Transition to Digital Sustainability in Smart Farming: Belief-Action-Outcome (BAO) Framework Insights from Thai Young Farming Communities

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Short Paper

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Abstract

This study explores how Thai farming communities transition toward digital sustainability by integrating digital technologies into grassroots farming practices. While existing research primarily focuses on enterprise-driven sustainability, the role of digital innovations in rural agricultural communities remains underexamined. Grounded in the Belief-Action-Outcome (BAO) framework, this study investigates the relationship between community beliefs, technological adoption, and sustainability outcomes. This research highlights the unique dynamics of rural digital adoption by shifting the focus from corporate-led sustainability to grassroots digital transformation. It provides a nuanced understanding of how community beliefs shape technological adoption and drive sustainability outcomes. It contributes to the information systems (IS) literature on digital sustainability transitions. The findings provide actionable insights for policymakers and development practitioners to design scalable, IS-driven initiatives that promote rural self-sufficiency, environmental resilience, and economic viability.

Keywords: Belief-Action-Outcome, Digital Sustainability, Digital Transformation, Smart Farming

Introduction

Thailand's agricultural sector faces mounting challenges from climate change and economic instability. (Prommawin et al., 2024). Extreme weather, rising costs, and unsustainable farm debts are straining farmers, with losses projected at THB 55.8 billion in 2024 (Jantarasiri, 2022; Marks et al., 2024; Sowcharoensuk, 2024). An ageing farming population further threatens the sector as younger generations increasingly turn away from agriculture (Jansuwan & Zander, 2021). To sustain the industry, a shift toward smart farming—integrating IoT, drones, and weather stations—is crucial for improving efficiency and climate resilience (Bangkokpost, 2023).

While existing research focuses on sustainability transformation in enterprises, how digital innovations drive sustainability in rural farming communities remains unexplored (Xu et al., 2024). Most studies examine corporate sustainability through operational efficiency, employee behaviour, and regulatory compliance (Cooper & Molla, 2017; Loeser et al., 2017), overlooking how digital innovations foster sustainability at the community level. Community-level transformations require collaborative efforts among farmers, local governments, and technology providers, making them distinct from enterprise-driven models (Elliot & Webster, 2017).

Digital sustainability in rural farming communities extends beyond environmental benefits to social and technological development. Digital sustainability is defined in different ways in the IS literature (Haugjord & Aanestad, 2024; Kotlarsky et al., 2023; Schoormann et al., 2025). In this study, d*igital sustainability* is conceptualised as the deployment of digital resources toward improving the community well-being and achieving desirable sustainability outcomes in different sustainability dimensions like environment, society, and economy (Haugjord & Aanestad, 2024; Kotlarsky et al., 2023; Schoormann et al., 2025). For example, some communities have achieved net-zero carbon emissions and surplus clean energy exports by adopting IS-enabled renewable energy systems (Xu et al., 2024; Young & Brans, 2017). Yet, little research explores how rural farmers leverage digital tools to achieve sustainable food systems (Rolandi et al., 2021). Addressing this gap, this study examines how farming communities transition to digital sustainability at the grassroots level.

This research adopts the Belief-Action-Outcome (BAO) framework to analyse the relationship between community beliefs, technological adoption, and sustainability outcomes. By shifting the focus from enterprise-led sustainability to grassroots digital transformation, the study contributes to IS literature on sustainability transitions by highlighting the unique dynamics of rural digital adoption and providing a nuanced understanding of how community beliefs shape technological adoption and drive sustainability outcomes. The findings offer policymakers and development practitioners actionable insights to design scalable, IS-driven sustainability initiatives, fostering rural self-sufficiency, environmental resilience, and economic viability.

Theoretical Framing

The Belief-Action-Outcome (BAO) framework (Melville, 2010) provides a structured approach to examining how farming communities leverage digital technologies to foster sustainability. To understand how farming communities adopt digital technologies to drive sustainability, this study applies the BAO framework (Melville, 2010). Traditionally used in Information Systems (IS) research, BAO frames belief, action, and outcome as key dimensions of digital transformation, offering insights into how IS enables sustainability (Molla et al., 2014). This study extends its application to smart farming communities in Thailand, investigating how digital technologies operationalise sustainability efforts within rural farming communities.

At the core of digital transformation in farming communities lies the belief phase, where individuals or organisations' cognitive and attitudinal foundation regarding specific issues or goals is formed. A mix of personal experiences, societal norms, organisational cultures, regulatory pressures, and environmental awareness influences beliefs (Lei et al., 2023; Melville, 2010). Various socio-organisational antecedents shape the perceptions about the role of digital technologies in sustainability (Melville, 2010). Social factors such as community norms, agricultural policies, market incentives, and digital accessibility significantly influence farmers' willingness to adopt new technologies (Felin & Foss, 2006). Communities with strong social support systems, favourable policies, and visible success stories of digital adoption are likelier to develop a positive outlook toward sustainability-oriented innovations. Organisational factors such as collective leadership, resource availability, and digital infrastructure determine how smart farming technologies are embraced (Bose & Luo, 2011; Xu et al., 2024). Farming communities with greater institutional backing, technical expertise, and financial support are better positioned to experiment with and integrate digital tools into their practices (Abiri et al., 2023; Cheng et al., 2024). By examining how these antecedents shape farmers' beliefs, this study provides deeper insights into the initial conditions that drive technology adoption in rural agricultural settings.

Once positive sustainability beliefs take root, they influence the action phase, where farmers actively integrate IS-driven solutions into their agricultural practices (Melville, 2010). Digital tools such as real-

time weather monitoring, data-driven precision farming, and automated irrigation systems play a crucial role in enhancing productivity and reducing environmental impact (Melville, 2010). However, adoption is not uniform across communities; it depends on how well digital solutions align with local farming needs and socio-economic realities (Farmtopia, 2025). While some communities successfully leverage technology for improved efficiency, others face barriers such as limited digital literacy, inadequate infrastructure, and economic constraints. The success of digital adoption in this phase hinges on ensuring that farming communities receive the necessary training, institutional support, and financial incentives to fully utilise smart farming technologies.

The outcome phase assesses the tangible impacts of digital innovations on sustainability, including improved farm productivity, optimised resource efficiency, and environmental resilience (Gholami et al., 2016; Melville, 2010). Communities that effectively integrate IS solutions often experience reductions in resource waste, increased yield stability, and stronger economic viability through data-driven decision-making (Ullah et al., 2023). However, achieving these outcomes requires ongoing investment in digital infrastructure, knowledge-sharing networks, and policy support to sustain the momentum of digital transformation (Xu et al., 2023). By analysing these interconnected processes, this study provides a comprehensive understanding of how farming communities transition from traditional to digital farming and the long-term sustainability benefits of digital adoption.

Prior IS research has demonstrated the relevance of the BAO framework in understanding how beliefs translate into digital action. For example, Anthony (2019) extended the framework by integrating it with Green IS research, highlighting the role of IT infrastructure and organisational strategies in shaping sustainable practices. Building on this foundation, this study explores how farming communities leverage digital technologies to foster sustainability transformation at the grassroots level (Loeser et al., 2017; Xu et al., 2024). Applying the BAO framework to rural farming settings provides critical insights into how digital innovations drive sustainability transitions, offering valuable contributions to the broader IS literature. The findings will enhance theoretical understanding and inform policymakers and development practitioners in designing targeted, IS-driven sustainability initiatives that empower rural farming communities, promote environmental resilience and ensure economic sustainability.

Research Design

We employed a qualitative case study approach to examine the complex phenomenon of digital sustainability adoption among young Thai smart farmers, conceptualising farming communities as networked collectives that drive sustainability in response to climate change. A case study methodology enables a contextualised exploration of how digital technologies shape farmers' beliefs, actions, and sustainability outcomes (Myers, 1997). To structure our case study, we adopted the structured-pragmatic-situational (SPS) approach (Pan & Tan, 2011), ensuring a rigorous yet adaptive research process.

Data Collection

Following the first step of the SPS approach, we worked on negotiating access to the potential case organisations and farmers. Access to farms required extensive coordination with local guides, frequent last-minute itinerary adjustments, and flexibility in navigating isolated areas. We engaged with a Thai researcher to develop an in-depth understanding of the country's agricultural landscape and key sustainability challenges. This engagement was instrumental in securing government support, which facilitated field access. To build foundational knowledge, we first conducted a preliminary analysis of secondary data from publicly available sources, allowing us to refine our research focus before initiating primary data collection.

Field visits were timed during the post-harvest season, when farmers are less occupied, enabling deeper engagement in the research process. Fieldwork posed several logistical challenges due to the remote locations, rugged terrain, and limited infrastructure across central and northern Thailand. Our research team often travelled hundreds of kilometres under unpredictable road conditions and changing weather patterns. Despite these challenges, in-person visits provided rich ethnographic insights, as farmers welcomed us into their communities, generously shared their experiences, guided us through their farms, and offered local produce, enhancing the authenticity of our findings. This also helped us develop and refine

a mental concept of the phenomenon along with the literature and adopted theory, which is the second step of the SPS approach.

In line with the third and fourth steps of SPS, we conducted semi-structured interviews with 25 informants: 15 smart farmers (five female, ten male), six representatives from five agri-tech companies, four independent researchers, and a key government official overseeing the agri-tech effort. This diverse sample allowed us to capture perspectives across the agricultural ecosystem, from on-the-ground experiences to policy and innovation insights. By engaging these varied stakeholders, we uncover the socio-technical dynamics shaping the adoption of digital sustainability practices and further develop the BAO framework. Triangulation was achieved through interviews, direct observations of farmers' app and device usage, and the analysis of digital artefacts, including device dashboards, app analytics, and social media. This multi-source approach verified behaviours, usage, and benefits, strengthening our findings.

To ensure reliability and validity, we employed a rigorous translation process for interview materials in the fifth step of SPS. Questions were first translated using Sonix, an AI-assisted translation and transcription tool and subsequently verified by a professional translator to ensure linguistic and contextual accuracy (Castilho et al., 2017). During interviews, a real-time interpreter facilitated communication, while a government official fluent in Thai and English supported our team by validating key responses. The researchers first recorded the interviews in Thai and used Sonix to generate Thai transcripts. A native Thai translator then reviewed these transcripts for accuracy. Sonix was subsequently used to produce English transcripts from the verified Thai text, and the final English transcripts were cross-checked to ensure correctness. This multi-layered approach, though time-intensive, enhanced the credibility of our findings by minimising translation bias and ensuring precise interpretation of farmers' narratives.

Data Analysis

We applied the Belief-Action-Outcome (BAO) framework to conceptualize farming communities as communities of practice adopting digital technologies for sustainability. Data analysis followed an iterative approach aligned with Steps 6 and 7 of the SPS method, ensuring strong theory-data alignment (Pan & Tan, 2011). Initial interviews were open-coded to identify beliefs, actions, and outcomes related to digital adoption in three phases based on interviewee responses. These first-cycle codes were grouped into higher-order themes, which informed the refinement of the interview protocol for a second round of data collection. We developed relational patterns among key concepts through axial coding, leading to the preliminary framework presented in Figure 1. While our final analytical stage is still in progress, we present a preliminary exploratory framework that captures key dynamics of digital sustainability adoption within farming communities. This approach enhances the empirical depth and theoretical rigour, significantly contributing to Information Systems (IS) research on grassroots digital transformation in sustainable agriculture.

Case Description

Rural Thai farmers have relied on inherited knowledge and community practices for generations and now face existential challenges. Rising costs, extreme weather, and an ageing farming population have made survival increasingly uncertain, threatening the sector's long-term viability (Jansuwan & Zander, 2021). Farmer B explains, *"Previously, weather conditions weren't a problem, so we never focused on them. But since last year, when the durian trees failed to bloom due to the heat and drought, it became crucial to prioritise understanding what factors, like temperature or humidity, might affect them."*

Faced with an uncertain future, young farmers embraced digital solutions. They leveraged IoT sensors, drones, and mobile applications while exchanging knowledge within their communities, collaborating with agricultural institutions, and securing government support to overcome challenges. Smart irrigation, precision agriculture, and automation have become integral to smart farming. This bold grassroots movement is now reshaping agriculture, driving resilience, sustainability, and a new farming era. For instance, a young farmer D shared how technology has transformed his work: "*Compared to last year, just my home's farm, about 4.5 acres, took three days with manual spraying. With a drone, it only took two hours. It's a huge difference."*

Today, smart farming has evolved into a thriving, community-driven movement, reshaping agriculture across Thailand. Digital technologies have enhanced yields, optimised resources, and improved

sustainability. As farmers experience the benefits, they expand these practices to new regions and crops, driving wider adoption. Collaboration with government and industry continues to strengthen resilience against climate and economic challenges, positioning technology as the key to a more sustainable future for Thai agriculture. For instance, one farmer notes, *"Technologies can aid in conserving water, improving soil quality, pest control, energy efficiency, and adapting to climate conditions. But it's not just about technology; it's about the awareness and knowledge of the farmers to choose safer alternatives, like biotechnology over harmful chemicals." Claimed a farmer E*

Preliminary Insights

In this section, we draw upon our case study to develop a model of BAO before, during, and after digital sustainability transformation (Figure 1). Our preliminary analysis reveals a three-stage transformation in Thailand's agricultural sector, progressing from traditional farming practices to smart farming adoption, culminating in a digitally enabled sustainable agri-ecosystem. This evolution underscores the role of IS in facilitating digital sustainability transitions, where technological adoption drives structural and behavioural shifts within farming communities.

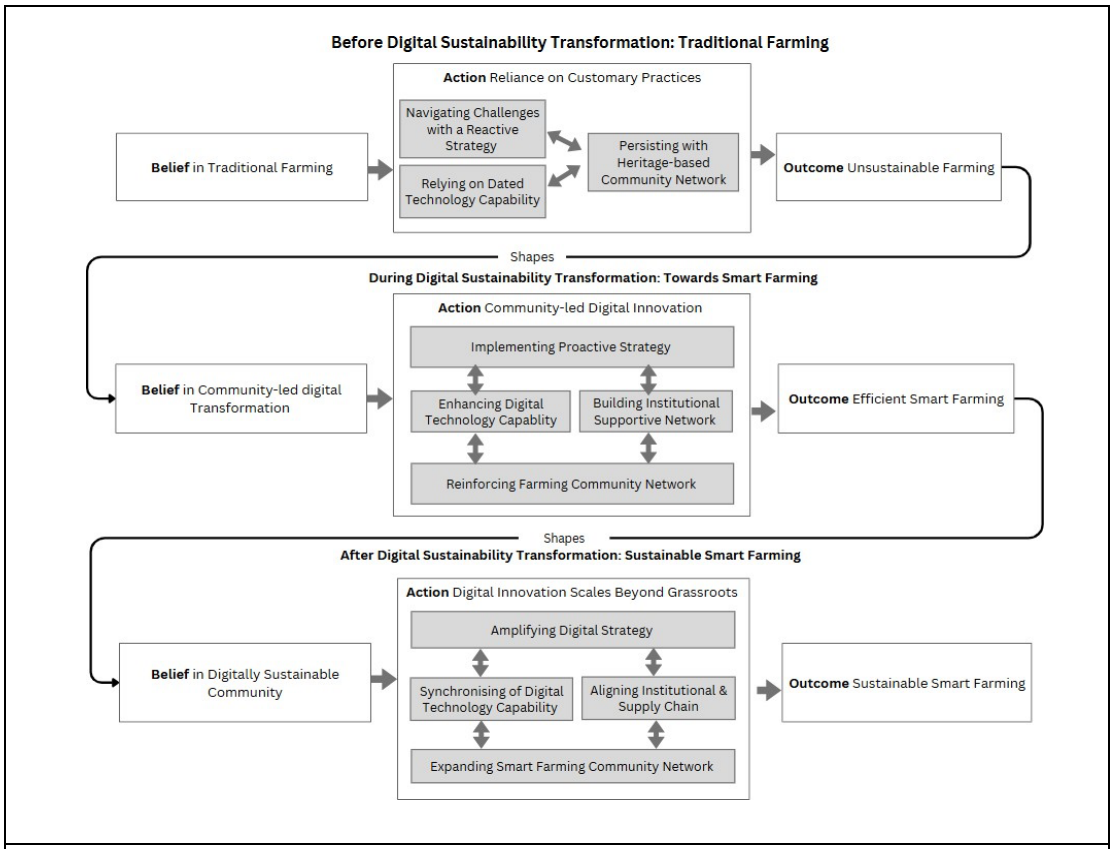

Figure 1. Smart Farming Transformations Based on the BAO Framework

BAO Framework Before Digital Sustainability Transformation

The belief phase in the BAO framework represents the foundational perceptions and mental models that shape decision-making within a given context (Lei et al., 2023; Melville, 2010)Our preliminary findings indicate that trust in traditional practices and established community-based values within the farming communities influenced farmers to continue traditional farming. Trust in community-shared knowledge preserves generational farming techniques, shaping social and cultural practices in traditional farming.

The action phase examines the farming community's activities based on strategy, resources, capabilities and limitations (Isensee et al., 2023; Melville, 2010). Our preliminary analysis reveals that rural Thailand's traditional farming still relies on heritage-based customary practices, shaped by reactive strategies and dated technology (Pimpa, 2024). The reactive nature of farming strategies limits planning, reducing farmers' ability to anticipate environmental or market shifts (Altieri & Nicholls, 2017). Heritage-based community networks foster resilience and collective identity but reinforce customary knowledge transmission, slowing the adoption of data-driven, precision agriculture practices.

Reliance on traditional farming systems has led to unsustainable outcomes, including environmental degradation, social disparities, and technological lag, weakening resilience and long-term sustainability. The lack of modern technology reinforces inefficiencies, limiting farmers' ability to adapt to climate variability, optimise resources, and improve productivity (Abiri et al., 2023). While traditional practices support local adaptation, they lack the flexibility to address disruptions like water scarcity, pollution, and soil degradation, pushing many farms below sustainable productivity levels (Udomkerdmongkol & Chalermpao, 2020).

BAO Framework Transitioning Towards Smart Farming

The unsustainable outcomes of traditional farming have created an urgent need for change, shaping the belief and driving the transition to smart farming. Community-led digital sustainability transformation is crucial in shaping belief formation and fostering openness to new farming practices and technological adoption in this shift.

This transformation is driven by necessity and reinforced through shared success stories, which fuel technological optimism and strengthen confidence in digital solutions, ultimately fostering belief in digital innovation. While prior research on the BAO framework has predominantly emphasised social and organisational antecedents (Bose & Luo, 2011; Xu et al., 2024). Our findings highlight the equally significant role of technical antecedents in shaping farmers' belief formation

In the action phase, farming communities adopt proactive strategies, reinforced by cooperative models, peer learning, and shared access to digital resources, ensuring that technology adoption remains inclusive and sustainable. The integration of advanced digital technologies, such as IoT, drones, and mobile applications, drives a transition from intuition-based decision-making to data-driven agricultural practices (Nationthailand, 2025). Their collective efforts empower them to advocate for institutional support. In response, government agencies have introduced financial incentives and capacity-building programs, facilitating the sustainable digital transformation of farming (JTMAsia, 2024).

The outcome of this transition is a more resilient smart farming system, enhancing adaptability to environmental and market fluctuations. By leveraging data-driven decision-making, farmers achieve greater efficiency, optimise resource allocation, and adopt sustainable practices. This shift lays the foundation for institutionalised, long-term digital sustainability.

BAO Framework of Digital Sustainability in Smart Farming

As smart farming resilience strengthens, farming communities progress beyond initial adoption, developing a belief in digitally sustainable community farming. This transformation signifies a shift from perceiving digital tools as supplementary enhancements to recognising them as essential for long-term sustainability. Positive smart farming outcomes reinforced this confidence in technology (Tsoumas et al., 2022).

Farmers' confidence in success motivated them to take action, scaling rural grassroots initiatives into regional-level implementations. This expansion is driven by digital strategies that align digital sustainability innovation with national Thai sustainability policies, ensuring that technological advancements are embedded within broader policy frameworks (OECD, 2018)As digital capabilities advance across Thai farming systems, integrating digital innovations, such as IoT, mobile platform customisation, and automation, enhances efficiency and data-driven decision-making. With growing confidence, smart farming community networks continue to expand, supported by farmer-led grassroots mentorship programs, further accelerating digital adoption across the whole farming supply chain.

The outcome of this final phase is a fully institutionalised and regionally integrated smart farming system that is adaptable, interoperable, and sustainable. Smart farming practices are increasingly embedded within the smart farming landscape, enabling farmers to proactively respond dynamically to environmental and economic fluctuations. This transformation results in more resilient, economically viable, and ecologically sustainable farming, offering long-term food security and climate resilience.

Preliminary Theoretical and Practical Contributions

This study advances research in digital sustainability within the Information Systems (IS) domain by providing a focused extension of the Belief-Action-Outcome (BAO) framework to explain grassroots digital transformation dynamics in rural farming communities. While previous Green IS research has emphasised the adoption of environmentally friendly technologies at organisational or individual levels, our study shifts attention to community-driven, socio-technical transitions, addressing a critical gap identified in recent IS literature (e.g., Kotlarsky et al., 2023; Gholami et al., 2016). Specifically, we refine the BAO framework by integrating the role of networked ecosystems (e.g., trust networks, peer knowledge sharing) and farmer-initiated support requests (e.g., government assistance on request) as mediating mechanisms between beliefs and actions. This enriches understanding of sustainability transitions as nonlinear, emergent processes rather than linear adoption paths.

Further, by conceptualising digital sustainability as an embedded, evolving system shaped by community beliefs, socio-technical affordances, and grassroots interventions, our research offers novel IS-based insights distinct from traditional sustainability science models that often emphasise top-down diffusion mechanisms. This study contributes to advancing and shaping a new understanding of digital sustainability (Kotlasky et al. 2023) at the grassroots level, an area currently underrepresented in IS scholarship.

Practically, this study offers actionable insights for policymakers, agritech firms, and sustainability practitioners. It identifies key enablers (e.g., trust in technology, community knowledge-sharing, and grassroots initiatives) and barriers (e.g., digital literacy gaps, infrastructural challenges) that influence IS adoption in agriculture (Yu et al., 2020). By uncovering the socio-institutional dynamics underlying smart farming transformations, this research guides the design of targeted, localised interventions to promote digital sustainability in rural communities. Our findings stress the importance of bottom-up, community-driven strategies over purely technology-centric approaches for achieving inclusive and scalable sustainability transitions in developing economies.

Discussion, Next Steps and Limitations

This research examines how farming communities transition from traditional farming practices to digitally enabled sustainability, providing preliminary insights into the role of IS in agricultural transformation. The findings suggest successful IS adoption depends on technological implementation, strong community networks, policy support, and strategic scaling mechanisms. However, further empirical validation is required to substantiate these claims and refine the proposed framework.

Future work will focus on collecting additional data, analysing long-term impacts, and evaluating the scalability of digital sustainability initiatives. This ongoing study contributes to the IS literature on grassroots digital transformation. It aims to develop a more comprehensive understanding of how IS solutions can drive sustainable agricultural practices in diverse socio-economic contexts.

As a research-in-progress paper, our study presents early insights into community-driven digital sustainability in agriculture. We acknowledge that the theoretical contribution is still under development and would benefit from more precise articulation of the conceptual framing and the potential extension of the BAO framework. While we draw on Green IS and broader sustainability literature, future iterations will focus on core IS and sustainability science debates. Additionally, we recognise the need to strengthen alignment between our research goals, framing (e.g., grassroots focus), and the structure of the BAO phases to enhance coherence and theoretical clarity.

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