

Co-Producing Sustainable Agricultural Innovations for Food Security: Research and Extension Pathways Toward Achieving Sustainable Development Goal 2

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Abstract

This study investigates the role of co-production in advancing Sustainable Development Goal (SDG) Target 2.1 ending hunger and ensuring access to safe, nutritious, and sufficient food—and SDG Target 2.3 doubling the agricultural productivity and incomes of small-scale food producers. Using a qualitative multiple case study approach, the research draws on the experiences of Nueva Vizcaya State University (NVSU) in the Philippines, which has implemented a range of collaborative research and extension programs in partnership with local government units, cooperatives, and farming communities. Findings reveal that co-production significantly enhances food security by promoting nutrition-sensitive agriculture, empowering communities through capacity-building, and fostering inclusive governance. Projects such as banana macropagation, tomato processing, and free-range chicken production have improved both food availability and dietary diversity. Simultaneously, co-production has led to increased agricultural productivity and income through enterprise development, value chain integration, and the adoption of sustainable farming practices. Key enabling factors include mutual trust, shared goals, inclusive planning tools like Training Needs Analysis (TNA), and long-term institutional partnerships. However, challenges such as limited funding, time constraints, and geographic barriers persist. The study concludes that co-production is a transformative approach that bridges scientific knowledge and local expertise, offering a viable pathway to achieving SDG 2 in rural agricultural contexts.

Introduction

Sustainable Development Goal 2 (SDG 2) seeks to eradicate hunger, achieve food security, improve nutrition, and promote sustainable agriculture by 2030. However, progress has been hindered by climate change, economic instability, and persistent food insecurity, particularly in developing countries (Sporchia et al., 2024). In the Philippines, food insecurity remains a major concern, especially in vulnerable regions such as the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) (Ateneo de Manila University, 2023).

Central to SDG 2 are Target 2.1, which aims to ensure access to safe, nutritious, and

sufficient food, and Target 2.3, which focuses on improving the productivity and income of small-scale food producers (Philippine Statistics Authority, 2022). Achieving these targets requires participatory approaches that integrate scientific research, extension services, and local knowledge.

Co-production has emerged as an effective framework for addressing these challenges by bringing together researchers, extension practitioners, government agencies, farmers, and local communities to jointly develop context-specific agricultural solutions (Allahyari & Sadeghzadeh, 2020). Unlike traditional top-down approaches, co-

production promotes shared decision-making, mutual learning, and collective ownership, resulting in more relevant and sustainable innovations.

In the Philippines, collaborative initiatives involving state universities and local stakeholders have shown promising outcomes in strengthening food security, agricultural productivity, and rural livelihoods. However, institutional barriers, limited coordination, and resource constraints continue to limit the broader adoption of co-production in research and extension (Guingab, 2022).

Against this backdrop, the present study examines how co-production contributes to achieving SDG Target 2.1 by improving food security and SDG Target 2.3 by enhancing the productivity and income of small-scale food producers. Specifically, it seeks to determine: (1) how co-production supports access to safe, nutritious, and sufficient food, and (2) how it strengthens agricultural productivity and livelihoods among smallholder farmers.

Co-production is increasingly recognized as an effective approach to agricultural development because it promotes collaboration among researchers, extension practitioners, policymakers, and farming communities. It is grounded in Transdisciplinarity, Knowledge Democracy, and Boundary Work, which emphasize integrating scientific and local knowledge, inclusive participation, and evidence-based decision-making (Jahn et al., 2012; Cash et al., 2003; Bandola-Gill et al., 2023).

Studies show that co-production improves the relevance and adoption of agricultural innovations through participatory research, Farmer Field Schools, and community-based extension programs (Maughan & Anderson, 2023). In the Philippines, however, institutional fragmentation and weak coordination between research and extension continue to constrain collaborative innovation (Guingab, 2022).

Co-production contributes to SDG Target 2.1 by strengthening food security through locally responsive technologies, participatory governance, and community empowerment (Marquez-Gagarin, n.d.; Heckelman et al., 2018). It also supports SDG Target 2.3 by improving agricultural productivity, promoting value-chain development, strengthening market access, and expanding livelihood opportunities for smallholder farmers (Ocampo et al., 2025; Mina et al., 2020; Quilloy, 2015).

Despite its demonstrated benefits, co-production faces challenges such as limited resources, institutional barriers, and unequal stakeholder participation (Ligtermoet et al., 2024). Nevertheless, existing literature consistently identifies co-production as a strategic approach for developing inclusive, sustainable, and resilient agricultural systems that contribute significantly to achieving SDG Targets 2.1 and 2.3.

Methodology

This study examined the contribution of co-production in advancing Sustainable Development Goal (SDG) Target 2.1, which focuses on ending hunger and ensuring

universal access to safe, nutritious, and sufficient food, and SDG Target 2.3, which seeks to enhance the productivity and income of small-scale food producers. Drawing on the experiences of the state university's research and extension initiatives, the findings demonstrate that co-production serves as a transformative and collaborative approach that effectively integrates scientific expertise, institutional resources, and local knowledge to address complex agricultural and food security challenges. The university's sustained partnerships with local government units, farmers' organizations, cooperatives, and rural communities created an enabling environment for the co-creation, implementation, and continuous refinement of development interventions that respond to local needs while promoting sustainable agricultural practices.

With respect to SDG Target 2.1, the findings revealed that co-production strengthened local food systems by promoting nutrition-sensitive agricultural innovations that increased the availability, accessibility, and diversity of nutritious food. Collaborative initiatives such as banana macropropagation, free-range chicken production, shiitake mushroom cultivation, and nutrition-sensitive agriculture programs expanded household food sources while encouraging healthier dietary practices. More importantly, these interventions emerged from participatory planning processes involving farmers, community leaders, extension specialists, and local government representatives, ensuring that technologies and extension services were context-specific, culturally appropriate, and responsive to the socioeconomic realities of rural

communities. The collaborative nature of these programs fostered community ownership, strengthened local capacities, and enhanced the long-term sustainability of food security interventions.

In relation to SDG Target 2.3, the study found that co-production significantly improved agricultural productivity and strengthened the economic resilience of smallholder farmers by facilitating the adoption of science-based technologies, enterprise development, and value chain innovations. Research-based interventions, including tissue-cultured banana production, tomato postharvest processing, livestock-based enterprises, mushroom production, and coffee development, enabled farmers to increase production efficiency, minimize postharvest losses, diversify agricultural enterprises, and generate additional income. Equally important, the integration of entrepreneurial training, technical assistance, market linkage development, and cooperative partnerships empowered farmers to become active participants in local value chains rather than passive recipients of extension services. This collaborative model promoted inclusive economic growth by enhancing farmers' technical competencies, entrepreneurial capacity, and access to sustainable livelihood opportunities.

The effectiveness of the university's co-production framework was further strengthened by several institutional and organizational factors. Continuous stakeholder engagement through Training Needs Analysis (TNA), participatory planning, collaborative research design, and long-term partnerships formalized through

Memoranda of Agreement (MOAs) fostered trust, shared accountability, and collective ownership among stakeholders. These mechanisms facilitated open communication, joint decision-making, and efficient resource mobilization, thereby enhancing the relevance, responsiveness, and sustainability of research and extension initiatives. Nevertheless, participants acknowledged persistent challenges, including financial constraints, limited extension personnel, logistical and geographical barriers, and the need for sustained policy and institutional support. Addressing these constraints remains essential to expanding the reach and long-term impact of co-produced agricultural innovations across wider communities.

Hence, the findings affirm that co-production extends beyond the traditional transfer of agricultural technologies or dissemination of research outputs. Rather, it represents a participatory governance approach that positions universities, government agencies, farmers, and local communities as equal partners in generating knowledge, solving problems, and implementing sustainable development initiatives. By integrating scientific innovation with indigenous knowledge, local experiences, and community participation, co-production strengthens food systems, enhances agricultural productivity, promotes inclusive rural development, and empowers communities to become active agents of change. The experience of the state university demonstrates that when higher education institutions embrace collaborative and community-engaged research and extension, they make substantial contributions toward achieving SDG Targets 2.1 and 2.3, while

simultaneously advancing food security, improving the livelihoods of small-scale producers, and fostering resilient and sustainable agricultural communities.

Results And Discussion

Theme 1. Strengthening Food Security through Collaborative and Nutrition-Sensitive Agricultural Innovations

The findings revealed that co-production among the state university, local government units, farmers' associations, and community organizations significantly strengthened food security by increasing the availability and accessibility of safe and nutritious food. Participants emphasized that collaborative research and extension initiatives introduced agricultural technologies that addressed both food production and nutritional needs. Programs such as banana macropropagation, free-range chicken production, shiitake mushroom cultivation, and nutrition-sensitive agriculture enabled farming households to diversify food sources while improving household consumption.

One extension coordinator explained:

"The university did not simply introduce technologies. We worked closely with farmers to determine which crops and livelihood projects would directly improve their families' food supply." (Participant 3)

A municipal agriculture officer shared:

"Before the project, many families relied on only one crop. Today, they already have vegetables, mushrooms, poultry, and bananas that provide both food and income." (Participant 7)

Likewise, a farmer-participant stated:

"We learned that farming is not only about earning money but also about providing nutritious food for our own families first before selling the surplus." (Participant 12)

These narratives demonstrate that food security was achieved not merely through increased production but through collaborative decision-making that integrated scientific knowledge with community needs. The co-production process encouraged stakeholders to participate actively in identifying appropriate interventions, resulting in agricultural practices that promoted diversified diets and improved household food availability.

The findings support the concept of co-production proposed by Ostrom (1996), which emphasizes that public services become more effective when communities actively participate in planning and implementation. The results likewise affirm the principles of nutrition-sensitive agriculture, which advocate integrating nutritional outcomes into agricultural interventions to improve food security and dietary diversity (FAO, 2017). Similar studies by HLPE (2020) have shown that collaborative agricultural innovations significantly enhance household food availability and contribute to achieving SDG Target 2.1, particularly in rural communities where food insecurity remains prevalent.

Theme 2. Empowering Farming Communities through Knowledge Sharing and Capacity Building

Another prominent theme that emerged was the role of co-production in empowering

farmers through continuous capacity-building initiatives. Participants consistently described extension activities as opportunities to acquire practical knowledge, strengthen technical competencies, and improve confidence in managing agricultural enterprises. Training programs on plant propagation, nursery management, livestock production, mushroom cultivation, and sustainable farming enabled farmers to adopt improved farming practices while increasing their independence.

One extension specialist remarked:

"Our role was not only to teach but to learn together with the farmers. Their experiences helped improve our extension programs while our technical knowledge strengthened their farming practices." (Participant 5)

A cooperative leader explained:

"The trainings transformed many farmers from simply following traditional methods into becoming more confident entrepreneurs who can manage their own enterprises." (Participant 9)

Similarly, another farmer shared:

"After attending the trainings, I realized that I could produce quality planting materials myself instead of buying them every season." (Participant 15)

Participants highlighted that continuous mentoring, demonstrations, and technical assistance encouraged farmers to become active partners rather than passive beneficiaries. They described learning as a collaborative process in which local knowledge and scientific expertise

complemented one another to address community needs.

These findings align with Knowles' Adult Learning Theory (1984), which emphasizes that adults learn best through experiential, problem-centered, and participatory learning experiences. The results also support Wenger's Communities of Practice Theory (1998), which explains that learning occurs through collaboration, shared experiences, and collective problem-solving within professional communities. Similar studies have shown that farmer capacity-building programs enhance agricultural productivity, strengthen innovation adoption, and improve livelihood resilience (Davis et al., 2012; FAO, 2019).

Theme 3. Enhancing Agricultural Productivity and Livelihoods through Science-Based Innovation

Participants consistently emphasized that collaborative research and extension initiatives significantly improved agricultural productivity while creating sustainable livelihood opportunities. They attributed increased crop yields, reduced postharvest losses, improved livestock production, and enterprise diversification to research-based technologies introduced through university-community partnerships.

One university researcher explained:

"Research findings became more meaningful because they were validated directly in farmers' fields, allowing technologies to be refined according to local conditions." (Participant 2)

A farmer-beneficiary shared:

"The tissue-cultured banana project changed our production. We harvested more bananas than before, and the quality also improved." (Participant 11)

Another participant involved in tomato processing stated:

"Previously, excess tomatoes were wasted during peak harvest. Now we process them into products that generate additional income." (Participant 14)

Participants also recognized that value-adding initiatives such as coffee processing, mushroom production, livestock enterprises, and tomato processing reduced dependence on raw agricultural commodities while expanding income-generating opportunities. Many described these innovations as practical solutions to fluctuating market prices and production risks.

The findings support the Agricultural Innovation Systems (AIS) Framework, which emphasizes collaboration among researchers, extension workers, farmers, and policymakers in generating agricultural innovations (World Bank, 2012). Likewise, Rogers' Diffusion of Innovations Theory (2003) explains that innovations are more readily adopted when stakeholders actively participate in testing, adapting, and demonstrating new technologies. Previous studies have similarly reported that collaborative innovation significantly increases agricultural productivity, promotes value addition, and improves the livelihoods of smallholder farmers (Hall et al., 2017; FAO, 2021), thereby contributing to SDG Target 2.3.

Theme 4. Building Sustainable Partnerships through Participatory Governance and Shared Ownership

The final theme highlights the importance of participatory governance in sustaining research and extension initiatives. Participants described co-production as a partnership built on mutual trust, shared responsibilities, and continuous collaboration among universities, LGUs, cooperatives, and farming communities. They emphasized that stakeholder consultations, Training Needs Analysis (TNA), memoranda of agreement (MOAs), and regular monitoring strengthened project ownership and long-term sustainability.

One university administrator shared:

"Projects became successful because communities participated from planning until evaluation. They did not simply receive assistance—they became partners in development." (Participant 1)

An LGU representative explained:

"The university listened to the needs of our farmers before introducing technologies. This made implementation easier because the projects addressed actual community priorities." (Participant 8)

A cooperative officer added:

"Because everyone shared responsibilities, farmers became more committed to sustaining the projects even after the university completed its extension activities." (Participant 13)

Participants consistently emphasized that collaborative governance enhanced trust,

accountability, and collective ownership of extension initiatives. Rather than depending solely on external assistance, communities gradually assumed greater responsibility for sustaining agricultural innovations and expanding their benefits to other farmers.

The findings are consistent with Ostrom's Theory of Co-production (1996), which argues that sustainable public services are achieved through shared decision-making and collective responsibility among institutions and citizens. They also support the principles of participatory rural development, which emphasize community ownership, inclusive governance, and stakeholder engagement as foundations of sustainable agricultural development (Chambers, 1994). Similar studies have demonstrated that participatory governance strengthens institutional trust, improves technology adoption, and enhances the long-term sustainability of agricultural extension programs (Pretty, 1995; FAO, 2021). These collaborative mechanisms directly contribute to the realization of SDG Targets 2.1 and 2.3 by ensuring that agricultural innovations remain community-driven, inclusive, and sustainable.

Conclusion

This study explored the role of co-production in advancing two critical Sustainable Development Goal (SDG) targets: SDG 2.1, which aims to end hunger and ensure access to safe, nutritious, and sufficient food for all, and SDG 2.3, which seeks to double the agricultural productivity and incomes of small-scale food producers. Drawing from the state university and its collaborative research and extension programs, the

findings affirm that co-production is a powerful mechanism for achieving these goals.

For SDG 2.1, co-production has proven effective in enhancing food security through inclusive, nutrition-sensitive agricultural interventions. Projects such as banana macropropagation, free-range chicken production, and mushroom cultivation have increased the availability of diverse, nutrient-rich food sources. These initiatives were not only technically sound but also socially embedded developed and implemented in partnership with local communities, indigenous groups, and government agencies. The participatory nature of these programs ensured that solutions were context-specific, culturally appropriate, and widely adopted.

In relation to SDG 2.3, co-production has contributed to improved agricultural productivity and income generation among smallholder farmers. Through capacity-building, enterprise development, and value chain integration, farmers gained access to new technologies, markets, and livelihood opportunities. Initiatives like tomato processing and livestock-based rural enterprises helped farmers mitigate risks, reduce postharvest losses, and diversify income streams. The collaborative governance model anchored in mutual trust, shared goals, and inclusive planning was instrumental in sustaining these outcomes.

The success of state university's co-production model was facilitated by several enabling factors: strong institutional commitment, stakeholder engagement through Training Needs Analysis (TNA),

inclusive research design, and long-term partnerships formalized through Memoranda of Agreement (MOAs). However, challenges such as limited funding, time constraints, and geographic barriers highlight the need for continued investment and policy support to scale these efforts.

In conclusion, co-production is not merely a method of knowledge transfer—it is a transformative approach that empowers communities, strengthens local food systems, and bridges the gap between science and society. As demonstrated by university, when academic institutions, government agencies, and communities work together as co-creators of knowledge and solutions, they can make meaningful strides toward ending hunger and uplifting the livelihoods of small-scale food producers.

This research therefore recommend the following:

1. Institutionalize Co-Production Frameworks in Research and Extension

Develop formal guidelines for co-production that emphasize shared decision-making, mutual accountability, and inclusive participation.

Integrate co-production principles into university extension manuals and research protocols to ensure consistency and sustainability across programs.

2. Strengthen Capacity Building for Farmers and Extension Workers

Expand training programs on sustainable agriculture, value addition, and enterprise development tailored to smallholder needs.

Provide continuous professional development for extension workers to enhance their facilitation, communication, and participatory research skills.

3. Enhance Multi-Stakeholder Collaboration

Foster stronger partnerships between HEIs, LGUs, NGOs, and farmer cooperatives to co-design and co-implement agricultural innovations.

Institutionalize Memoranda of Agreement (MOAs) with clear roles, responsibilities, and shared goals to build long-term trust and accountability.

4. Promote Nutrition-Sensitive and Climate-Resilient Agriculture

Prioritize projects that integrate nutrition goals (e.g., vegetable and protein-rich food production) and climate adaptation strategies (e.g., organic farming, agroforestry).

Support postharvest and processing technologies to reduce food waste and improve food availability year-round.

5. Invest in Inclusive and Participatory Planning Tools

Regularly conduct Training Needs Analysis (TNA) and stakeholder consultations to ensure that research and extension programs are responsive to community needs.

Use participatory monitoring and evaluation (PM&E) to track outcomes and adapt programs based on feedback.

6. Address Structural Barriers to Co-Production

Advocate for increased funding for institutionally led research and extension projects, especially those targeting marginalized and remote communities.

Allocate dedicated time and logistical support for faculty and staff involved in field-based co-production activities to avoid delays and burnout.

7. Scale Successful Models and Share Best Practices

Document and disseminate successful co-production models (e.g., banana macropagation, tomato processing, free-range chicken enterprise) for replication in other regions.

Encourage peer learning exchanges among farmers, extensionists, and researchers to foster innovation and cross-regional collaboration.

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