InvestiGO Revista Científica Multidisciplinaria

ISSN 2953-6367
http://revistainvestigo.com

Julio - diciembre 2026
Vol. 7 No. 20, PP. 76-85
https://doi.org/10.56519/jeg3nm02

BIOHUERTOS COMUNITARIOS Y ECONOMÍA CIRCULAR COMO HERRAMIENTAS PEDAGÓGICAS PARA EDUCACIÓN AMBIENTAL Y PROMOCIÓN DE HÁBITOS SALUDABLES EN FAMILIAS RURALES MEDIANTE PARTICIPACIÓN COMUNITARIA ACTIVA SOSTENIBLE

COMMUNITY ORGANIC GARDENS AND THE CIRCULAR ECONOMY AS EDUCATIONAL TOOLS FOR ENVIRONMENTAL EDUCATION AND THE PROMOTION OF HEALTHY HABITS AMONG RURAL FAMILIES THROUGH ACTIVE, SUSTAINABLE COMMUNITY PARTICIPATION

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Fecha de recepción: 08/05/2026 / Fecha de aceptación: 16/06/2026 / Fecha de publicación: 08/07/2026

RESUMEN: La investigación reviste la problemática socioambiental que ocurre en el sector Huacho, parroquia Proaño, provincia Morona Santiago, donde el consumo de los alimentos que tienen trazas de agroquímicos, la dependencia económica externa y la mala gestión de los residuos sólidos afectan en el contexto de la salud y el medio ambiente. El objetivo general fue implementar biohuertos comunitarios como una estrategia sostenible que articule la conservación del medio ambiente y la economía circular durante el año 2025. La metodología fue la empleada fue de enfoque mixto (cualitativo-cuantitativo) con un diseño de tipo proyectivo-funcional, el estudio de campo y la investigación documental mediante encuestas estructuradas aplicadas en el censo poblacional de 95 familias. Los resultados diagnósticos muestran que, si bien el 55% conoce el concepto de biohuerto, hay una disposición del 88% para participar, así como un 97% que ve la iniciativa como una forma de desarrollo sostenible. Se implementaron 3 modelos técnicos escalonables (terrenos, patios, balcones) acordes a la realidad espacial del sector, logrando que el 92% de las familias clasifique los residuos para obtener bioinsumos como compost, biol y bocashi. Se concluyó que los biohuertos comunitarios refuerzan la resiliencia socioecológica de las familias rurales amazónicas,

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promueven la seguridad alimentaria, la reducción de la huella de carbono y la economía autónoma mediante la producción agroecológica y el aprovechamiento de recursos locales bajo los principios de economía circular.

Palabras clave: Huertos comunitarios, economía circular, agroecología, seguridad alimentaria, desarrollo sostenible

ABSTRACT: This study examines the socio-environmental issues occurring in the Huacho sector, Proaño parish, Morona Santiago province, where the consumption of food containing traces of agrochemicals, external economic dependence, and poor solid waste management have adverse effects on public health and the environment. The overall objective was to implement community organic gardens as a sustainable strategy that integrates environmental conservation and the circular economy by 2025. The methodology employed was a mixed-methods approach (qualitative-quantitative) with a projective-functional design, involving fieldwork and documentary research through structured surveys administered to a sample of 95 families. The diagnostic results show that while 55% are familiar with the concept of a bio-garden, 88% are willing to participate, and 97% view the initiative as a form of sustainable development. Three scalable technical models (plots of land, yards, balconies) were implemented in accordance with the spatial reality of the area, resulting in 92% of families sorting waste to obtain bio-inputs such as compost, biol, and bocashi. It was concluded that community bio-gardens strengthen the socio-ecological resilience of rural Amazonian families, promote food security, reduce the carbon footprint, and foster a self-sustaining economy through agroecological production and the use of local resources under the principles of the circular economy.

Keywords: Community gardens, circular economy, agroecology, food security, sustainable development

INTRODUCTION

Amid a global crisis characterized by the accelerated degradation of natural resources and increasing food insecurity, the current global agri-food system faces significant challenges. It is estimated that the intensive use of agrochemicals and the expansion of monoculture farming have degraded approximately 33% of the world's soils, thereby compromising the ability of future generations to produce healthy food (1), (2). Within this context, the Food and Agriculture Organization of the United Nations (FAO) promotes agroecological models that not only ensure food sovereignty but also serve as effective strategies for climate change mitigation (3), (4).

In Latin America, and particularly within the Amazon region, the expansion of the agricultural frontier and dependence on external inputs have begun to alter local biological cycles. In Ecuador, although the Constitution of the Republic recognizes the right to Sumak Kawsay, or Good Living, many rural communities continue to face barriers to accessing diverse and contaminant-free food (5), (6). Solid waste management represents another determining factor in this problem, since the inadequate use of organic waste at its source overloads landfills and wastes nutrients that should be returned to the soil in accordance with the principles of the circular economy (7), (8).

Specifically, in the province of Morona Santiago, Proaño parish, the Huacho sector represents a multidimensional case study. Despite being a rural area, local families have adopted consumption patterns based on externally sourced products with high levels of chemical residues, increasing both the cost of the basic food basket and health risks within the community (9). The initial diagnosis revealed that 71% of household heads did not have stable employment, further increasing economic vulnerability. Moreover, although 92% of households reported separating waste, no technical methods were in place to transform these materials into bio-inputs, thereby interrupting the nutrient cycle required for sustainability (1), (10).

This study is justified by the need to implement community-based solutions that integrate environmental education with productive practices. Community organic gardens function as living educational laboratories where ancestral knowledge can be recovered while incorporating technical innovations such as composting and the production of biol (11). Furthermore, as conceived in this study, they contribute to reducing the household ecological footprint by decreasing dependence on externally supplied food, while simultaneously strengthening social cohesion through collective action and the exchange of agricultural surplus (12), (13).

Based on the foregoing, this research addresses the need to transform underutilized spaces into centers of sustainable production. Accordingly, the objective of the study was to implement community organic gardens as a sustainable alternative for environmental conservation and the circular economy in the Huacho sector, Proaño parish, Morona Santiago province, promoting social empowerment and healthy lifestyles through a model of active and resilient community participation (1).

MATERIALS AND METHODS

The research was based on a projective-functional design, which, although framed within a mixed-methods approach (qualitative and quantitative), not only enabled the analysis of socioeconomic variables but also facilitated an understanding of the community relationships and dynamics required to provide the conditions necessary for the long-term sustainability of the intervention.

The study was developed as a Technical Project aimed at solving real-world problems in the Huacho sector. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was applied exclusively during the literature review phase to ensure that the theoretical foundation of the community organic gardens was supported by high-impact, scientifically rigorous sources.

Table 1. Methodology.

Component	Description of the Procedure
Population and sample	A population census was conducted, including all 95 families residing in the Huacho sector, thereby eliminating sampling error.
Study setting	Amazonian ecosystem located in Proaño parish, characterized by highly acidic soils (pH 4.5) and high-rainfall climatic conditions.
Techniques and instruments	Structured survey: 22 validated items. Direct observation: Technical records documenting soil quality and solid waste characteristics.
Technical modeling	Design of three types of community organic gardens (Models A, B, and C) according to space availability (open land, small yards, or containers).
Statistical analysis	Data were processed using specialized statistical software through descriptive statistics (frequencies and percentages) and cross-tabulation of variables.

Operational Procedure

1. **Situational Diagnosis**

Baseline assessment

The baseline social and soil conditions of the 95 families residing in the Huacho sector were assessed. For the social component, a 22-item structured survey was administered. Scientific rigor was ensured through validation by the judgment of three experts, who evaluated the instrument for relevance and clarity, followed by a statistical reliability analysis that yielded a Cronbach's alpha coefficient of 0.84 after pilot testing.

For the environmental component, soil samples were collected using a zigzag sampling pattern at a depth of 20 cm. Chemical analysis revealed that the initial soil exhibited a sandy clay loam texture and critical acidity, with an average pH of 4.5. These conditions limit the availability of essential nutrients, particularly phosphorus and magnesium, while promoting the fixation of free aluminum. In addition, the soil contained a low level of organic matter (<2.5%) because of nutrient leaching caused by the high rainfall characteristic of the Amazon region. These findings provided technical justification for the urgent application of the bio-inputs developed in this study.

2. **Technical Planning**

The dimensions of the planting beds were calculated, and substrate compositions were determined based on the transformation of locally available organic waste through composting.

Mechanical and Organic Design

3. **Implementation and Organic Design**

Circular Economy

Training sessions were conducted, followed by the implementation of techniques for producing compost, biol, and bocashi, thereby closing the nutrient cycle without the use of chemical products.

4. Evaluation and Monitoring

Performance assessment

Monitoring focused on seed germination, vegetable growth, and the degree to which healthy dietary habits were adopted by participating families.

The methodology extended beyond the simple cultivation of vegetables by incorporating the principles of the circular economy as a cross-cutting component throughout the intervention. Through the application of the inductive method, the research progressed from the situational diagnosis—based on the assessment of household-generated waste—to the design of a nutrient recycling system that returned organic matter to the soil. This approach ensured that the community organic gardens would not depend on external inputs and would remain sustainable over time, even after the completion of the technical intervention.

RESULTS

The implementation phase demonstrated the transition from a linear economy (consumption–disposal) to a circular economy (production–reuse) in the Huacho sector.

The first set of findings, corresponding to the situational diagnosis and participatory potential (Table 2), established the social baseline. The most notable finding was the disparity between the high percentage of households that separated waste (92%) and the comparatively lower level of technical knowledge regarding community organic gardens (55%).

Table 2. Characterization of Solid Waste Management, Agroecological Knowledge, and Participatory Willingness Among Families in the Huacho Sector.

Variable of Analysis	Results (%)	Key Finding
Waste separation	92%	Existing social capital facilitates the adoption of bio-inputs.
Knowledge of community organic gardens	55%	Critical intervention point: agroecological literacy is required.
Economic vulnerability	71%	Unemployment acts as a motivating factor for food self-sufficiency.

As shown in Table 2, this statistical profile suggests that the Huacho sector possesses a well-established culture of waste separation, but not yet a productive culture for converting organic waste into valuable resources. The fact that 92% of households already separate organic and inorganic waste substantially reduced the project's learning curve. However, the technical knowledge gap, reflected in the 45% of respondents unfamiliar with community organic gardens, justified the development of a dedicated pedagogical manual. The economic relevance of the project is equally evident: with a 71% unemployment rate, community organic gardens became not merely a recreational activity but an effective strategy for economic resilience capable of reducing household food expenditures.

Adaptation of Technical Models and Utilization of Recycled Materials in Table 3 illustrates how environmental engineering solutions were successfully adapted to household conditions, ensuring that limited space did not become an obstacle to implementation.

Table 3. Technical Classification of Community Organic Garden Models According to Space Availability and Integration of Recycled Materials.

Community Organic Garden Model	**Predominant Material**	**Adoption**	**Space-Use Efficiency**
Model A (Extensive)	Local Guadua bamboo	31%	High: maximizes direct soil use for root crops.
Model B (Compact)	Reused wooden boxes	48%	Maximum: allows mobility and manual pest control.
Model C (Vertical)	Recycled PET bottles	21%	Optimal: ideal for cultivating medicinal plants indoors.

The predominance of Model B (48%), shown in Table 3, indicates that rural households preferred elevated and controlled cultivation systems. From a technical perspective, this represented a significant advantage under Amazonian environmental conditions, since raised wooden beds prevented root waterlogging caused by the region's abundant rainfall. Furthermore, the combined use of PET bottles and recycled wooden boxes (Models B and C) enabled 69% of the community organic gardens to be established without infrastructure costs, thereby fulfilling the principles of the circular economy through the reintegration of plastic and wood into the productive cycle.

Performance of Bio-inputs and Contribution to Food Security

The biological success of the project was largely attributable to the quality of the bio-inputs produced. Table 4 summarizes their maturation periods and their effects on plant biomass production.

Table 4. Agronomic Efficiency of Local Organic Bio-inputs and Their Effects on Plant Biomass Production and Soil pH Recovery in Amazonian Soils.

Bio-input	**Maturation Period**	**Increase in Biomass**	**Technical Application**

Bocashi	14 - 18 days	+22%	Rapid supply of microorganism activators.
Compost	60 - 90 days	+15%	Long-term improvement of soil structure.
Biol	30 days	+18%	Foliar nutrition and natural insect repellent.

As presented in Table 4, bocashi proved to be the most effective bio-input under the intervention conditions. Its relatively short maturation period (approximately 15 days) produced a rapid improvement in soil fertility, which played an important role in maintaining community motivation. The combined application of biol and organic fertilizers increased the vigor of vegetables and medicinal plants by approximately 20% compared with untreated crops. These findings demonstrate that the circular economy not only contributes to environmental cleanliness but also generates bio-inputs of high agronomic value that can effectively compete with synthetic chemical fertilizers while eliminating the toxic residues commonly associated with conventionally produced food consumed by rural families.

DISCUSSION

The community organic gardens implemented in the Huacho sector validated a model of socio-ecological resilience adapted to the characteristics of the Amazonian foothills. The analytical framework was established by contrasting the local findings with the international scientific literature. The results revealed a "willingness paradox": although 92% of the families already separated organic waste, nearly half lacked the technical skills required to transform it into food. This disconnect between practice and productivity has been documented in rural communities throughout Latin America, where social willingness is abundant while technology transfer remains the principal limiting factor (14). The pedagogical manual developed in this study proved to be an effective educational tool, demonstrating that the transition toward food security involves not only replacing agricultural inputs but also fostering a deeper learning process through which families recognize organic waste as valuable biological capital (15), (16).

One of the project's most significant technical achievements was the partial neutralization of soil acidity, increasing soil pH from 4.5 to 6.0. In Amazonian ecosystems, extreme soil acidity substantially limits the availability of essential nutrients such as phosphorus and magnesium (17). Technical literature indicates that fermented organic fertilizers, particularly bocashi, provide a competitive advantage over synthetic fertilizers under these climatic conditions because their high microbial content promotes the decomposition of organic matter under conditions of high humidity and temperature (18), (19). These findings are consistent with previous studies identifying agroecology as one of the most effective approaches for restoring soils degraded by conventional agricultural practices in tropical environments (20), (21).

From the perspective of the circular economy, the predominance of Model B (48%), based on recycled wooden boxes, highlights the importance of user-centered design. While government development projects frequently rely on costly infrastructure that is ultimately abandoned because of maintenance requirements (22), the appropriate technology model implemented in the Huacho sector ensures long-term sustainability (23). The use of recycled PET bottles and locally available wood eliminated infrastructure costs for participating families while simultaneously reducing the community carbon footprint by avoiding the transportation of external construction materials, thereby fulfilling the principles of the circular economy at the household level (24), (25).

The multidimensional impact of the project on health and gender was reflected in the distribution of cultivated species, with vegetables and medicinal plants each representing 32% of total production, thereby promoting greater household health autonomy. Furthermore, the increase in soil pH from 4.5 to 6.0 improved the chemical dynamics of Amazonian soils by enhancing the availability of essential macronutrients such as phosphorus, calcium, and magnesium, while reducing the solubility and toxicity of free aluminum and stimulating native microbial activity responsible for decomposing the organic matter contained in the bio-inputs. Previous research has likewise demonstrated that fermented organic fertilizers such as bocashi outperform synthetic fertilizers in tropical climates because of their rich microbial communities and their ability to accelerate decomposition under conditions of high humidity and temperature (18), (19).

Furthermore, the fact that 63% of the community organic gardens were managed by women reinforces the role of rural women as custodians of biodiversity and key contributors to household nutrition (26). Their active participation became the principal driver of the project's long-term sustainability, as the management of community organic gardens was naturally integrated into the household care economy. By assuming this responsibility, women not only ensured immediate access to healthy food but also facilitated the intergenerational transmission of healthy habits and agroecological practices to younger family members. Consequently, the productive space evolved into a resilient and permanent system capable of reducing economic vulnerability through continuous family self-management. These findings are consistent with global projections indicating that access to fresh, chemical-free food contributes to lower rates of chronic disease and improved community well-being (27), (28). Ultimately, the community organic gardens evolved beyond a physical cultivation space to become permanent spaces for community empowerment and environmental education (29).

CONCLUSIONS

The implementation of community organic gardens successfully transformed the region's economic vulnerability, where 71% of the population lacked stable employment, into an opportunity for household self-sufficiency. It was concluded that the small-scale diversified production of vegetables and medicinal plants reduced dependence on markets supplying products with high agrochemical content, generated significant savings in household food expenditures, and ensured access to healthy, locally produced food within a rural Amazonian territory.

The study demonstrated that the nutrient cycle can be effectively closed at the household level through the utilization of the 92% of organic waste that the community had already begun to separate. The transformation of organic waste into bio-inputs, particularly bocashi, proved to be the most effective technique for neutralizing the natural acidity of local soils, increasing soil pH from 4.5 to 6.0. These findings confirm that the circular economy constitutes a cost-effective environmental restoration strategy with high agronomic performance.

The long-term sustainability of the project depends on the adaptability of the three technical models (A, B, and C) and the use of recycled materials, such as PET bottles and wood, which eliminate the economic barriers associated with the initial investment. Likewise, the prominent participation of women (63%) and the technical competencies developed through the implementation of the pedagogical manual demonstrate that participatory environmental education is the key driving force ensuring the continuity of community organic gardens as living laboratories for learning and the promotion of healthy lifestyles.

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