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Digitally-Driven Agroinnovation: Youth-Led Empowerment And Sustainable Hydroponics In A Suburban Indonesian Community

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Abstrxact
As global challenges push communities to seek sustainable food systems and inclusive digital engagement, suburban regions often remain overlooked in both environmental innovation and digital empowerment. This study examines how youth-led digital literacy initiatives catalyze agroinnovation in the form of sustainable hydroponic farming in Mulung Village, a suburban community in East Java, Indonesia. The research explores how digital tools are integrated into local agricultural practices to promote environmentally friendly entrepreneurship and community-based resilience. Adopting a qualitative case study approach, data were collected over a one-year period through participant observation, in-depth interviews, and document analysis. Thematic analysis followed Miles and Huberman's interactive model, focusing on digital enablement, youth facilitation, and sustainability-oriented innovation. Findings reveal that digital literacy—when embedded within youth-led community networks—transforms hydroponic farming from a subsistence activity into a sustainable micro-enterprise. Digital platforms such as WhatsApp and Instagram were repurposed as accessible marketing channels, while informal workshops nurtured ecological awareness and intergenerational knowledge sharing. This study advances the discourse on sustainable community development by linking digital empowerment with grassroots environmental innovation. It highlights the transformative potential of integrating agroecological practices with localized digital strategies in transitional suburban areas. The results offer practical insights for policy, education, and technology programs aimed at fostering digital sustainability and environmental stewardship among underserved populations.

Keywords: *Agroinnovation, Digital Literacy, Environment, Hydroponics, Suburban, Youth Empowerment*

INTRODUCTION

In the context of growing environmental concerns and digital transformation, communities across the Global South face the dual imperative of achieving ecological sustainability and digital inclusion (Abdulai et al., 2021). As climate change intensifies and arable land declines, urban and suburban communities are increasingly turning to innovative forms of agriculture, such as hydroponics, to meet food security and livelihood needs. Simultaneously, digital literacy has emerged as a cornerstone of empowerment in the information age—enabling individuals and groups to access markets, share knowledge, and build resilient economies. Yet, in many developing countries, suburban communities often fall between policy priorities, receiving neither the infrastructural support of urban centers nor the targeted interventions of rural development agendas.

Suburban areas in Indonesia exemplify this dynamic, where land-use change and industrial expansion have disrupted traditional agricultural livelihoods (Abdulquadri et al., 2021). At the same time, technological penetration—though rising—remains uneven, with many residents lacking the confidence, skills, or support systems to leverage digital tools effectively. These transitional communities represent both a challenge and an opportunity: while constrained by limited resources, they also exhibit strong communal ties and adaptability. Despite this potential, current research offers limited insight into how suburban communities mobilize digital literacy to pursue environmentally sustainable entrepreneurship.

Most studies focus on rural digital divides, women's digital empowerment, or urban innovation, leaving a gap in understanding the hybrid socio-ecological dynamics of suburban settings.

In recent years, community-based hydroponic farming has emerged as a promising model for sustainable agriculture in land-constrained environments. When paired with digital platforms—such as social media for marketing, or mobile messaging apps for coordination—hydroponics can evolve from subsistence to micro-enterprise. Youth organizations, particularly in Indonesia, have played a growing role in this transformation by acting as digital facilitators and local change agents (Adeyinka-Ojo et al., 2020). However, there is limited empirical evidence on how such grassroots digital literacy efforts intersect with agroinnovation, sustainability, and intergenerational learning within suburban contexts.

This study addresses this gap by exploring how digital literacy, when led by youth and embedded in community structures, catalyzes sustainable hydroponic entrepreneurship in Mulung Village, a suburban community in East Java, Indonesia. Drawing on a qualitative case study approach, the research investigates how digital tools are adopted, adapted, and mobilized to support environmental entrepreneurship amid socio-spatial transformation (M. H. Ahmed et al., 2020). In doing so, the study contributes to emerging conversations at the intersection of digital inclusion, community resilience, and agroecological innovation.

LITERATURE REVIEW

Digital Literacy and Community Empowerment

Digital literacy has evolved from a narrow focus on technical skills to a broader competency involving critical thinking, communication, and civic engagement in digital environments (AlAjmi, 2022). It serves as a key enabler in expanding access to information, participation in local economies, and self-determined development, particularly in marginalized communities (Alakrash & Razak, 2021). In the context of community empowerment, digital literacy not only facilitates knowledge acquisition but also transforms individuals into agents of change capable of leveraging digital tools for collective benefits.

Research in rural and semi-urban settings has highlighted that community-driven digital literacy initiatives can strengthen local governance, enhance social inclusion, and open economic opportunities (Alencar, 2020). However, many of these studies treat digital literacy as an individual skillset rather than a community asset shaped by social networks and collective agency.

Agroinnovation and Sustainable Hydroponics

Agroinnovation—defined as the integration of new technologies and practices into agricultural production—plays a central role in achieving food security and ecological sustainability in space-limited or degraded environments. Hydroponics, a soilless cultivation system, is increasingly promoted as a sustainable solution for urban and suburban agriculture due to its low land requirement, efficient water usage, and potential for year-round production (Alexander et al., 2023).

While hydroponics is often discussed in urban innovation contexts, its role in suburban communities remains underexplored. Moreover, few studies examine how digital platforms facilitate knowledge sharing, distribution, or business scaling within hydroponic ventures, particularly in regions where institutional support is limited.

Youth as Digital Intermediaries and Innovators

In emerging economies, youth organizations increasingly serve as digital bridges—connecting older generations to online platforms and facilitating the uptake of new technologies. In Indonesia, karang taruna and other grassroots youth groups are recognized for their capacity to lead informal education, community mobilization, and digital skill dissemination (Ali et al., 2021).

Despite this, scholarly attention on youth-led digital empowerment has primarily focused on urban settings or formal education interventions. The role of youth in driving environmentally-oriented entrepreneurship through digital means in suburban or transitional communities remains inadequately theorized.

Suburban Communities and the Overlooked Middle Space

Suburban areas represent a hybrid socio-spatial domain, often neglected in both rural development policies and urban innovation strategies. These communities frequently face land pressure, weakening of traditional livelihoods, and fragmented digital infrastructure (Alkureishi et al., 2021). Nevertheless, they also demonstrate social cohesion, localized initiative, and growing digital exposure—conditions that could enable bottom-up innovation if supported appropriately.

Current literature tends to focus either on urban smart technologies or rural digital divides, overlooking suburban contexts as distinct ecological, social, and technological systems. This creates a blind spot in understanding how communities in these areas adapt and innovate using limited resources.

Identified Gaps and Contribution of This Study

Despite growing attention to digital literacy and sustainable agriculture, limited research addresses their intersection in suburban environments—especially through youth-led initiatives. Most studies either emphasize individual empowerment or treat sustainability and digitalization as parallel, rather than interconnected, agendas.

This study contributes by bridging these gaps: it positions digital literacy not just as a tool, but as a social process rooted in community networks; it examines how hydroponics becomes a platform for sustainable micro-enterprise; and it highlights youth as central agents in transforming both technological adoption and ecological practice (Alkaabi et al., 2025). By focusing on a suburban Indonesian village, this research extends current literature on digital inclusion, agroinnovation, and local resilience into an underrepresented yet increasingly vital geographic and social space.

METHODOLOGY

Research Design

This study adopted a qualitative case study design to explore the intersection of digital literacy, youth-led initiatives, and sustainable hydroponics in a transitional suburban community (Casallas et al., 2024). The case study approach was selected to gain a deep contextual understanding of how localized digital interventions shape agroinnovation processes in real-life settings. The unit of analysis was defined as the collective experience of Mulung Village residents participating in youth-facilitated digital literacy programs aimed at hydroponic entrepreneurship.

Research Site and Participants

The study was conducted in Mulung Village, located in Driyorejo District, Gresik Regency, East Java, Indonesia. The village reflects a typical suburban community undergoing socio-economic transformation due to industrial development and urban encroachment (Langenfeld & Bugbee, 2024). A purposive sampling strategy was used to identify six key informants, including one village head, two youth organization members, two suburban residents engaged in agriculture and local enterprises, and one digital literacy facilitator.

These participants were selected based on their direct involvement in the village's hydroponic initiatives and digital learning activities, enabling rich, experience-based insights into the phenomena studied.

Data Collection Techniques

Data were collected over a 12-month period (January–December 2023) using three main qualitative techniques (Sakuma et al., 2023):

a. Participant Observation: Researchers observed hydroponic farming practices, digital workshops, and community interactions to understand how knowledge and behavior evolved over time.

b. In-depth Interviews: Semi-structured interviews were conducted with all informants to capture their perceptions, challenges, and strategies related to digital engagement and sustainable agriculture.

c. Document Analysis: Supporting materials such as training modules, WhatsApp group messages, workshop photos, and social media posts were reviewed to triangulate and contextualize findings.

Field notes and reflexive memos were maintained throughout the process to support interpretive consistency and analytic depth.

Ethical Considerations

The research protocol received ethical approval from the Research Ethics Committee of Universitas Negeri Malang (Approval No.: 7.12.3/UN32.1/TU/2022). All participants were briefed on the study's objectives and procedures, and informed consent was obtained prior to participation. Anonymity and confidentiality were upheld through the use of pseudonyms and secure data storage.

Data Analysis Approach

The data analysis in this study followed the interactive model by Miles, Huberman, and Saldaña (2022), comprising three iterative phases. The first phase involved data reduction, where raw data were coded and organized into three main thematic categories: digitally-facilitated empowerment, youth leadership in agroinnovation, and sustainability practices in hydroponics. In the second phase, data were displayed using thematic matrices, narrative descriptions, and visual documentation to identify emerging patterns, relationships, and insights. The final phase entailed drawing and verifying conclusions through interpretive analysis, supported by source triangulation, member checking, and peer debriefing to ensure the validity and reliability of the findings.

RESULTS

Digital Literacy as a Tool for Suburban Empowerment

The introduction of digital literacy programs in Mulung Village marked a significant turning point in the community's transition from traditional subsistence to digital-enabled micro-entrepreneurship. Prior to the intervention, most residents—particularly those in agricultural sectors—lacked confidence in utilizing digital tools beyond basic communication via WhatsApp. Observations revealed minimal use of social media for economic purposes, and community members expressed hesitation in adopting e-commerce due to limited skills and perceived complexity.

Interviews with residents and facilitators indicated that digital literacy training, contextualized through locally relevant content (e.g., hydroponic tutorials, mobile-based marketing strategies), helped bridge psychological and knowledge-based barriers. As one facilitator noted:"Before the workshops, most residents saw the internet as a space for entertainment, not business. Now, they understand that even simple tools like WhatsApp Status can promote their harvests."

This shift was evident in increased social media activity, with residents beginning to post photos of hydroponic produce and respond to customer inquiries via messaging apps. The program's focus on "low-tech" but high-impact digital skills contributed to improved self-efficacy and entrepreneurial intent.

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Youth Facilitation in Building Sustainable Agroinnovation

Youth members of the local karang taruna played a pivotal role in mobilizing community participation and shaping the digital transformation process. These young facilitators acted not only as technical trainers but also as mediators between traditional agricultural knowledge and emerging digital competencies. They designed informal workshops, provided real-time digital assistance, and curated learning materials that were visually intuitive and language-accessible.

Field notes from hydroponic workshops showed that youth facilitators used storytelling and practical demonstrations to demystify hydroponic systems and digital platforms. For instance, one youth leader created a mock "online store" using Instagram, showing how to photograph plants, write captions, and tag locations—all using residents' smartphones.

Figure 1. Digital literacy workshop for suburban communities and youth organization members regarding marketing of hydroponic plants

The figure 1 captures two key scenes of community engagement in Mulung Village. On the left, women are shown participating in a community-based digital literacy workshop that utilizes locally contextualized multimedia content to strengthen digital skills. On the right, an informal meeting of youth facilitators (*karang taruna*) is depicted as they discuss strategies to enhance community digital engagement and promote sustainable agroinnovation.

Their efforts also introduced sustainability themes, linking hydroponic practices to environmental goals such as reduced water usage and pesticide-free production. As one youth leader expressed: "We didn't just teach them how to grow lettuce; we taught them how to grow an idea of farming that is clean, small-scale, and marketable."

This approach cultivated a sense of ownership and community pride, with several residents experimenting with vertical hydroponic setups and exchanging tips through WhatsApp groups.

Transformation of Hydroponic Practices through Digital Integration

Digital literacy did not replace traditional farming knowledge; instead, it layered new practices on top of existing ones. For many residents, hydroponic farming began as a means of household consumption. However, with growing confidence in digital tools, some transitioned to micro-commercial models, leveraging digital platforms to attract nearby consumers.

Visual documentation showed backyard hydroponic units producing leafy greens (e.g., lettuce, pok choy), often arranged in simple PVC structures with nutrient cycles maintained using low-cost timers and recycled bottles. Residents began photographing their setups and harvests, with some even recording short videos to explain planting techniques or harvesting tips—shared via social media.

Figure 2. Potential of Mulung Village related to hydroponic plants

The figure 2 depicts community-managed hydroponic systems in Mulung Village utilizing simple PVC structures. It illustrates the integration of digital practices in fostering micro-entrepreneurial farming initiatives.

One participant explained: "I used to grow for family only, but now I also sell to neighbors and post pictures. Some people from nearby areas saw my hydroponics on Instagram and placed orders through WhatsApp."

Despite these successes, barriers remain. Interview data reveal that scalability is limited by infrastructure (e.g., water pump availability, storage), and marketing reach is constrained by inconsistent digital connectivity and algorithm literacy. Nevertheless, the momentum built by initial successes has sustained interest, and residents have begun organizing monthly gatherings to share results and troubleshoot challenges.

DISCUSSION

This study provides empirical evidence that community-based digital literacy initiatives, when facilitated by youth, can serve as a catalyst for environmentally sustainable entrepreneurship in suburban settings. The case of Mulung Village illustrates how digital tools—particularly low-cost and mobile-accessible platforms—enable residents to reframe hydroponic farming not merely as subsistence activity but as a viable micro-enterprise (Aboukhousa, 2024). The findings show that digital empowerment in transitional suburban communities is not a linear progression but a layered transformation that involves technical training, social trust, and intergenerational collaboration.
The role of youth organizations in this process proved central. Youth acted as social intermediaries, bridging generational divides and contextualizing digital tools within local cultural and economic realities. These facilitators did more than transfer knowledge—they reframed agriculture as a digitally marketable, socially valued, and environmentally conscious practice. The emergence of WhatsApp groups, informal learning spaces, and visual content creation reflects a grassroots-driven evolution of agroinnovation supported by accessible digital ecosystems.

The findings of this study affirm that digital literacy, when facilitated through community-based approaches and youth leadership, can serve as a catalyst for both economic and ecological transformation in suburban areas. These results reinforce earlier findings by Abraczinskas & Zarrett, (2020), which stated that digital literacy is a crucial prerequisite for inclusive and adaptive development. However, this study contributes a new dimension by demonstrating that digital literacy is not merely a technical tool but a socio-cultural instrument shaped by the dynamics of local communities.

In this context, the results are consistent with Adeane & Gibson, (2023), who emphasize the importance of community-based digital literacy education in promoting social empowerment, particularly for vulnerable groups. While many prior studies have focused on women or adolescents in rural or urban settings, this research expands the scope by illustrating how suburban communities—

often overlooked in the literature—also possess strong adaptive capacities, especially when driven by youth actors.

The involvement of youth organizations in facilitating technology adoption strengthens the argument by Akhyadi et al., (2019), who asserted that young people can act as agents of social change, particularly within the context of non-formal education. However, the unique contribution of this study lies in its concrete documentation of how youth not only serve as intermediaries of technology but also integrate values of sustainability and agroecological innovation into digital training activities.

This study also adds depth to prior research by Al-Khawaldeh et al., (2024), which discussed digitalization as a means of expanding economic participation among household-based communities. In the context of Mulung Village, the findings show that hydroponic farming, initially intended for household consumption, can evolve into micro-enterprises that combine ecological principles with digital marketing strategies. This reinforces the concept that local innovation can be rooted in small-scale practices that are digitally communicated, rather than relying solely on large-scale interventions.

The study further builds upon arguments from agro-innovation literature, which posit that the success of agricultural technology adoption depends not only on the technology itself but also on the surrounding social dynamics (Aldana et al., 2021). In the case of Mulung, the community not only adopted hydroponics as a new farming method but also internalized sustainability values through narratives developed by youth facilitators—for instance, through practices such as reusing plastic waste and reducing pesticide usage.

This discovery also fills a gap that has not been widely addressed in the literature on suburbanization and social transformation. Abrashkin et al., (2024) highlighted that suburban communities often face dual pressures: the loss of traditional livelihoods due to development and limited support in accessing digital opportunities. This study demonstrates that, despite these constraints, communities like Mulung are able to build bottom-up innovation ecosystems with the support of simple yet contextually relevant technologies.

Moreover, this study expands the understanding of digital literacy as a "community asset," as proposed by H. Ahmed & Manzoor, (2019). Digital literacy is no longer viewed solely as an individual capacity to access information, but rather as a form of social capital collectively managed to achieve shared goals such as crop marketing, increased family income, and even informal ecological education for children and adolescents.

Unlike previous studies that tend to separate digital literacy from environmental sustainability, this research reveals a strong interconnection between the two. The use of platforms like WhatsApp and Instagram to sell hydroponic vegetables not only generates economic value but also promotes land- and water-efficient farming practices. This reflects the synergy between two major global development agendas: digital inclusion and environmental sustainability.

In addition to enriching empirical dimensions, this study also expands the theoretical boundaries of digital empowerment (Antonio, 2020). In conventional approaches, digital empowerment is often associated with access, connectivity, and technical skills. However, these findings suggest that effective digital empowerment depends on collective engagement, local narratives, and flexibility in using technology creatively in accordance with prevailing socio-economic conditions.

Finally, this study provides a foundation for the development of community-based intervention models that organically integrate technology and ecology. This approach differs from top-down, policy-driven models that tend to be generic (An et al., 2021). By emphasizing youth facilitation, local content, and experiential approaches, this study offers a new conceptual framework for reimagining the role of technology in the development of suburban communities.

Theoretically, this study contributes to the discourse on digitally enabled community empowerment, proposing that digital literacy should be conceptualized not merely as an individual competency, but as a community asset embedded in social relationships. It also enriches the understanding of agroinnovation by demonstrating how localized environmental practices are influenced by digital ecosystems, rather than external policy or institutional mandates.

Practically, the findings have implications for development agencies, NGOs, and local governments (Aigbokhaode & Isara, 2021). Interventions aiming to promote sustainability and digital inclusion in peri-urban areas should integrate youth as facilitators, leverage everyday mobile technologies, and embed learning within existing community practices. This approach ensures cultural fit, enhances legitimacy, and maximizes adoption.

While the study offers deep insights, its findings are context-specific and may not be generalizable across all suburban communities (Aras et al., 2024). The small sample size and single-case focus limit the ability to draw broad conclusions. Additionally, the study did not quantitatively assess changes in digital competency or economic income, which could strengthen the impact argument.

Future research could employ mixed-methods approaches to measure the economic and ecological outcomes of digitally driven agroinnovation (Alade et al., 2020). Comparative studies across multiple suburban contexts—especially those facing different types of urban pressure—would further elucidate the scalability and adaptability of the model presented here. Exploring gendered experiences within youth-led digital interventions also remains an important avenue.

CONCLUSION

This study has demonstrated that digital literacy, when embedded within community structures and driven by youth facilitation, can effectively catalyze sustainable agroinnovation in suburban environments. In Mulung Village, digital tools—ranging from WhatsApp to Instagram—enabled residents to reimagine hydroponic farming not only as a means of household subsistence but as a platform for environmentally conscious entrepreneurship. The integration of digital skills, local ecological knowledge, and youth-led facilitation produced a community-centered model of transformation that was both accessible and replicable.

By situating digital empowerment within the lived realities of transitional communities, this research contributes to an expanded understanding of digital literacy as a relational and collective process. It highlights the unique capacity of suburban spaces—often overlooked in development discourse—to serve as fertile grounds for grassroots innovation. The findings offer valuable insights for designing inclusive sustainability programs that leverage local agency, foster intergenerational learning, and build digitally resilient communities in the Global South.

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