because you feel more confident to say what you think and to propose ideas.”* This statement evidences the transition towards a model of critical and dialogical extension, where trust and mutual recognition become the foundation for the co-creation of knowledge and the sustainability of processes. The experience confirms that when the university acts as a horizontal facilitator, listening to and valuing local knowledge, more favorable conditions are generated for the appropriation of innovations and the strengthening of endogenous capacities in rural communities.

The data in **Table 2** demonstrate that FF is not a homogeneous sector. Public policies are required that recognize these limitations and offer differentiated support: subsidies for the purchase of draft animals or tools, plot-level irrigation programs, and technical assistance for local input production. A supportive policy environment is crucial for an agroecological transition, as recognized in international frameworks that call for public investment in sustainable agriculture and the right to food^[27].

It is necessary to advance research that, hand in hand with producers, seeks local alternatives to these problems. For example, evaluating which cover species are most efficient under conditions of low water availability, or designing manual tools that reduce the rigor of work.

It is important to note that these data come from a survey. However, limitations are identified, so it would be valuable to perform multivariate analyses to explore the relationships between these problems: for example, are the producers who lack water the same ones who lack seeds? Is there a correlation between the lack of draft animals and the perception of “rigor of work” in **Table 1**? These analyses would allow identifying producer profiles and designing more precise interventions.

Many producers do not have a defined idea of what Conservation Agriculture is, but their practices have been adopted by them and recognized as very necessary, in contrast to others (who are a minority, since 65% of the plots adopt CA practices), who need to change their mentality to adopt it.

Numerous natural resources, including soil and water, are found in agriculture; water reserves for future food production, human consumption, forest conservation and biodiversity, as fundamental heritages, depend largely on their proper management and productivity. Cuban farmers have been guardians of valuable genetic resources that today become an economic promise and food security for the future. This role of farmers as custodians of agrobiodiversity is increasingly recognized in international research and policy frameworks^[4].

However, a transition towards this practice must be promoted with a first stage consisting of a change in mentality regarding ambiguous technical criteria and the consideration that the soil is a habitat for roots and organisms, since permanent soil cover is the only way to protect and regenerate it, as tillage creates a temporary soil structure but damages the stable habitat of soil life.

Preliminary measures should be taken such as starting in small areas and with the best conditions, to eliminate soil compaction, correct its fertility, carry out good land leveling, minimize difficult-to-control weeds, start with crop residues, use appropriate equipment or machinery, newly acquired or adapted; plan crop rotations for the first two years. It is advisable to desiccate covers for 7 to 10 days after mechanical management, so that there is time for possible weed seeds to emerge and thus reduce the seed bank.

4. Conclusions

The systematization of the experience of the Universidad de Oriente in supporting Family Farming (FF) systems for the adoption of Conservation Agriculture (CA) in the Santiago de Cuba municipality during the period 2010–2025 allows drawing the following main conclusions:

The results show that 65% of family plots incorporate at least some practices compatible with CA, highlighting the valuation of self-sufficiency (48.4%) and soil

protection (45.1%) as the main perceived advantages. This indicates that, although there is no full appropriation of the technical concept of CA, producers empirically recognize the benefits of practices such as cover and minimum soil disturbance. However, the presence of 12.9% who find no advantages and 32.3% who report no disadvantages suggests heterogeneity in the levels of understanding and adoption, which demands differentiated extension strategies.

The problems identified for the effective implementation of CA are predominantly structural in nature and exceed the individual producer's sphere of decision. Water scarcity (63.3%), lack of seeds (55.6%) and low availability of organic matter (43.3%) constitute a "restrictive triad" that severely conditions any attempt at agroecological transition. These findings reveal that CA, far from being an autonomous solution, requires basic enabling conditions (water infrastructure, seed networks, access to organic inputs) that must be guaranteed by public policies and rural development programs.

The analyzed experience demonstrates that the university can play a relevant role when it adopts participatory action research approaches and dialogue of knowledge. The generation of training spaces, the production of contextualized materials and on-site accompaniment contributed to strengthening the self-esteem of producers, collective organization and the generation of knowledge adapted to local realities. However, persistent tensions are identified between academic times and productive cycles, as well as difficulties in scaling innovations beyond pilot cases. The university's impact is limited when structural bottlenecks (water, seeds, mechanization) are not simultaneously addressed by other institutional actors.

The findings confirm that the adoption of CA cannot be understood solely as a technical change, but as a process involving sociocultural, economic and political dimensions. The recognition of "rigor of work" as the main disadvantage (38.3%) reflects the need to consider the living and working conditions of producer families, as well as generational succession. Likewise, the lack of draft animals (16.1%) and appropriate tools points to the de-capitalization of the peasantry, a phenomenon that requires comprehensive responses combining technical assistance, financing and organizational strengthening.

This systematization has limitations that must be considered. The quantitative data come from a survey conducted in 2024, so it would be necessary to update them to assess the evolution of the situation in the last decade. Furthermore, the analysis did not include variables such as crop yields, family income or biophysical indicators of soil quality, which would allow a more robust evaluation of the impact of CA. Future research should be oriented towards: (a) conducting longitudinal studies measuring changes in adoption and their effects on food security; (b) deepening the analysis of water management strategies at the plot scale, considering the diversity of crops present (vegetables, fruit trees, coffee); (c) comparatively exploring other university extension experiences in the Caribbean region to identify common patterns and good practices.

Based on the lessons learned, the following recommendations are derived:

- Consolidate interdisciplinary teams and strengthen links with producers beyond specific projects, incorporating systematization as an institutionalized practice. It is necessary to move towards a critical extension that not only transfers knowledge, but also influences the generation of public policies that address the identified structural obstacles.
- Design specific programs that address the water crisis in family farming areas, through investments in water harvesting systems, plot irrigation and source recovery. Likewise, strengthen community seed banks and promote local production of organic fertilizers as part of an input sovereignty strategy.
- Enhance spaces for knowledge and experience exchange, recognizing local knowledge as the basis for innovation. The formation of family plot networks can facilitate collective learning and collaborative resolution of common problems.

In summary, the experience of the Universidad de Oriente confirms that Conservation Agriculture in Family Farming contexts is a viable and pertinent alternative, but its success critically depends on an integral approach that articulates technical-academic accompaniment with public policies that remove structural barriers. The university, acting as a facilitator of horizontal processes, can contribute significantly to the agroecological transition, as long as it

assumes its role with humility, capacity for listening and commitment to social transformation.

Author Contributions

D.R.V.L.: Conceptualization of the research, methodological design of the study, supervision of fieldwork, analysis and interpretation of quantitative and qualitative data, writing of the original draft, critical review of the manuscript, and approval of the final version. M.R.M.: Coordination of fieldwork, application of surveys and interviews, data processing, participation in the analysis of results, literature review, writing of methodological sections, and revision of the final manuscript. K.C.D.: Support in the application of surveys to producers, transcription of interviews, organization of validation workshops with participants, collaboration in the bibliographic review, and assistance in the preparation of tables and figures. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Not applicable.

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Conflicts of Interest

The authors declare no conflict of interest.

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