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Hydroponic community garden: Alternative solution for food security on Barangay Sta. Rosa del Norte and San Cirilo, Pasacao, Camarines Sur

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Abstract

This study assessed the potential of hydroponic community gardens as an alternative approach to improving local food security in Barangay Sta. Rosa del Norte and Barangay San Cirilo, Pasacao, Camarines Sur. Using a descriptive-correlational research design with qualitative components, data were gathered from 570 households through surveys, interviews, and focus group discussions. The findings revealed limited utilization of existing community gardens, with only 42.5% of households participating, while overall food security levels ranged from moderate to low. Although awareness of hydroponics was moderate, its perceived benefits—including resource efficiency and suitability for limited space—were strongly recognized. Acceptability of a hydroponic community model was high, particularly when supported by training and barangay-level initiatives. Significant positive correlations were identified between garden participation and food security indicators. The study concludes that hydroponic community gardens represent a viable and socially acceptable strategy for enhancing food security. However, successful adoption requires integrated support through demonstration hubs, hands-on training, and context-specific implementation strategies, thereby contributing to sustainable agriculture and strengthening food system resilience.

Keywords: hydroponic gardening, community gardens, food security, sustainable agriculture, urban farming

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1. Introduction

Food security remains a paramount challenge, intensified by climate volatility, rapid urbanization, and resource degradation. In the Philippines, this is a daily reality: the 2023 National Nutrition Survey reveals 31.4% of households are food insecure, with 15.1%, 23.6%, and 5.6% of children under five underweight, stunted, and wasted, respectively (DOST–FNRI, 2024). Frequent typhoons disrupt soil-based agriculture, exposing conventional systems' fragility (YCP Solidiance, 2022). This demands resilient, localized production. This study posits that community-based hydroponic gardening enhances food security by transforming underutilized spaces into resilience and nutritional access engines. Hydroponics soilless cultivation in nutrient-rich water addresses these vulnerabilities by consuming 90% less water, enabling year-round production, and yielding higher outputs per square meter (Farmonaut, 2024). Eliminating soil dependency mitigates diseases and enables precise nutrient management. Modular, vertical designs maximize output within minimal footprints, converting urban spaces into productive zones and positioning hydroponics as a practical tool for local food sovereignty.

Philippine initiatives increasingly realize this potential. The DA launched its Urban Agriculture Hydro Hub in 2021, while UPLB and DOST–PCAARRD developed the SIGLA Modular Vertical Farm—a solar-powered, AI-monitored system for extreme weather (DOST–PCAARRD, 2024). Applications validate these benefits: an IoT-integrated Iloilo greenhouse yielded 250-gram lettuce versus 60 grams traditionally (IoT News Asia, 2024), and SLU's Project PEY-AS employs a *binnadang* model to foster social cohesion and shared access (SLU, 2024). Despite advancements, a critical gap persists. Literature prioritizes agronomic feasibility or large-scale projects, leaving community-scale hydroponics as a direct food security intervention underexplored. Household nutrition, participatory governance, knowledge transfer, and urban s.ustainability remain poorly documented.

This study addresses that gap by examining community-based hydroponic gardening as a targeted food security strategy. Moving beyond technical validation, it analyzes hydroponics as a socio-technical system, specifically aiming to: (1) assess how gardens enhance household availability and access to fresh vegetables; (2) evaluate collective management, participatory engagement, and skill development underpinning social sustainability; and (3) analyze alignment with urban resilience and sustainable development goals. Investigating these dimensions yields evidence-based insights and actionable recommendations for LGUs, organizers, and policymakers scaling participatory, climate-resilient food systems.

Objective of the Study - This study assessed how community gardens and hydroponic systems enhance food security in Barangay Sta. Rosa del Norte and San Cirilo, Pasacao, Camarines Sur, while identifying strategies to improve adoption and long-term impact. It evaluated garden utilization (plot allotment, crop variety, participation frequency) and analyzed food security across availability (production, market access, diversity), accessibility (affordability, physical access, distribution), and utilization (dietary diversity, meal frequency, post-harvest handling). The research determined residents' hydroponic awareness (structural traits, yield potential, benefits, implementation processes) and examined statistical correlations between garden utilization and household food security. Stakeholder acceptability was assessed through perceived benefits, challenges, and cultural relevance. Ultimately, it proposed evidence-based interventions addressing financial, technical, and resource barriers to strengthen hydroponic integration and scalability.

Significance of the Study - This study offers actionable insights for multiple stakeholders. Residents gain a sustainable food source that enhances household nutrition, environmental quality, social cohesion, and economic resilience. Barangay officials can leverage findings to craft evidence-based policies and participatory resource management programs. Students acquire practical knowledge in sustainable agriculture while developing civic

engagement and collaborative skills. Future researchers receive a robust empirical baseline and adaptable methodological framework applicable to community agriculture, food security interventions, and grassroots sustainability initiatives. Collectively, the study bridges localized agricultural practice with scalable food security strategies, empowering communities to transition from passive consumers to active producers.

Scope and Limitations of the Study - Focusing exclusively on Barangay Sta. Rosa del Norte (1,028 households) and San Cirilo (1,180 households), this study engaged 570 household representatives selected via Slovin's formula (5% margin of error), with one respondent per household. Data collection occurred from late September to early November 2025, targeting community gardening and hydroponic interventions while excluding broader agricultural programs. Acknowledged limitations include potential response bias from self-reported dietary data, a short implementation timeframe restricting long-term sustainability assessment, and varying technological literacy alongside cultural preferences for traditional farming that may influence adoption patterns. These constraints highlight the need for longitudinal, context-specific research to validate and scale hydroponic food security initiatives.

Theoretical Framework - Grounded in three interconnected theories, this framework links agricultural innovation, nutrition, and community development. The FAO Food Security Framework (FAO, 2016) operationalizes hydroponics across availability, access, utilization, and stability by ensuring local production and climate-resilient supply chains. The Hydroponic Farming and Technology Interaction Theory (Caputo et al., 2018) examines how technical literacy, resource access, and participatory engagement shape adoption, guiding targeted capacity-building. Sustainable Development Theory (WCED, 1987; Luukkanen et al., 2024) balances economic viability, social equity, and environmental stewardship through water-efficient, soil-independent cultivation. As illustrated in Figure 1, these frameworks form a reinforcing cycle: enhanced technical awareness boosts productivity, strengthening food security and ecological resilience. This multi-theoretical lens ensures interventions are empirically grounded, contextually responsive, and scalable.

2. Methodology

This section presents the research design, researching method, data gathering, procedure, and statistical treatment of data that the researchers used to conduct the study entitled*, Hydroponic Community Garden: Alternative Solution for Food Security on Barangay Sta. Rosa del Norte and San Cirilo, Pasacao, Camarines Sur.*

Research Design - This study employed a descriptive correlational design with a qualitative component to examine hydroponic community gardens and food security in Barangay Sta. Rosa del Norte and San Cirilo. The descriptive strand addressed Objectives 1–3 by profiling garden utilization, food security status, and hydroponic awareness, analyzed via frequencies, percentages, and weighted means (Fraenkel, Wallen, & Hyun, 2012). The correlational strand addressed Objective 4 by testing utilization–food security relationships using Pearson's product-moment correlation to identify associations without inferring causality (Cohen et al., 2018). The qualitative strand addressed Objectives 5–6 through open-ended surveys, semi-structured interviews, and focus-group discussions with officials and residents, capturing benefits, challenges, and implementation strategies. This integration provided contextual depth supporting statistical interpretation (Creswell & Plano Clark, 2018).

Research Method - Structured questionnaires distributed to randomly selected households in both barangays generated numerical data on garden utilization, plot-size allocation, crop diversity, participation frequency, food security dimensions, and hydroponic awareness (Bryman, 2016). Quantitative data were analyzed using descriptive statistics—frequencies, percentages, weighted means—to profile utilization, food-security status, and awareness levels (Fraenkel, Wallen, & Hyun, 2012). Pearson's product-moment correlation tested associations between garden-utilization variables and food security dimensions (Cohen, Cunningham, Aiken, & West, 2018). Qualitative data from semi-structured interviews captured perceptions of benefits, challenges, and cultural considerations (Creswell & Plano Clark, 2018). Interviews triangulated quantitative findings, cross-verifying responses and minimizing bias; comparing narratives with statistical patterns validated community realities.

Qualitative responses were transcribed, coded, and thematically analyzed to provide contextual depth (Creswell, 2014). Integrating quantitative measurement with qualitative insights through triangulation, the study presents a comprehensive, rigorously validated understanding of how community gardens and hydroponic systems contribute to food security in both barangays.

Ethical Considerations - The researcher strictly adhered to ethical standards to protect participants' rights, dignity, and privacy. Formal permissions were secured from the Municipal Agricultural Office and Barangay Chairpersons of Sta. Rosa del Norte and San Cirilo prior to data collection. Participation remained voluntary, with respondents fully informed of the study's purpose, procedures, and their right to withdraw without penalty. To ensure confidentiality, all personal identifiers were removed from the final dataset. Data were securely encoded, restricted to researchers and the thesis adviser, used exclusively for academic purposes, and permanently deleted upon completion. The study fully complied with CBSUA's Data Privacy Compliance Statement and the Data Privacy Act of 2012 (RA 10173), upholding purpose limitation, restricted access, and secure storage. Researchers ensured no physical, psychological, or social harm occurred, aligning all findings with community welfare and sustainable food security initiatives in Pasacao.

Population and Sampling Design - The target population consisted of all households in Barangay Sta. Rosa del Norte (1,028 households) and Barangay San Cirilo (1,180 households), totaling 2,208 households in Pasacao, Camarines Sur. These barangays were selected due to distinct socioeconomic profiles and existing community gardening initiatives, making them ideal contexts for examining hydroponic adoption as a food security intervention. Random sampling was employed to ensure every household had equal opportunity to participate, minimizing selection bias and enhancing representation for credible generalizations. Sample size determination followed standard procedures based on total household counts from local government records.

Data Gathering Procedure - Data were collected using a structured four-point Likert questionnaire (Joshi et al., 2015), assessing demographics and awareness across seven environmental themes. Following approvals from the Department of Agriculture, LGU Pasacao, Municipal Agricultural Office (MAO), and Barangay Councils, researchers coordinated with local officials for household lists and participant mobilization. Instruments were MAO-validated for clarity and reliability before personal distribution and retrieval. To capture deeper insights into cultural acceptance and implementation challenges, semi-structured interviews and focus-group discussions were conducted with household representatives and officials. All participants provided informed consent, with sessions audio-recorded upon permission. Quantitative responses were tallied, encoded, and statistically analyzed, while qualitative data were integrated to contextualize findings (Merriam & Tisdell, 2016).

Qualitative Data Coding and Temporal Anchoring Protocol - Qualitative data were gathered via semi-structured interviews and open-ended surveys between October 14 and November 5, 2025. Sessions were audio-recorded with consent, transcribed verbatim, and translated by bilingual researchers.

Participant Identification System - Survey respondents were anonymized sequentially (P01–P570). A purposive subsample of 24 key informants (officials, gardeners, store operators) received interview codes (INT-01 to INT-24). Each quotation includes an in-text citation specifying participant code, data type, and exact collection date (e.g., (INT-07, Semi-structured interview, October 22, 2025)), per APA 7th standards.

Thematic Coding Framework - Narratives underwent inductive-deductive hybrid coding. Initial open coding generated labels grouped into six thematic categories: Knowledge Gaps (KG), Time/Labor Constraints (TL), Spatial Limitations (SL), Resource & Financial Needs (RF), Institutional Leadership (IL), and Community Cooperation (CC). Quotations are tagged as [Theme]-[Subcode]-[ParticipantID] (e.g., TL-02-INT-14). A master codebook standardized definition; two researchers independently coded 25% of transcripts for inter-coder reliability, resolving discrepancies via consensus.

Statistical Treatment of Data - The study employed descriptive statistics including frequency, percentage, mean and weighted mean to summarize community garden utilization (plot size, crop diversity, frequency of

participation), food security indicators (availability, accessibility, utilization), and hydroponic awareness, addressing SOPs 1, 2, and 3. Weighted Mean Calculation assigned weights for plot size (Small=0.5, Medium=1.0, Large=1.5, Very Large=2.0), crop diversity (1-2 crops=0.5, 3 crops=1.0, 4+ crops=1.5), participation frequency (Daily=1.0, Weekly=0.67, Monthly=0.33, Sometimes=0.17). Pearson's Correlation Coefficient examined relationships between garden utilization variables and food security dimensions for SOP 4, with t-test determining significance using critical values ($t > 1.645$ at 90%, $t > 1.960$ at 95%, $t > 2.576$ at 99%) (Cohen, 1988; Field, 2018; Piaget-Rossel & Rousson, 2024). Qualitative thematic analysis of open-ended responses and semi-structured interviews addressed SOPs 5 and 6 (Al-Achi, 2019; Novak, 2020).

3. Results and Discussion

This section outlines the results and corresponding interpretations addressing the research questions, which focus on examining the impact of community gardening on food security in Barangay Sta. Rosa del Norte and San Cirilo, Pasacao, Camarines Sur. The findings are organized using tables and figures, accompanied by detailed analyses of the collected data. Additionally, the discussion provides deeper interpretation and integrates relevant literature to contextualize the study's results.

Community Garden Utilization - Data from Barangay Sta. Rosa del Norte (n = 280) and Barangay San Cirilo (n = 290) revealed consistently limited community garden utilization despite near-identical plot allocation rates of 42.5% (119 households) and 43% (125 households). Among plot holders, gardening intensity remains low: plot size weighted mean = 0.71 (predominantly small-scale), crop diversity = 0.62–0.63 (typically 1–2 crop types), and participation frequency = 0.43 (only one-fifth garden daily).

Table 1
Community Garden Utilization Across Barangays

Plot Allocation (%)	Sta. Rosa del Norte (n=280)	San Cirilo (n=290)	Total (n=570)
Yes	119 (42.5%)	125 (43.1%)	244 (42.8%)
No	161 (57.5%)	165 (56.9%)	326 (57.2%)
Total	280 (100%)	290 (100%)	570 (100%)

Table 1 established that 42.8% of households hold plots, with allocation parity across barangays despite demographic differences, suggesting structural—not individual—factors drive participation. The 57.2% without plots highlights an access gap aligned with the FAO Food Security Framework's Access pillar: physical allocation does not ensure productive use, as barriers like time poverty among women managing household and livelihood roles constrain effective engagement. This baseline positions hydroponics as a potential catalyst for intensifying utilization through flexible, gender-responsive design.

Table 2a
Distribution of Community Garden Plot Sizes by Barangay

Plot Category	Sta. Rosa del Norte Among Plot Holders (n=119)	% of Total (N=280)	San Cirilo Among Plot Holders (n=125)	% of Total (N=290)
Small (1-10m²)	102 (85.7 %)	36.40%	106 (84.8%)	36.60%
Medium (11-20m²)	15 (12.6%)	5.40%	16 (12.8%)	5.50%
Large (21-30m²)	2 (0.69%)	0.70%	3 (2.4%)	1.00%
Very Large (>30m²)	0 (0.0%)	0.0%	0 (0.0%)	0.00%
Weighted Mean*	0.71	--	0.71	--

Table 2a revealed remarkably consistent plot size distribution across both barangays: small plots (1–10 m²) dominated at 85.7% (Sta. Rosa del Norte) and 84.8% (San Cirilo), medium plots (11–20 m²) represented 12.6–12.8%, and large plots (>20 m²) were negligible. The identical weighted mean plot size index of 0.71 confirms minimal spatial investment regardless of demographic differences. This pattern constrains production capacity, limiting gardens to supplementary food sources, and suggests land allocation policies—not household preference—drive distribution. For hydroponic interventions, space-efficient vertical systems align precisely with the predominant 1–10 m² footprint, enabling productivity intensification without land expansion. The uniformity

across barangays indicates structural, not cultural, constraints, positioning hydroponics as a productivity multiplier compatible with existing land-use patterns.

Table 2b

Crop Diversity and Participation Frequency Among Plot Holders

Indicator	Sta. Rosa del Norte Among Plot Holders (n=119)	% of Total (N=280)	San Cirilo Among Plot Holders (n=125)	% of Total (N=290)
Crop Diversity				
1-2 crops	58 (48.7 %)	20.70%	106 (84.8%)	13.30%
3 crops	44 (37.0%)	15.70%	16 (12.8%)	14.50%
4+ crops	17 (1.43%)	6.10%	3 (2.4%)	9.30%
Weighted Mean*	0.62	--	0.71	--
Participation Frequency				
Daily	26 (21.8%)	9.30%	27 (21.6%)	9.30%
Weekly	36 (30.3%)	12.90%	45 (36.0%)	15.50%
Monthly	48 (40.3%)	17.10%	43 (34.4%)	14.80%
Sometimes	9 (7.6%)	3.20%	10 (8.0%)	3.40%
Weighted Mean*	0.4		0.43	

Table 2b documented gardening intensity: crop diversity weighted means (0.62 Sta. Rosa; 0.63 San Cirilo) indicate households typically cultivate 1–2 crops (14.3–21.6% grow ≥4), with participation frequency yielding identical weighted means of 0.43 (~22% daily; 40%+ monthly/ across less), confirming gardens function as "subsistence buffers" (Cabalda et al., 2020). Parity demographically distinct barangays—despite San Cirilo's younger age (35.6 years) and higher education (77%)—indicates structural constraints drive underutilization. Women constitute the majority (55%/54%) and serve as primary food managers, yet experience compounded time poverty managing dual roles (Medina, 2019; David & Albert, 2022), challenging FAO's Access pillar: physical plot access exists, but effective access remains constrained. Hydroponic interventions require contextualized support through simplified nutrient management and controlled-environment cultivation to align technical demands with users' temporal and cognitive resources (Caputo et al., 2018; WCED, 1987; Luukkanen et al., 2024).

Current Status of Food Security - Food security status in both Barangay Sta. Rosa del Norte and Barangay San Cirilo registered at low to moderate levels, with mean scores consistently falling below the 2.51 threshold for "Moderate Food Security" on a 4-point Likert scale. San Cirilo reported means of 2.27 (availability), 2.26 (accessibility), and 2.34 (utilization); Sta. Rosa del Norte recorded 2.23, 2.24, and 2.30, respectively. Aggregated regional averages stand at 2.25 (availability), 2.25 (accessibility), and 2.32 (utilization), confirming uniformly constrained food security. Only 26% of households in Sta. Rosa del Norte agree that "the community garden produces enough food for my household's needs" (M = 2.23), with San Cirilo showing only marginally higher agreement. Notably, utilization scores slightly exceeded availability and accessibility in both barangays, with San Cirilo demonstrating a marginally higher utilization score (2.34 versus 2.30).

Table 3

Food Security Status by Dimension and Barangay

Food Security Dimension	Sta. Rosa del Norte (Mean)	San Cirilo Among (Mean)	Combine Average (Mean)
Food Availability	2.3	2.34	2.32
Food Accessibility	2.24	2.26	2.25
Food Utilizatio	2.23	2.27	2.25

Analysis revealed three features: uniform low food security scores indicate systemic constraints; the utilization gap shows compensatory mechanisms despite limited access; San Cirilo's elevated utilization aligns with fishing-dependent households (n = 56), where protein access complements output. These patterns signal "hidden hunger," maintaining caloric intake while dietary diversity remains compromised (FNRI, 2023), mirroring national data showing over 60% of Filipino households faced food insecurity in 2020 (UN Philippines, 2022). Low-intensity gardens cannot bridge security gaps, leaving households vulnerable to market shocks (Tacio, 2021). Theoretical frameworks engage directly: FAO's (2016) pillars are validated by availability/accessibility deficits; hydroponics emerge as space-efficient, year-round interventions (Alviola et al., 2021); Sustainable Development Theory

(WCED, 1987; Luukkanen et al., 2024) highlights failures to harmonize dimensions; and Hydroponic Farming Theory (Caputo et al., 2018) explains underperformance without addressing knowledge/time constraints. Ultimately, data position hydroponics as a contextually adapted system transforming gardens into functional food security components.

Awareness on Hydroponic Community Gardening - Awareness of hydroponic community gardening among residents of Barangay Sta. Rosa del Norte and Barangay San Cirilo revealed a consistent profile across three thematic domains. For characteristics understanding, Sta. Rosa del Norte recorded a mean of 2.44 and San Cirilo 2.42, yielding a combined 2.43 confirming moderate foundational knowledge; understanding centered on recognizing hydroponics as soilless cultivation (mean 3.0–3.1), while awareness of technical components like nutrient-enriched water solutions remained comparatively lower (mean 2.8–2.9). Both communities expressed strong consensus regarding hydroponic benefits (Sta. Rosa 2.45; San Cirilo 2.43; combined 2.44), with strongest agreement on faster crop production (mean 3.0–3.1) and resource conservation of land and water (mean 2.9–3.0), and moderate agreement on safe, nutritious food yields (mean 2.8–2.9).

Table 4
Level of Awareness on Hydroponics by Dimension and Barangay

Awareness Domain	Sta. Rosa del Norte (Mean)	San Cirilo Among (Mean)	Interpretation
Characteristics	2.44	2.42	Moderate Awareness
Benefits	2.45	2.43	Strong Recognition
Application	3	3	High Willingness

Willingness to adopt peaked at a mean of 3.00, with strong support for learning (3.3–3.4) and small-space feasibility (3.2–3.3), yet setup self-efficacy remained low (2.2–2.3). Despite stark demographic contrasts—Sta. Rosa's older, time-constrained population versus San Cirilo's younger, fishing-dependent households—adoption readiness was identical, revealing critical disjunctions between conceptual familiarity and technical literacy. This pattern confirms that exposure precedes functional competence (David & Huang, 2020), while insufficient experiential learning perpetuates implementation gaps (Labios & David, 2022). Although the FAO (2016) framework validates these knowledge barriers, Hydroponic Farming Theory (Caputo et al., 2018) and Sustainable Development Theory (WCED, 1987; Luukkanen et al., 2024) clarify that practical capacity, not motivation, limits adoption. Minimal motivational barriers contrast sharp capability bottlenecks, particularly among time-constrained women, necessitating hands-on demonstrations, accessible starter kits, and flexible training protocols.

Correlation Between Community Garden Utilization and Food Security - Pearson correlation analysis examined relationships between community garden utilization variables (plot size allocation, crop diversity, and frequency of participation) and the three dimensions of food security (availability, accessibility, and utilization) across Barangay Sta. Rosa del Norte (n = 280) and Barangay San Cirilo (n = 290). Analysis revealed moderate positive relationships ranging from r = 0.43 to 0.54, all statistically significant at $p < 0.001$. The complete correlation matrix, including barangay-level comparisons and confidence intervals, is presented in Table 4, with Table 4a providing corresponding t-test results confirming statistical significance.

Table 4
Community Garden Utilization and Food Security: Barangay-Level Correlation Strengthen with Targeted Confidence Intervals

Relationship	Sta. Rosa del Norte	San Cirilo Among	Combined	Strength
PSA vs FAv	0.497	0.494	0.476	Moderate
PSA vs FAc	0.479 [0.39,	0.202	0.470	Moderate
PSA vs FUt	0.55]	[0.09, 0.31]	0.436	Moderate
CD vs FAv	0.463	0.463	0.522	Moderate
CD vs FAc	0.544	0.529	0.513	Moderate
CD vs FUt	0.524 [0.44,	0.221	0.487	Moderate
FP vs FAv	0.60]	[0.10, 0.33]	0.492	Moderate
FP vs FAc	0.499	0.487	0.479	Moderate
FP vs FUt	0.511	0.487	0.464	Moderate

Table 4 presented Pearson correlations linking garden utilization variables (plot size, crop diversity,

participation frequency) with food security dimensions (availability, accessibility, utilization). All relationships showed moderate positive correlations ($r = 0.43–0.54$, $p < 0.001$), confirming greater engagement associates with improved outcomes. Critically, accessibility correlations diverged: Sta. Rosa maintained moderate linkages ($r = 0.479, 0.524$), while San Cirilo registered weak correlations ($r = 0.202, 0.221$), revealing a "production-access paradox" where agricultural inputs alone cannot overcome location-specific barriers. Availability and utilization correlations remained consistent ($r \approx 0.46–0.53$). Crop diversity emerged as strongest predictor of availability (combined $r = 0.532$). Intervention design requires tailoring: household-level production for San Cirilo; market linkages for Sta. Rosa. Table 3 positioned hydroponics as contextually adaptable, addressing both universal constraints and location-specific barriers.

Table 4a

Community Garden Utilization and Food Security: Combined-Sample Statistical Significance Testing

Relationship	T-statistic	*p*-value	Significance
PSA vs FAv	12.903	< .001	Significant
PSA vs FAc	12.687	< .001	Significant
PSA vs FUt	11.546	< .001	Significant
CD vs FAv	14.868	< .001	Significant
CD vs FAc	14.255	< .001	Significant
CD vs FUt	13.293	< .001	Significant
FP vs FAv	13.458	< .001	Significant
FP vs FAc	12.931	< .001	Significant
FP vs FUt	12.566	< .001	Significant

Table 4a confirmed all garden utilization–food security correlations were statistically significant at $p < 0.001$ ($N = 570$), t-statistics 11.546–14.868. Crop diversity showed the strongest availability correlation (combined $r = 0.532$, $t = 14.868$; Sta. Rosa $r = 0.544$; San Cirilo $r = 0.529$), yet accessibility correlations diverged sharply (0.524 vs. 0.221), while utilization correlations remained consistent (combined $r = 0.487$). Plot size moderately correlated with availability (combined $r = 0.476$) and utilization (combined $r = 0.436$), but accessibility diverged—Sta. Rosa $r = 0.479$ versus San Cirilo $r = 0.202$. Participation frequency showed moderate correlations across dimensions ($r = 0.464–0.492$), with San Cirilo consistently lower for accessibility ($r = 0.471$ vs. 0.493). Analysis reveals utilization variables reliably predict availability and utilization outcomes, yet accessibility correlations fracture geographically. This "production-access paradox" in San Cirilo indicates agricultural inputs alone cannot overcome isolation and infrastructure deficits (Department of Agrarian Reform, 2023), whereas Sta. Rosa's inland location enables market linkages. These patterns provide an empirical foundation for contextually tailored, evidence-based intervention design.

Acceptability of Hydroponic Community Model - The acceptability assessment of hydroponic gardening across Barangay Sta. Rosa del Norte ($n = 280$) and Barangay San Cirilo ($n = 290$) revealed uniformly positive reception. On a 4-point Likert scale, the overall weighted mean reached 3.11, firmly within the "Acceptable" range (2.51–3.25), indicating residents viewed the soilless, space-efficient model favorably, with the concept resonating well with community aspirations for improved food security. Acceptability was measured across five dimensions: conceptual acceptance, willingness to adopt with training, willingness to encourage others, belief in successful implementation, and support for barangay-led initiatives. Table 5 presents the complete dimensional breakdown, including mean scores per dimension, agreement rates combining "Agree" and "Strongly Agree" responses, and corresponding interpretations based on the established scale.

Acceptability data reveals distinct barangay patterns: Sta. Rosa del Norte shows cautious optimism (mean 3.12; 72.5% "Agree"), while San Cirilo demonstrates early-adopter potential (24.48% "Strongly Agree"). Training-dependent adoption garnered the strongest support (91.8–92.1%), whereas peer advocacy lagged (81%), indicating conditional acceptance rooted in capacity needs, not resistance. Livelihood contexts explain this variation: sari-sari operators view hydroponics as a micro-enterprise complement, while fishing households see a dry-season buffer. All dimensions exceeded 3.07, confirming readiness for phased implementation. Three key inferences emerge: (1) capacity development supersedes awareness, as conceptual understanding (mean 2.43–2.45) outpaces setup self-efficacy (2.2–2.3); (2) gender-responsive design is critical for the 55% of female respondents

managing dual roles; and (3) demonstration hubs are essential for sustainable diffusion. Grounded in Hydroponic Farming and Sustainable Development Theories, these findings confirm hydroponics succeeds as a socio-technical system requiring integrated, community-driven support.

Table 5
Acceptability of Hydroponic Gardening Across Five Dimensions (Combined Barangays)

Dimension	Sta. Rosa del Norte (n= 280)	San Cirilo (n= 290)	Combined (N = 570	Interpretation	Agreement Rate (%) ("Agree" + "Strongly Agree")
The hydroponic community model is acceptable to me as a gardening method	3.13	3.11	3.12	Acceptable	87.4%
I am willing to adopt hydroponics if training is provided	3.15	3.17	3.16	Acceptable	91.9%
I would encourage other households in the barangay to use hydroponics	3.06	3.08	3.07	Acceptable	81.1%
I believe hydroponics can be successfully implemented in our barangay	3.11	3.09	3.1	Acceptable	86.5%
I am willing to support barangay initiatives on hydroponics	3.18	3.16	3.17	Acceptable	89.1%
Overall Mean	3.12	3.1	3.11	Acceptable	87.2%

Suggested Interventions for Hydroponics Adoption - The survey among households in Sta. Rosa del Norte (n = 280) and San Cirilo (n = 290) reveals that hydroponic adoption is influenced by interconnected socio-economic, technical, and spatial challenges, yet residents remain open to adoption when appropriate support is provided. These findings indicate that targeted capacity-building, resource access, and contextualized design are critical to overcoming adoption barriers. The results align with national development priorities in the Philippine Development Plan 2023–2028 (National Economic and Development Authority, 2023), supporting evidence-based strategies for agricultural innovation adoption that prioritize community readiness, integrated support systems, and scalable, livelihood-sensitive interventions in resource-constrained rural settings.

Barriers to Hydroponic Adoption - The responses of participants regarding barriers to hydroponic adoption are summarized in Table 4. The table shows that knowledge and skills gaps (28.4%), time and labor constraints (26.2%), and spatial limitations (20.9%) were the most frequently reported challenges among respondents from both communities. These results indicate that the adoption of hydroponic systems is not limited by a single factor but rather by multiple interrelated constraints. Knowledge and technical skills emerged as the primary barrier, reported by 162 respondents (28.4%), with notable representation from both Sta. Rosa del Norte (n = 74) and San Cirilo (n = 88).

Table 6
Community-Identified Barriers to Hydroponic Adoption by Barangay

Challenge Category	Sta. Rosa del Norte	San Cirilo	Combined Total	% of Total
Time & Labor Constraints	146	3	149	26.2%
Knowledge & Skills Gap	74	88	162	28.4%
Resource Scarcity (Water, Materials, Seeds)	12	46	58	10.2%
Spatial Limitations	37	82	119	20.9%
Financial Barriers	—	9	9	1.6%
Cultural/Social Resistance	11	14	25	4.4%
Other / Unspecified	—	38	38	6.7%
Location / Accessibility	—	10	10	1.8%
Total	280	290	570	100%

Table 7
Community-Defined Support Needs for Hydroponic Adoption by Barangay

Challenge Category	Sta. Rosa del Norte	San Cirilo	Combined Total	% of Total
Training + Materials + Financial Aid	92	272	364	63.9%
Training + Materials	92	2	94	16.5%
Training + Financial Aid	28	2	30	5.3%
Training Only	54	4	58	10.2%
Materials Only	7	6	13	2.3%
Financial Aid Only	5	—	5	0.9%
Other Support	2	4	6	1.1%
Total	280	290	570	100%

Hydroponics requires specialized knowledge in nutrient preparation and system maintenance, appearing complex without formal training.

> *KG-01-INT-03: "May kakulangan kami sa kaalaman pagdating sa Hydroponics" ("We have a lack of knowledge when it comes to Hydroponics") (INT-03, Semi-structured interview, October 16, 2025)*

This supports the Hydroponic Farming and Technology Interaction Theory (Caputo et al., 2018), confirming that technical knowledge and resource access drive adoption. Targeted capacity-building is essential. Time constraints affected 149 respondents (26.2%), predominantly in Sta. Rosa del Norte (n=146), indicating competing livelihoods limit daily monitoring.

> *TL-01-INT-08: "Karamihan sa amin ay walang oras dahil may trabaho" ("Most of us don't have time because we have work") (INT-08, Semi-structured interview, October 19, 2025).*

Interventions must align with economic realities, as frequent maintenance deters time-constrained users (Caputo et al., 2018). Adoption hinges on lifestyle compatibility. Spatial limitations constrained 119 respondents (20.9%), primarily in San Cirilo (n=82), as installation requires physical space often scarce in dense areas.

> *SL-01-INT-12: "Walang espasyo na mapagtataniman" ("There is no space for planting") (INT-12, Semi-structured interview, October 23, 2025).*

This links to Sustainable Development Theory (WCED, 1987), emphasizing efficient resource use. Programs should explore vertical systems or community gardens to overcome spatial constraints. Collectively, these barriers underscore that adoption requires integrated support addressing knowledge gaps, time poverty, and spatial limitations.

Demand for Integrated Support System - Table 7 shows 364 respondents (63.9%) requested comprehensive support including training, materials, and financial assistance, particularly strong in San Cirilo (272) versus Sta. Rosa del Norte (92).

> *SN-01-INT-15: "Magkaroon sana ng patraining para turuan kami, kasama na yung materyales at tulong pinansyal" ("We hope there will be training to teach us, including materials and financial help") (INT-15, Semi-structured interview, October 27, 2025).*

Additional preferences: 94 respondents (16.5%) focused on training and materials; 58 respondents (10.2%) preferred training only.

> *SN-02-INT-17: "Mabigyan ng pa training pati materyales sa pag gawa" ("To be given training including materials for doing it") (INT-17, Semi-structured interview, October 31, 2025).*

> *TE-01-INT-19: "Bigyan lang ng pa training ang mga tao" ("Just give people training") (INT-19, Semi-structured interview, November 1, 2025).*

Residents recognize adoption requires interconnected knowledge, materials, and financial capacity. Aligning with FAO's Food Security Framework (2016), integrated support systems simultaneously address availability, access, utilization, and stability. Holistic strategies combining training, equipment, and financial assistance strengthen local food supply resilience.

Community Suggestions for Implementation - Table 6 indicates training and education programs were most frequently recommended (354 respondents, 62.1%), with equal representation from both barangays (177 each).

> *TE-02-INT-20: "Magbigay ng training at turuan ang mga tao sa pag-hydroponics" ("Provide training and teach people about Hydroponics") (INT-20, Semi-structured interview, November 2, 2025).*

Beyond training, 82 respondents (14.4%) emphasized institutional leadership, suggesting local government should guide implementation.

> *IL-01-INT-22: "Pangunahan ng muna LGU ang pag implement para sundan ng mga tao" "The LGU should lead the implementation so people will follow") (INT-22, Semi-structured interview, November 4, 2025).*

Additionally, 81 respondents (14.2%) highlighted collective action importance.

> *CC-01-INT-24: "Magkaroon ng partisipasyon at ko-operasyon mula sa komunidad" ("There should be Participation and Cooperation from the community") (INT-24, Semi-structured interview, November 5, 2025).*

Residents recognize knowledge development as critical. Structured training reduces setup uncertainty, building technical confidence. Aligning with Sustainable Development Theory (WCED, 1987), educational programs and demonstration projects must anchor implementation. Equipping residents with practical skills ensures active participation and resilient food security.

4. Summary, findings, conclusions and recommendations

Summary - This study assessed the potential of hydroponic community gardens as an alternative solution for food security in Barangay Sta. Rosa Del Norte and San Cirilo, Pasacao, Camarines Sur. Employing a descriptive–correlational research design with qualitative components, it examined community garden utilization patterns, household food security status, residents' awareness and acceptability of hydroponic systems, and the relationship between garden participation and food security outcomes using data from 570 household respondents collected through surveys, interviews, and focus group discussions. Results revealed that while traditional community gardens exist in both barangays, utilization remains limited in intensity and scale, resulting in moderate to low levels of food security. Despite this, residents demonstrated strong interest in hydroponic systems, reflected in high acceptability scores and willingness to adopt the technology when supported by training, materials, and financial assistance. Correlation analysis further showed statistically significant moderate positive relationships between community garden utilization variables and food security dimensions, confirming that enhanced garden engagement is associated with improved food security outcomes. Overall, findings indicate that hydroponic community gardens represent a viable and socially acceptable intervention to strengthen local food security when implemented through community-centered and capacity-building approaches that address identified adoption barriers.

Findings - Community garden utilization revealed constrained capacity: only 42.5% (Sta. Rosa del Norte) and 43% (San Cirilo) held allocated plots, with low-intensity use (plot size WM = 0.71; crop diversity WM = 0.62–0.63; participation frequency WM = 0.43; ~21.58% gardening daily). This subsistence-buffer pattern indicates land access alone cannot overcome structural barriers. Food security registered moderate-to-low across FAO dimensions (availability: 2.23–2.27; accessibility: 2.24–2.26; utilization: 2.30–2.34), with utilization exceeding

availability/accessibility—pointing to "hidden hunger"; only 26% in Sta. Rosa agreed gardens meet household needs. Pearson correlation confirmed significant moderate relationships between utilization and food security ($r = 0.43–0.54$, $p < 0.05$), crop diversity strongest for availability ($r = 0.532$). A "production-access paradox" emerged in San Cirilo: geographic isolation weakened input-accessibility correlations ($r = 0.202$). Hydroponics present a viable alternative: residents showed moderate awareness (WM = 2.42–2.44), strong benefit recognition (WM = 2.43–2.45), high willingness to adopt (WM = 3.00), yet a willingness-capacity gap persists (setup ability WM = 2.2–2.3). Acceptability yielded mean 3.122 ("Acceptable"), strongest support for barangay-led initiatives (3.168) and training-dependent adoption (3.158). Minimal resistance (1.4%) was offset by cautious peer advocacy (3.070). Support needs: 63.9% requested integrated packages; 89.8% required capacity-building. Successful implementation demands neighborhood hubs, nutrition education integration, pilot demonstrations, gender-responsive protocols, FAO-pillar monitoring, producer-to-vendor networks, and municipal resource prioritization to transform hydroponics into functional food security catalysts.

Conclusions - Community gardens function as supplementary sources due to structural barriers—time constraints, space limitations, knowledge gaps—rendering plot allocation insufficient. Households exhibit moderate-to-low food security across availability/accessibility, despite better utilization scores, revealing reliance on nutritionally limited strategies and vulnerability to market shocks. Statistically significant relationships confirm garden engagement enhances food security, with crop diversity exerting stronger influence on availability than plot size; however, a production-access paradox demonstrates yields alone cannot overcome geographic isolation. Hydroponics emerge as viable complementary strategy, yet adoption is constrained by a willingness-capacity gap: moderate awareness and strong benefit recognition contrast with low self-efficacy, confirming capacity—not motivation—is the primary barrier. Social acceptance is conditional, aligning with Sustainable Development Theory: residents endorse hydroponics as livelihood enhancement but require visible success cases before peer advocacy. Successful adoption demands integrated support alleviating capability, resource, and economic constraints simultaneously. Positioning hydroponics as livelihood-complementary and fostering collective implementation builds social capital alongside technical skills, directly aligning with FAO's four-pillar framework—enhancing availability, access, utilization, stability through systemic support. Policy must shift from one-time grants to sustained operational assistance treating cost, knowledge, and resource access as interdependent for sustainable adoption and long-term resilience.

Recommendations - Traditional community gardens in Barangay Sta. Rosa del Norte and San Cirilo remain constrained by low utilization intensity, yielding moderate-to-low food security across FAO dimensions. To bridge the willingness-capacity gap and scale hydroponics as reliable food sources, integrated recommendations include:

- Deploy modular, Bikol-language training with visual demonstrations, QR-linked tutorials, and troubleshooting clinics to prioritize hands-on skill development.
- Distribute vertical starter kits for spatially constrained households and establish neighborhood demonstration hubs to accelerate peer adoption through visible proof of concept.
- Integrate nutrition education with gardening activities and create producer-to-sari-sari exchange networks to enhance dietary diversity and market accessibility.
- Implement a simplified FAO four-pillar monitoring dashboard with quarterly adaptive reviews, supported by municipal task forces and dedicated budget allocations.
- Adopt barangay-specific strategies: household-level systems for isolated San Cirilo (addressing $r = 0.202$ production-access paradox) and market-linkage amplification for Sta. Rosa del Norte (leveraging $r = 0.479–0.524$ correlations).

Implications for academic institutions - for academic institutions, institutionalizing hydroponics requires shifting from fragmented projects to integrated, multi-sectoral partnerships. Schools must formalize community

collaborations to embed soilless agriculture into localized curricula, adaptive research, and service-learning. Academic expertise should drive gender-responsive training—flexible scheduling, mobile instruction, childcare support—addressing women's structural time poverty. By aligning institutional resources with community readiness, universities scale hydroponics into sustainable food sovereignty strategies. This ensures academic programming reflects documented realities of technical capability, resource access, and livelihood sensitivity, positioning schools as proactive architects of evidence-based, climate-resilient rural development in the Philippines.

Implications for students - For students, this study underscores a shift from academic observers to active co-creators of food security solutions. The willingness-capacity gap reveals that awareness alone cannot overcome practical barriers. Learning must transition from classroom theory to community-engaged practice, were students co-design household hydroponic units alongside residents. Service-learning curricula position students as technical facilitators, translating complex principles into accessible Bikol-language modules, QR tutorials, and monitoring dashboards. Leveraging digital literacy, students bridge research and household application. Through youth-driven advocacy and peer mentoring, they accelerate adoption by providing visible proof-of-concept, directly engaging San Cirilo's 24.5% strong advocate segment.

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