

# Proposal for Crop Diversification in Fruit Farms of Artemisa Province, Cuba

## *Propuesta para la diversificación de cultivos en fincas de frutales de la provincia Artemisa, Cuba*

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**ABSTRACT:** In accordance with the Cuban Fruit Program, one of the 24 programs prioritized by the Ministry of Agriculture, which projects a fruit yield of 1,054,000 tons by 2030, this research was conducted to propose crop diversification for fruit farms in Artemisa province. This diversification would facilitate the conversion and redesign of production systems. The municipalities of Artemisa, Caimito, and Alquizar were selected as study sites, coinciding with those included in the UNDP-coordinated project to strengthen local fruit value chains. The study encompassed 12 communities, each with six families, all beneficiaries of the Integrated Farms Program. A comprehensive diagnostic assessment of the fruit agroecosystems in the study area was carried out. The primary crop studied was guava. Statistical analysis consisted of determining measures of central tendency and ratios for descriptive statistics. The level of family participation was assessed using the Likert scale. This allowed for the socio-productive characterization of the studied sites. A methodology was established for participatory and collectively constructed implementation, focusing on capacity building for local stakeholders, with a gender analysis. A diversification proposal was developed using fruit and vegetable species through intercropping and crop associations. Although 83% of producers purchase inputs, water use was optimized, with an average fruit production for family consumption of 89.2% across all the farms studied.

**Keywords:** Agroecology, Spatiotemporal arrangements, Phytotechnics for fruit trees, Guava, Food safety.

**RESUMEN:** En correspondencia con lo planificado en el Programa de Frutales en Cuba, uno de los 24 que prioriza el Ministerio de la Agricultura y cuya proyección para el año 2030 prevé alcanzar 1 054 000 toneladas de fruta, se desarrolla esta investigación, con el objetivo de realizar una propuesta de diversificación de cultivos en fincas de frutales en la provincia Artemisa, que permita la conversión y el rediseño de los sistemas de producción. Para ello se utilizó como sitios de estudio los municipios de Artemisa, Caimito y Alquizar, por coincidir con los que forman parte del proyecto de apoyo al fortalecimiento de cadenas de frutales a nivel local, coordinado por el PNUD. Para el estudio se consideraron 12 comunidades con seis familias en cada una, beneficiarias con el Programa de Fincas Integrales. Se realizó un diagnóstico de los agroecosistemas de frutales en la zona de estudio con un enfoque integral. El cultivo principal estudiado fue la guayaba. El procesamiento estadístico consistió en la determinación de los estadígrafos de tendencia central y de razón de la estadística descriptiva. Se evaluó el nivel de participación de la familia, por medio de la escala de Likert. Con ello se obtuvo la caracterización socioprodutiva de los sitios estudiados. Se logró establecer una metodología para la aplicación participativa y de construcción colectiva en función de la formación de capacidades de actores locales, con análisis de género. Se realizó una propuesta de diversificación con especies de frutales y hortalizas a partir del intercalamiento y asociaciones de cultivos. Aunque el 83% de los productores compra insumos, se logró la optimización del uso del agua; con un promedio de producción de frutas para consumo familiar de 89,2% del total de las fincas estudiadas.

**Palabras clave:** Agroecología, Arreglos espaciotemporales, Fitotecnica para frutales, Guayaba, Seguridad alimentaria.

Received: 01/12/2025

Accepted: 06/04/2026

**Conflict of interest:** The authors declare that there are no conflicts of interest.

**Author Contributions:** Conceptualization, Data curation, Investigation, Methodology, Supervisión, Validation, Writing-original draft, Writing-revision & editing: Ambar Rosa Guzmán Morales. Investigation, Methodology, Writing-revision & editing: Deborah González Viera. Investigation, Methodology, Writing-original draft: Orestes Cruz La Paz.

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## INTRODUCTION

The country has implemented various initiatives to promote the development of fruit trees, including the Urban, Suburban and Family Agriculture Movement, the Integrated Fruit Farms Program and the Fruit Cooperatives Movement, which includes 353 integrated cooperatives, the latter being responsible for boosting production in the cooperative sector (Minag-Cuba, 2020).

All of this aligns with the plan outlined in the Fruit Program, one of the 24 programs currently prioritized by the Ministry of Agriculture (MINAG), which projects a production of 1,054,000 tons of fruit by 2030. To achieve these results, investments have been made in acquiring the necessary technologies to increase production volumes in this sector, supporting local food production, specifically for guava, mango, and papaya crops. The program focuses on developing new approaches to agricultural development and resource management that foster social organization and local participation, addressing the needs and potential of farmers to increase production while simultaneously conserving and regenerating natural (Fortín & González, 2022).

In this context of rural development, decisions about the application of a new technology are driven by interventions in the form of projects, and their results depend on the interaction of the various social actors involved (Terry et al., 2023).

In this regard, the diversification proposal has served as the basis for both the design and implementation of a development strategy and action plans in three selected municipalities in the province of Artemisa. These plans contribute to the projections outlined by the Ministry of Agriculture's Fruit Program, the Agricultural Business Group's (GAG) Fruit Development Strategy, and the national Fruit Cooperative Movement. All of these organizations formulate, manage, and implement agricultural and social development projects at the national level, guided by the objectives of sustainability and social equity in agricultural development.

Among the main components of this project is the Integrated Farms Program, which aims to achieve maximum crop diversification and livestock integration on small producers' land to guarantee food security, generate surpluses for the market, and improve productivity in the medium and long term; this also considers the rational management of natural resources (IIFT-Cuba, 2020).

In this sense, the diversification of agricultural areas responds to the need to produce food as close as possible to population settlements and to make the most of existing land (Guerra et al., 2021).

Therefore, diversification in areas previously dedicated solely to fruit production, as a new sector within the agricultural production system, implements one of the alternatives for family development. This allows for the incorporation of species with high nutritional and commercial value, as well as local varieties or breeds that contribute to the region's biodiversity, with a vision of

sustainability from an economic, social, and environmental perspective in the medium and long term.

Municipal initiatives to promote development are even more necessary at this time, considering the current process of economic reorientation towards a service-based economy and the export of high value-added products. This impacts the opening of new spaces and challenges for territorial planning (Pérez, 2011).

Such is the case of Artemisa, a province privileged in fruit production, with three municipalities-Alquízar, Artemisa, and Caimito-considered pioneers in this type of cultivation, where guava stands out. In Cuba, this crop represents 10% of the total cultivated area, and its production has increased from 71,600 t in 2016 to 160,700 t in 2023, representing a 124% growth.

Therefore, it would be beneficial for the country's current fruit strategy to consider not only increasing the production of traditional fruits with the highest demand, but also diversifying and producing so-called "less common fruits" and including possible alternative crops to take advantage of the potential of agricultural areas dedicated to these crops; for example, incorporating vegetables, spices, or medicinal and ornamental plants into these traditional fruit orchard systems.

Therefore, the objective of this research was to: Develop a proposal for crop diversification in fruit farms in the Artemisa province, enabling the conversion and redesign of production systems.

## MATERIALS AND METHODS

The research was conducted in the province of Artemisa. The municipalities of Artemisa, Caimito, and Alquizar were selected as study sites, coinciding with those included in the UNDP-coordinated project supporting the strengthening of local fruit value chains. The study encompassed 12 communities, each with six families benefiting from the Integrated Farms Program. A comprehensive assessment of the fruit agroecosystems in the study area was carried out. The primary crop studied was guava. Statistical analysis consisted of determining measures of central tendency and ratios for descriptive statistics. Family participation levels were evaluated using a Likert scale. This allowed for the development of a socio-productive characterization of the study sites.

The criteria used for the selection of producers who were part of the sample were taken according to the recommendations of Sagastume et al. (2006); Obando y Castellón (2006):

- Beneficiary of the Integrated Farms Program
- More than three years of experience in the design and implementation of their farm plan
- Willing to collaborate in the research process

### Methodological framework of the research

The methodological scheme of the research was adjusted to the objectives of this study and conceived three main stages that are shown in Figure 1.

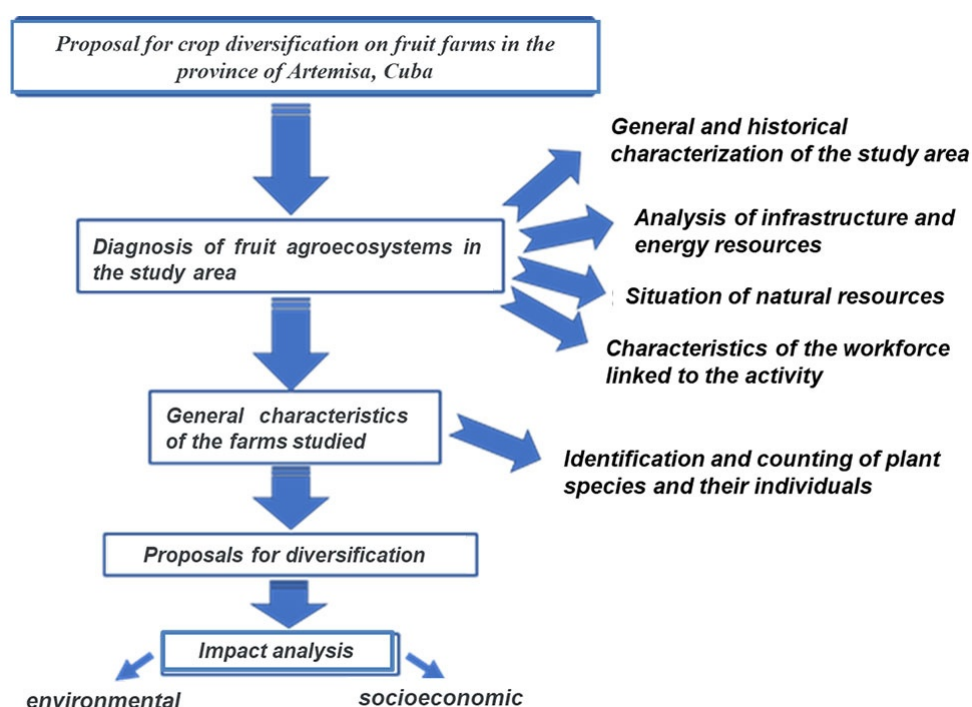


Figure 1. Methodological scheme for the research.

The observation and physical counting of plant species and their individuals was carried out. For the characterization and identification of the plant species, the following books were consulted: Botanical Dictionary of Roig (1969) and Tropical Fruit Growing by Peña *et al.* (1996).

A survey was conducted of all the agroecological practices carried out by the farmer, consulting the evaluation system for declaring agroecological farms implemented by the National Association of Small Farmers (ANAP- Cuba, 2003).

Once the species and production levels were identified, diversity was determined according to proposal Heredia (2002), based on the indicators Number of species/PIF, Total number of fruit trees per species and percentage of crops integrated into the fruit system.

A proposal was made on how to establish an alternative spatiotemporal arrangement between several crops, following the proposals made by Leon & Ravelo, (2010); Guerra *et al.* (2021); Fortin & González (2022).

The socio-productive and environmental characterization of the producers was carried out using a radial graph, based on previously selected indicators.

## RESULTS AND DISCUSSION

The fruit selected as the main crop for this research is guava (*Psidium guajava* L.), which requires little cultivation and, despite having two significant production peaks (from July to October and from February to April), can yield a large harvest year-round with irrigation and pruning. This characteristic distinguishes it from other fruit trees, such as mango, which has a limited seasonality.

It is also a crop with the potential to increase women's employment; on the one hand, because it is attractive to them and, on the other hand, because the sexist beliefs and stereotypes that women and men have (regarding what is a job "that they can do") do not prevent the incorporation of women into the chain, or even encourage the inclusion of women in guava cultivation over other agri-food productions (Salcedo y Guzmán, 2014 y FAO, 2020).

Another incentive for its production is the increase in prices paid by the State to cooperatives. Previously, the price was between 1,100 CUP t<sup>-1</sup> and 1,540 CUP t<sup>-1</sup>; currently it is between 2,420 CUP t<sup>-1</sup> and 2,640 CUP t<sup>-1</sup> during the growing season, and 3,630 CUP t<sup>-1</sup> outside of it. All of this has contributed to greater motivation for its cultivation.

For this research, family participation is of great value for the development and sustainability of the production system. This aligns with the findings of David *et al.* (2020), who argue that food sovereignty can be guaranteed by making better use of natural resources, maintaining green spaces, and generating employment and income. Therefore, family involvement in the various tasks required for establishing and maintaining fruit trees is an integral part of the farm's agricultural activities, and all of this is fundamental for sound agricultural development. According to the study, 95% of the families surveyed participate in the tasks required by the Integrated Farm Program, although to varying degrees, as shown in Figure 2.

Table 1 shows the descriptive statistics for this variable in each municipality. As can be seen, the average age ranged from 48 to 58 years, with Alquizar having the lowest average age, at 12%, exceeding 60 years.

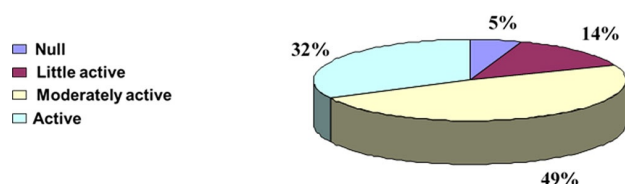


**Figure 2.** Levels of family participation in tasks in the Farm Plan.

**Table 1.** Descriptive statistics of the age variable by municipality.

| Municipalities | Average | Mode | Minimum | Máximo |
|----------------|---------|------|---------|--------|
| Artemisa       | 58      | 51   | 51      | 70     |
| Alquizar       | 48      | 40   | 37      | 69     |
| Caimito        | 54      | 50   | 35      | 72     |
| Total          | 53      | -    | -       | -      |

The opposite occurred in the other two municipalities, where the average age exceeding 60 years was between 16% for Artemisa and 17% for Caimito.

This last piece of information is very important because, according to [Salazar et al. \(2020\)](#), age helps define producers' expectations. For families where the head of household is over 50 years old, the project's maturity will

only occur when they reach 60 or older, thus jeopardizing the future of the investment. This information is crucial when defining investment levels, since if the community's population structure is that of a mature population, the technical proposals should be simpler and require a lower level of investment compared to a community where the majority of the population is young.

An agroecological principle that cannot be ignored when evaluating a new technology in a locality is understanding the potential impact of the research on the three dimensions of sustainability, as proposed by [Marasas et al. \(2014\)](#). Limitations for its implementation must also be considered ([González, 2020](#)). [Figure 3](#) illustrates this point.

It is highlighted that, for the implementation of the Comprehensive Farm Programs, there is no single package, since the components and techniques for each one are formulated with each beneficiary according to their social conditions, availability of natural resources and interests; as [Sarandon \(2021\)](#) states. Therefore, there are various agroecological practices on each farm. The results of the identification of the main agricultural practices are shown in [Table 2](#).

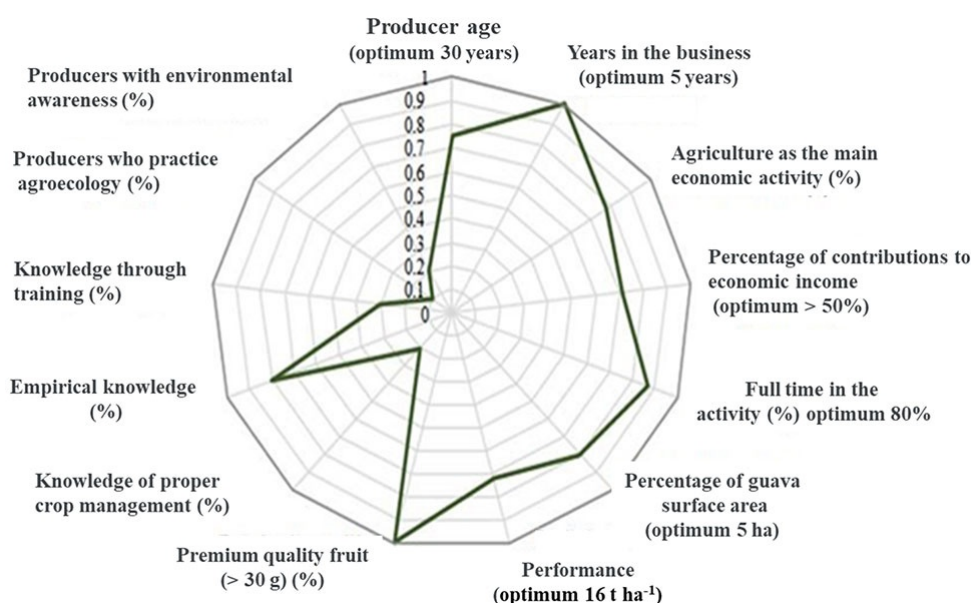


**Figure 3.** Socio-productive and environmental characterization of the guava producers surveyed at the provincial level.

**Table 2.** Main agroecological practices identified

| No. | Practice                            | No. Farms | %     |
|-----|-------------------------------------|-----------|-------|
| 1   | Does not burn                       | 17        | 100   |
| 2   | Stubble management                  | 17        | 100   |
| 3   | Living barriers                     | 14        | 82.3  |
| 4   | Mechanical control                  | 6         | 35.2  |
| 5   | Compost, Chicken Manure             | 15        | 88.2  |
| 6   | Other type of organic fertilizer    | 9         | 52.9  |
| 7   | Chemical fertilization              | 6         | 35.2  |
| 8   | Pest management by chemical methods | 8         | 47.05 |

**Table 3.** Number of fruit species and individuals by species, incorporated from the diversification proposal

| Crop type                 | No. of species delivered | Common name   | Scientific name              | Total individuals per species |
|---------------------------|--------------------------|---------------|------------------------------|-------------------------------|
| Permanentes               | 1                        | Mango         | <i>Mangifera indica</i>      | 336                           |
|                           | 2                        | Lemon         | <i>Citrus aurantifolia</i>   | 348                           |
|                           | 3                        | Orange        | <i>Citrus sinensis</i>       | 283                           |
|                           | 4                        | Tangerine     | <i>Citrus sp</i>             | 75                            |
|                           | 5                        | Mamey         | <i>Mammea americana</i>      | 6                             |
|                           | 6                        | Avocado       | <i>Persea americana</i>      | 86                            |
|                           | 7                        | Coconut       | <i>Cocos nucifera</i>        | 68                            |
| Semipermanentes y anuales | 1                        | Noni          | <i>Morinda citrifolia</i> L. | 60                            |
|                           | 2                        | Banana        | <i>Musa sapientum</i>        | 51                            |
|                           | 3                        | Fruitbomb     | <i>Carica papaya</i>         | 48                            |
|                           | 4                        | Pineapple     | <i>Ananas comosus</i>        | 115                           |
|                           | 5                        | Passion fruit | <i>Passiflora edulis</i> F.  | 7                             |

The progress is evident when compared to traditional production systems, generally without any soil and water protection measures, which coincides with what is proposed by Peña *et al.* (1996), Sarandón (2021).

#### Identification and counting of plant species and their individuals

In addition to the advantages in terms of food security and the income they generate in the medium and long term, diversification with fruit and vegetable species, grains, condiments and even ornamental plants becomes an alternative that favors environmental improvement as proposed by Ortega & Ordoñez (2020); Ochoa *et al.* (2022), in which an increase in coverage can be directly observed in the area of the region under study, animal species that provide energy in the form of biodegradable elements that favor agri-food production can also be included.

For the incorporation of fruit trees in the surfaces available to producers, seven different species of permanent fruit trees were available, which were assigned to producers according to their interests and soil potential, as recommended by IIFT-Cuba (2020), these species are detailed in Table 3. Also, the total number of plants per species currently established in the total of Comprehensive Farm Programs studied, as well as the number of farms that have them and the percentage of participation by species, are shown. with respect to the total analyzed.

In addition to the permanent fruit species, five species of semi-permanent fruits were included, such as noni (*Morinda citrifolia* L), banana (*Musa sapientum*), fruit bomb (*Carica papaya*), pineapple (*Ananas comosus*) and passion fruit (*Passiflora edulis* F.). The integration of this type of fruit in the Integrated Farms Program was important, since they contributed, in the short term, to the family diet and the economy with the sale of surpluses while the permanent fruit trees were established and began to produce.

The results of the identification and counting revealed that the total number of fruit species delivered amounted

to 55, with an average of 44 individuals for each farm. Furthermore, on average, nine species were delivered in each PIF. However, eight were established, that is, 87% of the species delivered.

The decisions about the number of trees, type and arrangement of perennial species depended mainly on the characteristics of the soil and the farmers themselves because they are the ones who know their needs, design the management of their plot and establish their priorities, as recommended by the IIFT-Cuba (2020). Fruit species with a high value for trade and local varieties were planted to preserve the biological diversity of the region, selected for their positive impact on the environment and because their production generates more opportunities in the productive chain, as proposed by the IIFT-Cuba (2023).

From an environmental point of view, a priority problem to be solved in communities is soil erosion and its different deterioration effects associated with soil and water conservation. In this sense, fruit trees play a primary role in erosion control since they provide vegetation cover to the soil, provide barriers against wind erosion, among other functions. They also improve the soil since they increase its fertility by supplying and maintaining organic matter; They also modify and reduce high temperatures, provide greater diversity and environment for fauna, etc.; Such benefits coincide with the approaches of Ortega & Ordoñez (2020); Ochoa *et al.* (2022).

With this proposal (more food in less space) the aim is to increase the yields obtained by farmers, in addition, it will be possible to reduce water and energy consumption by dispensing with chemical fertilizers, pesticides and herbicides. Studies carried out in Cuba by Reyes (2021); show that the greater agrodiversity, in terms of crops, livestock and tree species, as part of integrated and multifunctional agricultural systems, agroecological systems that achieve high levels of integration and recycling livestock agriculture, achieve greater productivity and efficiency.

Therefore, the incorporation of vegetables in cultivation associations described below is also proposed:

#### Beneficial Combinations

1. Basil and Pepper: Basil can help repel pests that affect peppers.
2. Coriander and Cucumber: Coriander attracts beneficial insects that can control cucumber pests.
3. Lettuce and Carrot: Lettuce grows quickly and does not aggressively compete with carrots for nutrients.
4. Spinach and Beet: Both can be grown together without competing for space.
5. Mint and Parsley: Mint can help repel certain pests that affect parsley.
6. Radish and Mustard: Radishes can help alert you to the presence of certain pests.

#### Sowing calendar proposals:

- January month: Mint (can be similar in warmer months).
- February-March month: Basil, Coriander, Cucumber, Lettuce, Radish.
- May-June-July month: Lettuce, carrot, cucumber, radish Carrot, radish, lettuce
- October-November month: Pepper, Spinach, Beet, Carrot, Parsley, Mustard.

The components that currently characterize the Comprehensive Farm Programs show that the new agroecological proposal to be introduced on the farms are diversified fruit trees and vegetables, with the objective of implementing alternatives that make it possible to increase and vary food production and that in the medium and long term the opportunities of the national market can be taken advantage of, generate new sources of work and income and improve the standard of living of the population; which agrees with Iermano *et al.* (2020) and Molpeceres (2022).

As for the delivery of birds, this was oriented toward the women of the household and mainly with regard to the use of chicken manure to fertilize the trees. However, by obtaining these birds, it is proposed to obtain eggs and meat for the diet within the home and some additional income will be generated as a result of their sale.

As a consequence of the proposal, the change in attitude of the producers is a success factor in the Integrated Farm Programs, since without it changes from traditional practices to others that are in harmony with the environment would not have been achieved; This is related to what was expressed by Ortega & Ordoñez (2020); Pastorino (2020); Puig (2020), who affirm that the promotion of technological change implies a cultural change regarding the daily behavior of producers. Furthermore, it is important to highlight that the technology transfer methodology is fundamental in the process of cultural change so that there is a guarantee that farmers will not return to the practices that characterize subsistence agriculture (CFS-El Salvador, 1999).

## CONCLUSIONS

The diagnosis of the fruit agroecosystems in the study area was carried out with a comprehensive approach that allowed establishing a methodology for participatory application and collective construction based on the capacity building of local actors, with the corresponding gender analysis to identify the existence of gaps between women and men in productive scenarios. This favored the diversification proposal that included fruit and vegetable species incorporated through the establishment of alternatives with spatio-temporal arrangements and animal species that offered profitable and food security options to adapt the use of the land to its productive capacity, which ensures economic efficiency for the farm, and reduces the risks of environmental deterioration.

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