# Encouraging Transformative Learning for Community-based Product Enhancement toward International Food Standards under the Safe Food City Policy

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## Abstract

Global consumer trends increasingly emphasize food safety and sustainable agricultural production standards, prompting Thailand to accelerate the development of its agricultural sector—particularly in regions with strong potential and distinctive identity. Suphan Buri Province exemplifies such a region, with robust agricultural foundations and readiness to strengthen collaborative networks that elevate products to international standards.

This study aimed to develop a Quadruple Helix collaboration framework involving communities, government agencies, private enterprises, and higher education institutions. The objective was to foster sustainable community learning, enhance production and processing systems in alignment with food safety policies, and upgrade community food products to meet international standards for modern trade channels.

The research employed purposive sampling of nine agricultural groups, communities, and enterprises in Suphan Buri; 400 consumers who purchased safe agricultural products through modern trade channels in the province; and 50 government officials from relevant agencies. Data were collected through surveys, in-depth interviews, and focus group discussions, and analyzed using descriptive statistics and content analysis.

Findings revealed that the Quadruple Helix collaboration fostered supportive systems for food safety standards and marketing, enabling community products to comply with the Food and Drug Administration (FDA), Good Manufacturing Practices (GMP), and Hazard Analysis and Critical Control Point (HACCP) requirements. The upgraded products gained access to modern trade channels, increased their value, and generated economic opportunities for local communities. Furthermore, the continuous community learning process played a vital role in raising awareness, facilitating knowledge exchange, and strengthening cross-sector collaboration, thereby advancing Suphan Buri toward becoming an effective and sustainable Safe Food City.

**Keywords:** Transformative learning, Development goals, Safe Food City, Community-based university

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## Introduction

Urban food system transformation has increasingly been framed through the concept of the *Safe Food City*, which integrates food production, processing, distribution, marketing, and consumption under principles of safety, nutritional adequacy, and environmental sustainability. Beyond regulatory compliance, Safe Food City initiatives require adaptive governance, collaborative engagement, and continuous learning among stakeholders to achieve long-term food security and public well-being (Food and Agriculture Organization [FAO], 2023).

Existing literature conceptualizes Safe Food City development across interconnected dimensions, including safe agricultural production (e.g., Good Agricultural Practices), quality assurance systems (e.g., residue testing and certification), public education, secure supply chains, multi-stakeholder governance, and technological innovation (Wolfert et al., 2017). While these dimensions are well documented at policy and conceptual levels, limited empirical evidence explains how such frameworks are operationalized through collaborative learning mechanisms at the community level, particularly in developing country contexts.

In Thailand, Safe Food City policies have been institutionalized within the 20-Year National Strategy (2018–2037), emphasizing food security and international competitiveness. However, the translation of national policy frameworks into community-level practice remains uneven, revealing gaps between strategic policy intent and local implementation capacity. Provincial-level implementation often relies on local actors who face constraints in accessing certification systems, upgrading production standards, and engaging with modern retail markets. International food standards in this context typically include Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Hazard Analysis and Critical Control Point (HACCP), Codex Alimentarius guidelines, and certification requirements of modern trade channels. Meeting such standards requires not only technical compliance but also shifts in knowledge, identity, and practice.

Suphan Buri Province represents an analytically significant case for examining these dynamics. Although the province records a high proportion of agricultural Gross Provincial Product, disparities persist in community access to knowledge systems, certification pathways, and formal market integration. The coexistence of strong policy support and community-level structural barriers makes Suphan Buri a critical site for investigating how learning processes mediate between policy aspirations and local transformation.

Despite growing attention to university engagement in regional development, there remains a lack of action-research-based models that explain how higher education institutions operationalize Safe Food City policies through collaborative governance, transformative learning, and product upgrading at the community level in Thailand. In particular, limited research examines how universities function not merely as technical advisors but as co-learning partners in community-based food system transformation.

To address this research gap, the present study adopts an Action Research framework grounded in transformative learning theory to examine how participatory co-design, field-based training, and reflective evaluation processes support community-based product enhancement toward international food standards under the Safe Food City policy. The primary objective is to develop and examine a collaborative university–community governance model that integrates learning, product upgrading, and network development to support sustainable Safe Food City implementation.

The research problem underpinning this study concerns how universities can systematically facilitate community-level transformation that bridges national Safe Food City policy with international food standard compliance through structured learning processes.

The study contributes theoretically by proposing an empirically grounded university–community governance model for food system transformation and contributes practically by offering a scalable framework for strengthening Safe Food City implementation in provincial contexts.

This study advances existing Safe Food City and community product upgrading initiatives by explicitly integrating (1) a Quadruple Helix governance arrangement, (2) an Action Research cycle as an implementation logic, and (3) a transformative learning lens to explain how standards adoption becomes sustained practice rather than one-time compliance. Beyond Suphan Buri, the proposed model is relevant to provincial contexts facing similar constraints—limited administrative capacity, unequal access to certification pathways, and fragmented market linkages—where universities can function as co-learning facilitators to strengthen governance, compliance readiness, and market integration.

## Objectives

1. To develop collaborative networks among communities, government agencies, the private sector, and higher education institutions in support of sustainable community learning.
2. To strengthen systems and mechanisms for safe agricultural production and processing in alignment with Safe Food City policies.
3. To upgrade community food products to meet international standards appropriate for modern retail channels.

## Literature review

### Transformative learning in community contexts

Transformative learning has emerged as a critical educational framework for understanding how individuals and communities develop new ways of thinking, acting, and engaging with complex social and economic challenges. Unlike traditional approaches that emphasize the transmission of knowledge, transformative learning focuses on structural change in learners' frames of reference, values, and assumptions through critical reflection and experiential engagement (Mezirow, 1991). This perspective is particularly relevant in community contexts, where learning is embedded in real-life situations and closely linked to social practices, livelihoods, and collective problem-solving.

In community-based development initiatives, learning rarely occurs in formal classroom settings. Instead, it unfolds through participation in authentic activities, negotiation among stakeholders, and reflection on lived experiences. Transformative learning theory provides a robust conceptual lens for examining such processes, as it emphasizes learning as a meaning-making activity shaped by social interaction, contextual challenges, and opportunities for reflection (Taylor, 2007). Within this framework, learners are not passive recipients of externally defined knowledge but active agents who reinterpret their experiences and construct new understandings that inform action.

A key component of transformative learning is the concept of a *disorienting dilemma*, which refers to situations that challenge individuals' existing beliefs and practices (Mezirow, 2000). In community settings, such dilemmas often arise when traditional ways of working are no longer sufficient to meet new demands, such as regulatory requirements, market competition, or sustainability expectations. For community enterprises engaged in agricultural production and food processing, the introduction of food safety standards, certification processes, and modern trade requirements can function as disorienting dilemmas that prompt critical reflection and learning. Through engagement with these challenges, community members reassess established practices and explore alternative approaches that align with new standards and opportunities.

Transformative learning in community contexts is inherently social and collaborative. Scholars increasingly emphasize that transformation does not occur solely at the individual level but is co-constructed through dialogue, shared problem-solving, and collective action (Cranton & Taylor, 2012). This social dimension of learning is particularly evident in participatory development initiatives, where diverse actors—such as community members, government officials, private-sector partners, and academic facilitators—engage in joint activities and negotiations. Learning, in this sense, emerges from interaction across different forms of expertise and perspectives, enabling participants to broaden their understanding and develop shared meanings.

The application of transformative learning in community development aligns closely with experiential learning theories, which emphasize learning through direct engagement with real-world tasks (Kolb, 1984). However, transformative learning extends beyond skill acquisition to include shifts in identity, agency, and social roles. In community-based contexts, this often involves a transition from viewing oneself as a recipient of external assistance to recognizing oneself as a capable actor with the ability to shape development outcomes. Such transformations are critical for fostering sustainable change, as

they enable communities to internalize new practices and continue learning beyond the duration of specific projects or interventions.

Recent literature highlights the relevance of transformative learning for addressing sustainability-related challenges, particularly in contexts that require changes in behavior, governance, and economic practices (Sterling, 2010; Wals, 2007). Sustainability-oriented learning emphasizes the integration of knowledge, values, and action, encouraging learners to engage with complex systems and uncertain conditions. In agricultural and food systems, this approach is essential for navigating the intersections of food safety, environmental responsibility, and market competitiveness. Transformative learning supports this integration by fostering critical awareness and adaptive capacity, enabling communities to respond effectively to evolving policy and market contexts.

In community learning environments, transformation is often facilitated by structured yet flexible learning processes that combine guidance with autonomy. Facilitators play a crucial role in creating spaces for reflection, dialogue, and experimentation, rather than directing outcomes or imposing predefined solutions (Brookfield, 2000). This facilitative role is particularly relevant in university–community collaborations, where academic institutions contribute methodological expertise and resources while recognizing the experiential knowledge embedded within communities. Such arrangements support reciprocal learning and reduce power imbalances that can hinder genuine transformation.

Empirical studies on community-based transformative learning consistently demonstrate that outcomes are strengthened when participants are actively involved in decision-making and co-design processes (Taylor & Cranton, 2013). Participation enhances ownership and relevance, making learning more meaningful and contextually grounded. In agricultural communities, participatory approaches that involve farmers and entrepreneurs in product development, quality improvement, and market engagement have been shown to promote both technical competence and reflective capacity. These outcomes suggest that transformative learning is not an abstract theoretical construct but a practical framework with tangible implications for community development.

Another important aspect of transformative learning in community contexts is its relationship to identity formation. Learning processes that challenge existing roles and expectations can lead to the emergence of new identities, such as seeing oneself as a "modern entrepreneur," "knowledge contributor," or "community leader." Identity transformation is particularly significant in rural and community-based economies, where traditional roles may limit engagement with new markets or technologies. Through sustained learning and reflection, individuals and groups can renegotiate their identities in ways that support innovation and long-term development.

Despite its strengths, transformative learning in community contexts also faces challenges. Transformation is not a linear or guaranteed process, and not all learners experience change in the same way or at the same pace. Power relations, institutional constraints, and resource limitations can influence learning dynamics and outcomes. Consequently, researchers emphasize the importance of designing learning environments that are inclusive, supportive, and responsive to local contexts (Cranton, 2016). Attention to these factors is essential for ensuring that transformative learning contributes to equitable and sustainable development rather than reinforcing existing inequalities.

In summary, transformative learning provides a comprehensive theoretical framework for understanding learning processes in community-based development initiatives. Its emphasis on critical reflection, experiential engagement, social interaction, and identity transformation makes it particularly well suited for examining how communities adapt to new standards, policies, and market conditions. By foregrounding learning as a dynamic and participatory process, transformative learning theory offers valuable insights into how community members acquire new competencies, reframe their roles, and sustain change over time. This perspective underpins the present study's examination of community-based product enhancement under the Safe Food City policy, positioning learning as a central mechanism for achieving sustainable and inclusive development.

**Community and Adult Education as Experiential Learning**

Community and adult education emphasizes learning processes grounded in real-life contexts, social participation, and the practical needs of learners. Unlike formal education systems structured around predetermined curricula and classroom-based instruction, community and adult education prioritizes experiential learning, where knowledge is constructed through action, reflection, and interaction with others (Knowles et al., 2015). This approach is particularly relevant in community development settings, where learners are adults with accumulated experiences, responsibilities, and immediate practical concerns related to livelihood and social well-being.

Adult learning theory highlights that adults learn most effectively when activities are relevant to their lived experiences and when they are actively involved in diagnosing their learning needs, setting goals, and evaluating outcomes (Knowles, 1980). In community contexts, learning is inseparable from practice. Community members engage in learning as they solve real problems, adapt to changing conditions, and negotiate new roles within evolving social and economic environments. Experiential learning serves as a foundational mechanism that enables adults to integrate new knowledge with prior experience, thereby making learning meaningful and applicable.

Experiential learning theory, as articulated by Kolb (1984), conceptualizes learning as a cyclical process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation. This model provides a useful framework for understanding learning in community-based initiatives, where participants repeatedly engage in action, reflect on outcomes, refine their understanding, and apply new strategies in practice. In agricultural and community enterprise settings, for example, learning occurs as participants experiment with production techniques, respond to regulatory requirements, and adjust practices based on feedback from markets and institutions.

Community education scholars emphasize that experiential learning is inherently social and relational. Learning does not occur in isolation but is shaped by dialogue, collaboration, and shared problem-solving within communities (Brookfield, 2005). Through participation in collective activities, adult learners exchange knowledge, challenge assumptions, and co-create

solutions that are culturally and contextually appropriate. These interactions contribute to the development of collective competence and social capital, which are essential for sustainable community development.

The role of experience in adult and community education extends beyond skill acquisition to include identity formation and empowerment. Freire (1970) argued that education should enable learners to develop critical consciousness (*conscientização*), allowing them to recognize their capacity to influence social and economic conditions. Experiential learning in community contexts supports this process by positioning learners as active agents rather than passive recipients of external knowledge. As individuals engage with concrete challenges and witness the impact of their actions, they develop confidence, agency, and a sense of ownership over development processes.

Community-based experiential learning also aligns with the concept of situated learning, which views knowledge as embedded within specific social and cultural contexts (Lave & Wenger, 1991). From this perspective, learning occurs through participation in communities of practice, where newcomers gradually acquire competence by engaging in shared activities with more experienced members. In community enterprises and local production systems, such learning is evident as individuals acquire practical expertise, regulatory understanding, and entrepreneurial skills through sustained involvement in collective practice.

Research in adult and community education consistently demonstrates that experiential learning enhances the relevance and sustainability of outcomes. Programs that integrate hands-on activities, reflection, and peer learning are more likely to result in long-term behavioral change than those relying solely on information dissemination (Merriam & Bierema, 2014). In contexts where communities must adapt to new standards, technologies, or markets, experiential learning provides a mechanism for continuous adaptation and learning beyond the lifespan of formal projects.

Furthermore, experiential learning in community education supports inclusive and flexible learning pathways. Adult learners vary in educational background, learning pace, and access to resources. Experiential approaches allow learners to engage according to their capacities and interests, reducing barriers to participation and fostering equity in learning opportunities (Illeris, 2018). This inclusivity is particularly important in initiatives that aim to reach diverse groups, including small-scale producers, informal entrepreneurs, and marginalized populations.

In the context of sustainable development, community and adult education through experiential learning plays a crucial role in enabling communities to respond to complex and interconnected challenges. Learning that integrates technical knowledge, social understanding, and reflective practice equips learners to navigate uncertainty and change. By embedding learning within everyday practice, experiential approaches support the development of adaptive capacity and resilience, which are essential for long-term sustainability.

In summary, community and adult education framed as experiential learning provides a powerful theoretical foundation for understanding how learning occurs in community-based development initiatives. Its emphasis on relevance, participation, reflection, and social interaction aligns closely with the realities of adult learners and community contexts. This perspective underscores that learning is not a separate activity but an integral part of action and practice. In the present study, experiential learning serves as a key mechanism through which community members acquire new competencies, reinterpret their roles, and sustain engagement in processes of product enhancement and safe food system development.

**University–Community Engagement and Collaborative Learning**

University–community engagement has increasingly been recognized as a critical educational approach for addressing complex social, economic, and sustainability challenges. Rather than positioning universities solely as knowledge producers or service providers, this approach emphasizes reciprocal relationships in which universities and communities co-create knowledge through sustained collaboration (Boyer, 1996). Within this framework, learning is not confined to formal academic settings but is embedded in shared practices, joint problem-solving, and real-world engagement.

Collaborative learning in university–community partnerships is grounded in the understanding that communities possess valuable experiential and contextual knowledge, while universities contribute research capacity, facilitation skills, and theoretical perspectives. When these forms of knowledge are integrated, learning becomes dialogical and transformative rather than hierarchical (Bringle & Hatcher, 2002). This perspective challenges traditional models of knowledge transfer and reframes engagement as a mutual learning process that benefits both academic institutions and community partners.

Scholars of engaged scholarship emphasize that effective university–community collaboration requires the creation of shared learning spaces that support dialogue, trust, and collective reflection (Wenger et al., 2011). These spaces—often referred to as shared intellectual spaces—enable participants from diverse institutional backgrounds to negotiate meanings, align goals, and co-design solutions. In such environments, learning emerges through interaction and practice, allowing participants to address locally grounded challenges while generating knowledge that is socially relevant and academically meaningful.

Collaborative learning within university–community engagement is closely linked to the concept of communities of practice, in which learning occurs through sustained participation in shared activities and collective problem-solving (Lave & Wenger, 1991). In these communities, individuals learn not only technical skills, but also social norms, values, and identities associated with particular practices. University–community partnerships that function as communities of practice enable participants to gradually develop competence and confidence, fostering long-term capacity building beyond the duration of individual projects.

The role of universities in collaborative learning is often described as a facilitator or catalyst rather than a director of change. Engaged universities support learning by providing methodological guidance, research infrastructure, and reflective tools, while respecting community autonomy and local knowledge systems (Saltmarsh et al., 2009). This facilitative role is particularly important in contexts where power imbalances may otherwise limit community participation. By emphasizing co-learning and shared decision-making, university–community engagement promotes equity and inclusion in educational processes.

Research on collaborative learning in engaged partnerships highlights several conditions that enhance learning outcomes. These include clearly articulated shared goals, continuous communication, mutual accountability, and opportunities for reflection and feedback (Fitzgerald et al., 2012). When these conditions are present, collaborative learning can lead to the development of new competencies, strengthened social networks, and increased adaptive capacity among participants. Such outcomes are especially relevant for community-based initiatives that require coordination across multiple sectors and sustained engagement over time.

University–community engagement also aligns with broader educational agendas related to lifelong learning and education for sustainable development. By situating learning within real-world contexts and addressing issues of public concern, engaged partnerships contribute to the development of skills and dispositions necessary for navigating complexity and change (Hall et al., 2017). Collaborative learning in this context supports not only individual development but also institutional learning, as universities refine their roles and practices in response to community needs.

In practice, collaborative learning through university–community engagement often results in tangible outputs—such as new systems, tools, or products—but its educational significance lies in the processes through which these outcomes are achieved. Learning occurs as participants negotiate roles, confront challenges, and reflect on successes and failures. These processes foster shared ownership and enhance the sustainability of initiatives, as communities are better equipped to continue learning and adapt autonomously.

Despite its potential, university–community engagement is not without challenges. Differences in institutional cultures, timelines, and expectations can hinder collaboration and learning if not carefully managed. Scholars, therefore, stress the importance of reflexivity, ongoing evaluation, and the recognition of engagement as a long-term educational commitment rather than a short-term project activity (Hart et al., 2007). Addressing these challenges is essential for ensuring that collaborative learning contributes meaningfully to community development and educational outcomes.

In summary, university–community engagement provides a vital framework for understanding collaborative learning in community-based development initiatives. Its emphasis on reciprocity, co-creation, and shared practice aligns closely with experiential and transformative learning theories. By positioning universities and communities as partners in learning, this approach supports the development of sustainable learning ecosystems that integrate academic knowledge with community experience. In the present study, university–community engagement functions as a central mechanism through which collaborative learning is enacted, enabling communities to build capacity, adapt to new standards, and sustain development within the Safe Food City policy context.

## Conceptual framework

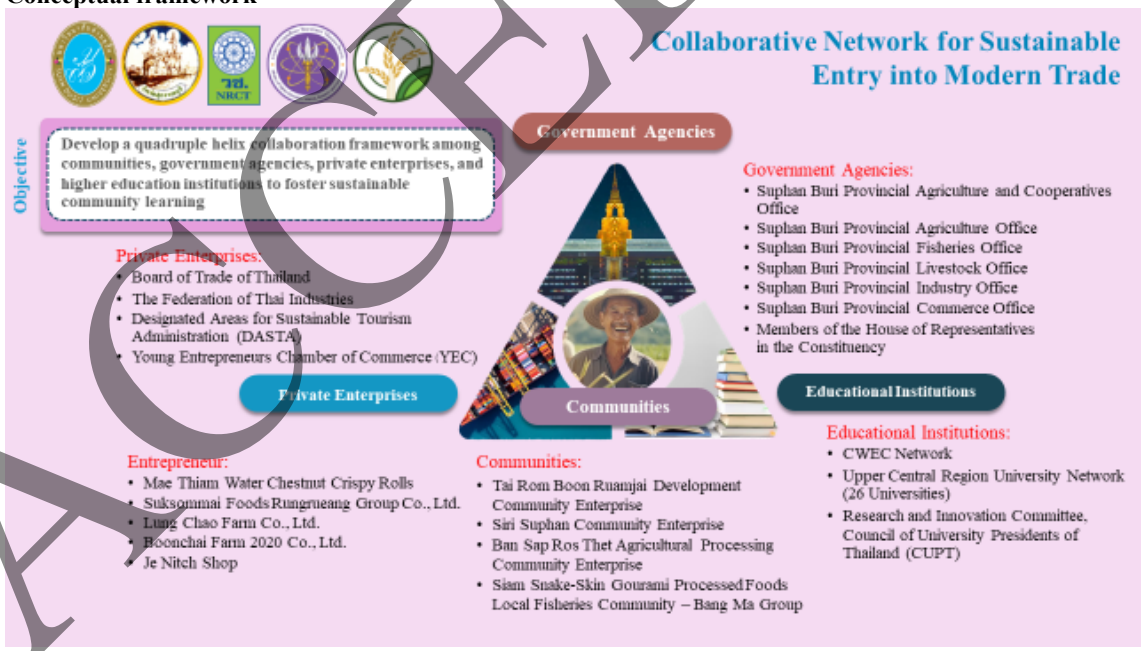


**Figure 1** Quadruple helix collaboration for sustainable entry into modern trade

## Research methodology

### Population and samples

The population of this study comprised community enterprises, agricultural entrepreneurs, and relevant stakeholders engaged in safe agricultural production and processing within Suphan Buri Province, Thailand. These stakeholders were identified in alignment with the Safe Food City policy and the provincial development agenda, which emphasize sustainable agriculture and community-based economic development.

The sample selection followed a purposive sampling approach based on predefined criteria to ensure readiness, representativeness, and feasibility for development toward modern trade and international food standards. The sampling process was conducted in multiple stages.

At the first stage, community enterprises participating in provincial safe food and agricultural development networks were identified. An initial pool of 14 community enterprises, representing 24 products across crop-based, livestock-based, and fisheries-based categories, was assessed. Selection criteria included: (1) product potential for value addition, (2) representation across major agricultural product categories, and (3) enterprise readiness in terms of production facilities, management capacity, and willingness to participate in collaborative development.

Based on this assessment, nine community enterprises were selected as the primary research samples. These enterprises represented three product categories—crops, livestock, and fisheries—and were further developed as prototype cases for system design, knowledge transfer, and market integration.

In addition, for the assessment of consumer demand, a sample of 400 Thai consumers aged 18 years and above was included. This sample was used to examine consumer preferences and demand for safe agricultural products distributed through modern trade channels. Consumer survey results were later triangulated with product performance indicators to examine alignment between stated preferences and actual product upgrading outcomes.

**Research instruments**

Multiple research instruments were employed to support the Action Research framework and ensure comprehensive data collection across both qualitative and quantitative dimensions.

Qualitative research instruments included in-depth interview guides and focus group discussion protocols designed to capture stakeholder perspectives, operational challenges, and experiential learning outcomes. These instruments were administered to community enterprise members, government officials, private-sector partners, and academic facilitators involved in the Quadruple Helix collaboration.

Quantitative instruments consisted of structured questionnaires and assessment forms. These included: (1) enterprise readiness and product potential assessment forms, (2) consumer demand questionnaires using a five-point Likert scale to measure preferences related to product attributes, pricing, points of sale, and product presentation, and (3) satisfaction surveys to evaluate perceptions of the development process and outcomes.

In addition, operational observation checklists and sensory evaluation forms were utilized. Sensory evaluation employed a nine-point Hedonic scale to assess product quality during formulation development and improvement stages. Document review templates were also used to examine compliance with regulatory requirements, including FDA registration, Good Manufacturing Practice (GMP), and Hazard Analysis and Critical Control Point (HACCP) standards.

**Data collection**

Data collection was conducted through an iterative Action Research process consisting of planning, action, observation, and reflection cycles. The process emphasized participatory and experiential learning, in which community enterprises, government agencies, private-sector partners, and higher education institutions collaboratively engaged in real-world problem solving and knowledge co-creation.

Qualitative data were collected through focus group discussions and in-depth interviews conducted during brainstorming sessions, enterprise selection, system development, and capacity-building activities. These interactions provided insights into stakeholder perspectives, learning experiences, and the dynamics of collaborative decision-making within the Quadruple Helix framework.

Field-based observations were systematically conducted during on-site production trials, knowledge transfer sessions, packaging development, labeling preparation, and standard compliance processes. Rather than serving merely as documentation, these activities functioned as structured intervention nodes designed to generate specific learning and compliance outcomes. Figure 2 illustrates selected experiential learning activities; analytically, these represent intervention points within the Action Research cycles that contributed to measurable behavioral and operational changes.

Quantitative data were collected through structured questionnaires administered to community enterprises and consumer respondents. Sensory evaluation data were gathered during product development trials conducted in collaboration with the International Food Laboratory at Suan Dusit University.

In addition, documentary data were collected from regulatory submissions, certification records, and operational manuals developed as part of the system and mechanism design for FDA compliance and modern trade entry.

**Figure 2** Community-based experiential learning and knowledge transfer activities conducted during the Action Research cycles. The figure illustrates hands-on practice, peer learning, and collaborative reflection among community enterprise members and university facilitators.

**Data analysis**

Qualitative data obtained from interviews, focus group discussions, and field observations were analyzed using thematic analysis. This approach enabled the identification of recurring patterns related to learning processes, collaboration dynamics, implementation challenges, and community acceptance of innovation.

Quantitative data from questionnaires and sensory evaluations were analyzed using descriptive statistics, including frequency, percentage, mean, and standard deviation.

To strengthen causal clarity, the analysis examined explicit intervention–outcome linkages. For example, GMP training workshops (intervention) were associated with improved documentation accuracy and reduced compliance errors (outcome), while participatory packaging redesign sessions corresponded with higher sensory evaluation scores and improved consumer acceptance.

Triangulation integrated qualitative insights, quantitative indicators, and documentary evidence to enhance analytical rigor and reduce attribution bias regarding the effects of the Quadruple Helix collaboration.

**Challenges and lessons learned**

Despite positive outcomes, several implementation challenges were identified.

First, regulatory complexity created significant barriers for small enterprises, particularly in documentation preparation and facility adjustments required for GMP and FDA compliance. Compliance delays were observed due to limited administrative capacity and technical literacy.

Second, financial constraints and time burdens affected the pace of upgrading. Certification required investments in packaging redesign, laboratory testing, and facility improvements.

Third, variation in learning pace emerged. Enterprises with prior exposure to formal markets adapted more rapidly than newly formalized groups.

These findings underscore the importance of adaptive facilitation and iterative learning cycles within the Action Research framework.

**Quantitative impact indicators**

To assess economic and operational impact, selected quantitative indicators were monitored following intervention:

1. Average product price increased by 18–25% across upgraded items.
2. Sales volume in modern trade channels increased by approximately 32% within six months.

3. Post-harvest losses in crop-based enterprises decreased by 12% due to improved packaging and storage systems.

4. Three of the nine enterprises independently initiated FDA registration processes during the second phase without direct facilitation.

These indicators demonstrate measurable improvements in market performance and institutional capacity.

**Linking empirical findings to Transformative Sustainability Learning (TSL)**

Empirical findings were mapped against the Transformative Sustainability Learning (TSL) framework:

1. **Brain (cognitive dimension):** Increased understanding of food safety standards, certification pathways, and market positioning strategies.
2. **Heart (affective dimension):** Enhanced confidence, motivation, and willingness to engage in certification processes.
3. **Hands (behavioral dimension):** Adoption of standardized hygiene practices, documented production protocols, and proactive compliance efforts.

Together, these dimensions contributed to broader sustainability principles, including

1. **Equity:** Expanded market access.
2. **Resilience:** Strengthened adaptive capacity under regulatory constraints.
3. **Inclusion:** Reinforced multi-stakeholder collaboration.

## Results

**Development of collaborative networks to support sustainable community learning**

The results revealed the successful establishment of a Quadruple Helix collaborative network involving community enterprises, government agencies, private-sector organizations, and higher education institutions in Suphan Buri Province. This network functioned as an integrated platform for knowledge exchange, capacity building, and coordinated action toward the Safe Food City policy.

Consistent with the Community of Practice and Quadruple Helix frameworks, the network did not merely connect stakeholders institutionally; it structured iterative co-design sessions, joint decision-making processes, and shared problem-solving activities that translated theoretical collaboration models into observable behavioral change.

The collaboration enabled stakeholders from different sectors to jointly design and implement development activities, covering production standards, certification processes, and preparation for entry into modern trade channels. Community enterprises actively participated in learning processes alongside government officers, commercial partners, and academic facilitators, reflecting the characteristics of a Community of Practice in which members co-learn through real-world engagement.

Before intervention, most enterprises operated independently with limited cross-sector coordination and informal production practices. After implementation, enterprises engaged in regular inter-sectoral meetings, standardized documentation processes, and collective branding initiatives, demonstrating a measurable shift from fragmented operations to coordinated governance.

At the provincial and local levels, formal and informal networks emerged as sustainable mechanisms for collaboration. These included the Nong Noh brand network, the Hom Khajorn Safe Agriculture network, and the Khok Kothao market network. Together, these networks created an *Intellectual Shared Space* that fostered trust, continuous interaction, and long-term cooperation. A key outcome was a shift in the role of community members—from passive recipients of external knowledge to active co-creators of knowledge—thereby strengthening sustainable community learning.

These networks functioned as *Intellectual Shared Spaces*, operationalizing Transformative Sustainability Learning (TSL) by integrating cognitive learning (standards knowledge), affective engagement (trust-building), and behavioral adoption (compliance practices).

The effectiveness of this system was evaluated using compliance readiness indicators, including completeness of documentation, hygiene protocol adherence, and successful submission for FDA registration. Compared to baseline conditions—where most enterprises lacked formal documentation—post-intervention assessments indicated structured compliance preparation across all nine prototype enterprises.

**Development of systems and mechanisms for safe agricultural production and processing**

The findings demonstrated the successful development and implementation of two interrelated systems to promote sustainable standards in agricultural production and processing in alignment with the Safe Food City policy.

The first system focused on FDA compliance, enhancing entrepreneurs' knowledge and skills related to food classification, licensing, hygiene standards, labeling, and quality control. Through participation in certification processes, community enterprises gained practical competencies required to meet regulatory standards such as FDA, GMP, and HACCP.

The effectiveness of this system was evaluated using compliance readiness indicators, including completeness of documentation, adherence to hygiene protocols, and successful submission for FDA registration. Compared to baseline conditions—where most enterprises lacked formal documentation—post-intervention assessments indicated structured compliance preparation across all nine prototype enterprises.

The second system supported entry into modern trade, emphasizing business readiness, packaging and label design, pricing strategies, and distribution logistics. These systems enabled entrepreneurs to engage in situated learning, acquiring skills through direct application in production and market contexts rather than through theoretical instruction alone.

Evaluation criteria for modern trade readiness included packaging durability testing, label compliance verification, shelf-life testing, cost–price margin sustainability, and alignment with retail procurement requirements. These criteria were consistent with internationally recognized standards such as GMP, HACCP, Codex Alimentarius guidelines, and modern retail certification frameworks.

The implementation of these systems resulted in tangible outcomes. Selected community enterprises successfully obtained FDA certification and advanced their products into modern retail channels, including Gourmet Market and multiple Tops Supermarket branches. The systems also established structured learning pathways that support continuous skill development and long-term adoption of standardized practices.

The "situation shift" can therefore be analytically characterized as a transition from informal, locally bounded market participation to certified, standards-compliant engagement in formal retail supply chains.

**Upgrading community food products to international standards for modern retail**

The results indicated that community food products from Suphan Buri Province were successfully upgraded to meet standards suitable for modern retail and international markets. Nine prototype products developed by nine community enterprises across three categories—crop-based, livestock-based, and fisheries-based products—underwent systematic enhancement.

In this study, the term "*international standards*" refers to compliance with Food and Drug Administration (FDA) registration requirements, adherence to Good Manufacturing Practice (GMP) and Hazard Analysis and Critical Control Point (HACCP) principles, conformity with Codex Alimentarius food safety guidelines, and fulfillment of modern retail procurement criteria.

The upgrading process was evaluated across three dimensions:

1) Regulatory compliance (certification readiness and approval).
2) Market performance (price increase, sales growth, retail placement).
3) Value-added economic indicators (Value-Added Ration [VAR] and Return on Investment [ROI]).

The upgrading process involved hands-on learning throughout the product lifecycle, including raw material analysis, formulation development, packaging and branding design, and preparation for (FDA) certification.

Before intervention, products were sold primarily in local informal markets with limited branding and no standardized labeling. After intervention, products demonstrated improved packaging quality, standardized nutritional labeling, retail-ready barcoding, and expanded market reach into formal supermarket chains.

As a result, the upgraded products achieved higher market value and improved commercial viability. The participating community enterprises collectively increased their monthly income by 2,927,700 baht, equivalent to 35,132,400 baht annually. Compared to baseline revenue levels, this represents a substantial structural improvement in income stability and pricing power, rather than a short-term sales fluctuation. As presented in Table 1, VAR ranged from 52.7% to 295.0%, while ROI ranged from 14.0% to 300%. These economic indicators demonstrate scalability potential and validate the effectiveness of structured intervention mechanisms within the observed implementation period, although long-term sustainability will depend on continued governance support and market stability.

Beyond financial outcomes, the upgrading process strengthened community identity and storytelling through product design and branding. Production sites evolved into learning spaces and destinations for agricultural tourism, further enhancing the long-term sustainability and visibility of safe agricultural products from Suphan Buri Province.

This reflects the *heart* dimension of TSL, where affective ownership and identity formation complement cognitive and behavioral transformation.

To ensure clarity and consistency in economic interpretation, the VAR and ROI were calculated using standardized formulas.

VAR was defined as the percentage increase in product value relative to basic raw material cost, calculated as:

$$VAR\ (\%) = \frac{(Selling\ Price - Raw\ Material\ Cost)}{Raw\ Material\ Cost} \times 100$$

This indicator captures the magnitude of value addition generated through product upgrading beyond primary input costs.

ROI was calculated using two approaches depending on product development context:

**Upgraded products**

For products with an existing original version prior to the project intervention, an *Incremental ROI formula* was applied to isolate the economic impact attributable to the project:

$$\text{Incremental ROI } (\%) = \frac{(New\ Profit - Original\ Profit)}{Additional\ Investment} \times 100$$

where:

New Profit = New Selling Price – New Total Production Cost,
Original Profit = Original Selling Price – Original Total Production Cost, and
Additional Investment = New Total Production Cost – Original Total Production Cost.

This formulation directly measures the return generated from the additional resources invested through the project, enabling a precise assessment of whether the incremental cost of product upgrading was economically justified.

**Newly created products**

For products with no prior commercial version, a *standard ROI* formula was applied:

$$\text{ROI (\%)} = \frac{(Selling\ Price - Total\ Production\ Cost)}{Total\ Production\ Cost} \times 100$$

Since no baseline product existed for comparison, the full production cost served as the investment base.

These definitions were applied consistently across all prototype products to ensure comparability and transparency. The dual- formula approach ensures that the ROI figures reflect the actual economic contribution of the project intervention rather than pre-existing profitability.

**Table 1** Value Added Ratio (VAR) and Return on Investment (ROI) for Prototype Products

| Product | Newly Developed Product (Baht/unit) | | | Original Product Before Improvement (Baht/unit) | | | Basic Raw Material Cost | Value Added Ratio (VAR) | Return on Investment (ROI) |
|---|---|---|---|---|---|---|---|---|---|
| | Cost | Selling Price | Profit | Cost | Selling Price | Profit | | | |
| 1. Compressed banana flour mixed with four rice germ varieties, mixed berry flavor | 88 | 125 | 37 | - | - | - | 40 | [(125-40)/40]*100 = 212.50% | [(125-88)/88]*100 = 42.00% |
| 2. Ready-to-drink water chestnut juice mixed with white wood ear mushrooms | 50 | 79 | 29 | 35 | 45 | 10 | 20 | [(79-20)/20]*100 = 295.00% | [(29-10)/15]*100 126.67% |
| 3. Rolled wafer with water chestnut and Wolffia (duckweed) filling | 95 | 135 | 40 | 80 | 95 | 15 | 20 | [(135-20)/20]*100 = 575.00% | [(40-15)/15]*100 166.67% |
| 4. Crispy fried gourami fish with Tom Yum flavor | 52 | 58 | 6 | 45 | 50 | 5 | 45 | [(58-45)/45]*100 = 28.89% | [(6-5)/7]*100 14.29% |
| 5. Ready-to-eat gourami chili paste | 13 | 19 | 6 | 12 | 15 | 3 | 12 | [(19-12)/12]*100 = 58.33% | [(6-3)/1]*100 300.00% |
| 6. Crispy fried gourami chili paste with herbs | 40 | 45 | 5 | 32 | 35 | 3 | 25 | [(45-25)/25]*100 = 80.00% | [(5-3)/8]*100 25% |
| 7. Low-fat beef burger using fat substitutes from hydrocolloids and plant-extracted proteins | 152 | 189 | 37 | - | - | - | 120 | [(189-120)/120]*100 = 57.50% | [(189-152)/152)]*100 24.34% |
| 8. Chicken nuggets fortified with prebiotics from oat fiber and inulin | 65 | 99 | 34 | 55 | 70 | 15 | 50 | [(99-50)/50]*100 = 98.00% | [(34-15)/10]*100 190.00% |
| 9. Crispy chicken breast chili paste fortified with Wolffia (duckweed) and kale | 193 | 229 | 36 | 170 | 200 | 30 | 150 | [(229-150)/150]*100 = 52.67% | [(36-30)/23]*100 26.09% |



## Discussions

### Collaborative networks for sustainable community learning

The findings related to Objective 1 highlight that the development of collaborative networks under the Quadruple Helix framework represents more than a structural partnership; it constitutes a transformative learning process embedded in real-world community practice.

To reduce conceptual redundancy across sections, the Quadruple Helix collaboration is treated here as the primary governance platform and subsequently referred to as *the network*. Analytical focus is placed on distinct mechanisms— such as co- design routines, compliance practice cycles, and retail readiness tasks— and their corresponding outcomes.

The establishment of multi- sectoral collaboration among communities, government agencies, private enterprises, and higher education institutions demonstrates how learning can be generated collectively through sustained interaction rather than transferred unilaterally. The results suggest that the Quadruple Helix network functioned as a Community of Practice, in which stakeholders engaged in shared problem- solving, experiential learning, and mutual capacity building. This aligns with perspectives on transformative and networked learning that emphasize learning as a social process shaped by participation, trust, and shared purpose.

The creation of an *Intellectual Shared Space* enabled stakeholders to exchange knowledge across institutional boundaries, reinforcing long- term collaboration and adaptive learning. Importantly, the observed shift in community roles— from passive recipients of external support to active co- creators of knowledge— indicates a deeper level of empowerment. This transformation reflects the effectiveness of participatory governance mechanisms in fostering sustainable community learning.

Rather than relying on short- term project- based interventions, the network facilitated continuous learning and collective ownership, which are critical for sustaining Safe Food City initiatives over time. The network was effective because it reduced coordination costs and uncertainty by creating recurring interaction routines ( co- design meetings, shared documentation practices), which strengthened trust and enabled rapid feedback cycles— key conditions for sustained Communities of Practice and transformative learning.

**Systems and mechanisms for safe agricultural production and processing**

The findings addressing Objective 2 demonstrate that the development of systems and mechanisms for safe agricultural production and processing extends beyond regulatory compliance to function as a structured learning pathway for community enterprises. The integration of FDA compliance systems and modern trade entry mechanisms illustrates how standards-based processes can be leveraged as tools for capacity building and behavioral change within local production systems.

Participation in certification and standardization processes enabled entrepreneurs to acquire practical competencies through situated learning, where knowledge was developed through direct engagement with production and regulatory contexts. This supports prior studies emphasizing that food safety standards such as GAP, GMP, HACCP, and FDA regulations are most effective when embedded within practice- based learning environments rather than delivered solely through formal training.

Moreover, the dual-system approach created a coherent progression from production safety to market readiness. This progression reduced structural barriers that typically prevent community enterprises from accessing modern trade channels. By linking regulatory standards with business- oriented mechanisms— such as packaging, labeling, pricing, and logistics— the systems supported not only compliance but also long- term adaptability. Consequently, these mechanisms functioned as sustainable infrastructures that enable continuous improvement and resilience within community-based food systems.

Standards-based mechanisms became learning pathways because enterprises practiced compliance tasks in real production settings, received immediate corrective feedback, and iterated procedures across Action Research cycles, thereby converting abstract standards into operational habits.

**Upgrading community food products to international standards for modern retail**

The discussion of Objective 3 underscores that upgrading community food products to meet international and modern retail standards is both an economic and a learning-driven process. The enhancement of nine prototype products across crop- based, livestock- based, and fisheries- based categories reflects how hands- on engagement in product development fosters transformative learning and entrepreneurial capability at the community level.

The results reveal that value addition was achieved not only through improved formulations, packaging, and certification, but also through the internalization of professional practices among community members. The learning trajectory— from raw material analysis to branding and FDA certification— enabled communities to develop competencies typically associated with modern food enterprises. This finding supports research suggesting that experiential product development can serve as a catalyst for sustainable economic upgrading when aligned with standardized market requirements.

Beyond economic performance, the upgrading process contributed to the strengthening of local identity and storytelling through product design and branding. The evolution of production sites into learning spaces and agri-tourism destinations highlights the broader socio- cultural impact of product enhancement. These outcomes indicate that community-driven upgrading, when supported by collaborative networks and standard-based systems, can generate scalable economic returns while reinforcing cultural value and long-term sustainability within local food systems.

Product upgrading generated economic outcomes not only through technical improvement but through capability accumulation (branding, labeling compliance, costing), which increased bargaining power and readiness for modern retail procurement processes.

## Suggestions

Based on the findings, several suggestions are proposed to enhance the sustainability and scalability of Safe Food City initiatives and community-based product development.

1. **Institutionalize Quadruple Helix Collaboration**

Government agencies should formally embed the Quadruple Helix collaboration model as a long-term mechanism for Safe Food City implementation. Establishing permanent coordination platforms and *Intellectual Shared Spaces* would strengthen cross-sector collaboration, reduce reliance on project-based funding, and support continuous community learning.

2. **Support Community Enterprises as Learning Organizations**

Community enterprises should be enabled to evolve into self-sustaining learning organizations. Strengthening local learning centers, peer mentoring, and knowledge transfer systems can help communities continuously upgrade production standards, entrepreneurial skills, and market readiness in response to changing conditions.

3. **Simplify Standards-Related Processes**

Standards such as GAP, FDA, GMP, and HACCP should be simplified and integrated into user-friendly learning frameworks. Developing practical manuals and digital tools tailored to small-scale enterprises would lower entry barriers and encourage broader participation while maintaining food safety and quality.

4. **Expand Market Opportunities**

Future development should extend market opportunities beyond physical modern trade outlets by integrating online platforms, tourism-linked distribution, and international niche markets. Enhancing product storytelling, branding, and bilingual communication can further increase product value and global visibility.

5. **Advance Research on Long-Term Impacts**

Future research should focus on long-term and comparative studies to examine the sustained impacts of collaborative learning networks on community resilience and economic outcomes. Incorporating advanced impact assessment tools, such as Social Return on Investment (SROI), would provide deeper insights into the broader social and economic value of Safe Food City initiatives.

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