

# Evaluating the Twin Transition and Sejiwa Senyawa Framework for Rural MSME Digital Resilience

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## ABSTRACT

In the aftermath of the global pandemic, rural Micro, Small, and Medium Enterprises (MSMEs) have undergone a significant transformation in market expectations, with the traditional appeal of handmade products now scrutinized under health-oriented standards. This study examines the socio-technical phenomenon of Twin Transition, the simultaneous adoption of appropriate physical technologies and digital platforms within the cassava-processing landscape in Pandansari Lor, East Java, Indonesia. Employing a qualitative methodology, the research analyzes the transition from artisanal, manual labor to mechanized *Sarmiler* printing technology. Beyond simple capacity expansion, the findings reveal a deeper conceptual shift: Quality Consistency emerges as a critical indicator of consumer health resilience. The analysis suggests that success in digital marketing is not only a technical milestone but also a validated signal of trust, heavily reliant on the physical standardization facilitated by mechanization. This paper introduces the Sejiwa-Senyawa framework, a model of engagement that harmonizes academic expertise with community practices. By emphasizing the importance of consistency rather than production volume, this research argues that the effective implementation of grassroots innovations is fundamental to the rural digital economy.

**Keywords:** Consumer Health Resilience, Good Manufacturing Practices, Digitalization, Quality Consistency  
JEL Codes: O33; L26; Q01; M31.

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## INTRODUCTION

The global economic landscape has undergone a tectonic shift following the COVID-19 pandemic. This era, often characterized as the New Normal, has fundamentally restructured consumer behavior, particularly within the food and beverage sector. Modern consumers are no longer solely driven by price; instead, there is an escalating demand for health-conscious, traceable, and clean-label products (Beglaryan et al., 2024). This shift is particularly evident in emerging economies like Indonesia, where the intersection of traditional culinary heritage and modern health awareness has created a burgeoning market for local snacks. For rural Micro, Small, and Medium Enterprises (MSMEs), this shift represents a historical window of opportunity. Traditional snacks, historically viewed as secondary or street-side commodities, are being reimagined as high-value, healthy alternatives to processed industrial snacks. However, this opportunity is shadowed by a significant structural challenge: the transition from subsistence-level manual production to formalized, industrial-grade quality (Affandi et al., 2024).

In addition, Indonesian rural development is deeply rooted in the MSME sector, which contributes

over 60% of the national GDP. Within these rural clusters, production has traditionally been an artisanal, handmade endeavor. While handmade once signaled authenticity, in the modern digital marketplace, it often serves as a proxy for inconsistency (Indrawati et al., 2025). The Quality Consistency Gap is a systemic barrier that prevents rural products from entering formal retail value chains. When production relies solely on manual labor, variables such as product thickness, texture, moisture content, and hygiene fluctuate significantly. In the snack food industry, specifically products like *Sarmiler* (cassava-based chips), consistency is the bedrock of consumer trust. If one batch is crisp and the next is soggy or unevenly cooked, the brand equity erodes instantly (Jaswadi et al., 2015).

Furthermore, hygiene standardization has moved from a secondary concern to a primary market requirement. The post-pandemic consumer is hyper-aware of food handling processes. Processes that require substantial direct human interaction are being met with growing skepticism. Thus, the rural entrepreneur is trapped: they have a product the market wants, but a production method the market no longer trusts. In response to these challenges,

government and academic interventions have heavily focused on Digitalization. The common belief is that joining an e-commerce platform or utilizing social media marketing will resolve the economic challenges faced by rural MSMEs. However, this study argues that Digital-Only interventions are a mirage (Trinugroho et al., 2022).

Digitalization acts as a high-fidelity Signal. Through web-based marketing and social media, an MSME promises a certain level of quality and experience to a consumer who may be hundreds of miles away. According to Signaling Theory, the digital interface is the signal, and the physical product is the Realization. When a rural MSME uses advanced digital marketing to sell an inconsistent, manually produced product, an Expectation-Performance Discrepancy occurs. The digital success actually accelerates the business's downfall because it amplifies negative feedback when the inconsistent physical product fails to meet the standardized digital promise (Tjahjadi et al., 2022).

This paper proposes a radical departure from Digital-First strategies. We introduce the Twin Transition framework, a concept originally popularized in European policy to describe the intersection of Green and Digital transitions, reimagined here for rural industrialization. In the framework, the Twin Transition is the synchronized integration between Appropriate Technology (the physical transition) and Digital Platforms (the virtual transition). Appropriate technology refers to mechanical interventions that are culturally, economically, and technically suited to the local environment. It is not high-tech in the sense of robotics, but smart-tech, focused in solving specific physical bottlenecks in the context of Pandansari Lor Village. The intervention centers on a mechanical *Sarmiler* printing machine and oil-spinner technology. This physical transition is the anchor. It ensures that every unit of production is identical in terms of dimensions and hygiene. Only when this physical anchor is in place does the digital transition become viable. The digital platform then moves from being a mere sales tool to becoming a scaling tool.

### LITERATURE REVIEW

#### Appropriate Technology (AT)

The conceptualization of Appropriate Technology (AT) originated with E.F. Schumacher's Small is Beautiful philosophy, which posits that technology should be designed to serve people and their environment rather than forcing people to adapt to it. In the context of rural MSMEs, AT is not merely a simplified version of modern machinery; it is a strategic intervention designed to resolve specific localized bottlenecks (Schumacher, 1973). For the cassava-processing clusters in Indonesia, the primary bottleneck

is not labor availability, but labor *variability*. Manual slicing and printing of *Sarmiler* chips involve human fatigue, varying pressure, and subjective measurements. This variability is the antithesis of industrial quality. Appropriate technology, such as the mechanical *Sarmiler* printing machine developed through the University of Brawijaya's expertise, addresses this by standardizing the product's physical attributes.

The literature on AT highlights three critical pillars for successful implementation in rural settings (Martini et al., 2023):

- a) Technological Fitness: The machine must be maintainable using local skills and spare parts. If a machine requires a specialized engineer from a capital city to fix a minor gear issue, it is no longer appropriate.
- b) Economic Viability: The capital expenditure (CAPEX) must align with the micro-financing capabilities of village cooperatives.
- c) Cultural Alignment: The technology must augment, rather than replace, the communal nature of village work, allowing the village's social capital to remain intact while boosting economic output.

#### Quality Consistency

In the food processing literature, Quality Consistency is often defined as the degree to which a product meets a predetermined specification with minimal variance. Schilling & Seuring (2023) argue that in the service and product industries, consistency is the primary driver of perceived value. For a consumer, consistency reduces the cognitive load of decision-making. However, in the context of post-pandemic food consumption, consistency takes on a deeper, more vital role: it serves as a proxy for health and safety. When a chip is printed with inconsistent thickness, its behavior during the frying or drying process becomes unpredictable. Thicker sections may remain undercooked (retaining moisture that leads to microbial growth), while thinner sections may overcook (producing acrylamides, a chemical byproduct of high-heat cooking) (Affandi et al., 2024). Therefore, the mechanical standardization provided by AT is not just an aesthetic improvement; it is a Health Guarantee. By ensuring that every *Sarmiler* chip has the same surface area and thickness, the heat distribution during processing becomes uniform. This uniformity ensures that pathogens are eradicated and moisture levels are consistent, thereby extending shelf-life without the need for excessive chemical preservatives. This alignment with Green and Healthy trends makes the product viable for modern retail (Srimulyani et al., 2023).

#### The Digital Divide

The Digital Divide is a multi-layered phenomenon. Initially, scholars defined it as a gap in physical access to hardware and the internet (the first-level divide). However, more recent research, such as that by Beglaryan et al. (2024), identifies a second-level divide: the gap in digital literacy and the ability to extract economic value from the internet. For rural Indonesian MSMEs, the digital divide is often a Functional Divide. Even when village entrepreneurs have smartphones and social media accounts, they lack the Industrial Infrastructure to back up their digital presence. A village producer might successfully market a product on Instagram. However, if they receive an order for 1,000 units and their manual production can only yield 50 inconsistent units per day, the digital tool has effectively broken the business (Burmaoglu et al., 2023). This research posits that the digital divide cannot be bridged solely by software. It requires a Socio-Technical approach where physical technology (AT) provides the production capacity that makes digital connectivity meaningful. Functional connectivity is achieved only when the MSME can fulfill the promises made in the digital space.

### Signaling Theory and the Virtual-Physical Trust Gap

Signaling Theory (Spence, 1973) is essential to understanding e-commerce in rural settings. In a physical market, a consumer uses sensory cues; they touch the product, smell it, and see the producer. In the digital marketplace, these cues are replaced by signals (photos, descriptions, reviews, and certifications). Because the buyer cannot physically inspect the *Sarmiler* chips before purchase, they face Information Asymmetry; the seller knows the quality, but the buyer does not. To overcome this, the seller must send Strong Signals. A high-quality, standardized product is a strong signal. When a customer sees a photo of perfectly uniform chips and then receives a package where every chip matches that photo, the signal is validated, and trust is built. If, however, the product is manual and inconsistent, the Signal (the photo) and the Realization (the product) do not match. In the digital age, this discrepancy leads to negative reviews, which act as Counter-Signals, effectively de-platforming the MSME (Hieu et al., 2021). The literature synthesis suggests that Appropriate Technology is the engine that produces the Signals which Digitalization then transmits.

### The Twin Transition Framework

The concept of the Twin Transition, traditionally utilized by the European Commission to describe the simultaneous global shift toward a green, sustainable, and digital economy, is extended in this study into the field of Rural Development Studies (Schilling & Seuring, 2023). For rural Micro, Small, and Medium Enterprises (MSMEs), the Twin

Transition manifests as a critical, codependent integration of physical standardization, achieved through Appropriate Technology (AT), and market expansion driven by digitalization. Within this framework, the two pillars are fundamentally inseparable. On one hand, advancing digitalization without the foundational support of AT inevitably triggers order failure, as rural enterprises fail to maintain product consistency for a broader market. Conversely, implementing AT without digital market channels leads to a severe inventory surplus, primarily because local village markets lack the capacity to absorb the resulting twenty-fold increase in production. When aligned properly, this integration creates a powerful virtuous cycle that drives rural industrialization. Achieving this balance requires an external catalyst, a role fulfilled by the university through structured expertise transfer (Gad & Leone, 2024). By actively bridging the gap, the university ignites both sides of the transition simultaneously. This dual intervention ensures that the deployed technology remains locally appropriate while guaranteeing that a reliable, consistent physical reality firmly backs the enterprise's digital marketing efforts.

## RESEARCH METHODOLOGY

### Research Approach

This study employs a Qualitative Research design, a methodology uniquely suited for bridging the gap between academic expertise and practical social change. Action research is characterized by a spiral of cycles involving planning, acting, observing, and reflecting. In this context, the researchers acted as Expertise Transfers, directly intervening in the production bottlenecks of the *Sarmiler* (cassava snack) industry in Pandansari Lor Village. Unlike traditional detached observation, this approach enabled a Sejiwa-Senyawa (Shared Vision and Integrated Interest) integration, in which researchers and MSME owners co-created solutions. The intervention was divided into two synchronized streams: the Physical-Mechanical Stream (the implementation of Appropriate Technology) and the Digital-Virtual Stream (the development of web-based marketing systems) (Fawaid et al., 2026; Hani et al., 2022).

### Site Selection and Participant Selection

The research was situated in Pandansari Lor, a rural cluster in East Java characterized by a high density of cassava-based micro-enterprises. Participants were selected using Purposive Sampling, focusing on Key Informants who met three criteria: (1) ownership of an active cassava-processing micro-enterprise, (2) reliance on manual production methods prior to the study, and (3) a willingness to integrate digital tools into their business model. A total of 25

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participants formed the core research group, representing a mix of seasoned traditional producers and younger, more tech-receptive entrepreneurs. This demographic diversity was essential to test the Twin Transition across different levels of digital and mechanical literacy (Máté et al., 2025).

### Data Collection and Intervention Phases

Data collection followed a longitudinal, multi-method approach spanning a two-year period from 2021 to 2023, structured across four distinct sequential phases. Phase I established a baseline observation by documenting manual production metrics, specifically focusing on output volume, thickness variance, and hygiene levels. This initial phase provided the empirical foundation necessary to measure the subsequent impacts of technological interventions. Phase II initiated the physical transition through the introduction of the Sarmiler Printing Machine and oil-spinner technology. During this phase, data was systematically gathered via mechanical performance testing and rigorous quality consistency audits to evaluate operational efficiency and product standardization.

The intervention progressed into a digital transition during Phase III, which took place in 2022. This phase involved the development and implementation of a web-based marketing portal by a cohort of University of Brawijaya students (Cohort 2022). Data collection for this phase shifted toward digital metrics, utilizing web traffic analytics, user conversion rates, and automated digital feedback loops to evaluate market reach and consumer engagement. Finally, Phase IV focused on reflection and synthesis, wherein semi-structured interviews were conducted with key stakeholders. These qualitative assessments were designed to evaluate the long-term impacts of the comprehensive intervention, specifically focusing on consumer health outcomes and the post-intervention economic resilience of the participants.

### Data Analysis

Qualitative data were analyzed using Thematic Analysis, focusing on emerging themes such as Technical Adaptability, Trust in Digital Signals, and Health Standardization. Quantitative production data (1x manual vs. 20x mechanized capacity) were used as triangulation to validate the qualitative findings. This dual-layer analysis ensured that the Expertise Transfer was evaluated not only by economic output but also by its social sustainability (Iyai et al., 2021).

## FINDINGS

### Demographic Profile of Participants

The following table outlines the demographic characteristics of the MSME owners and stakeholders involved in the study. This diversity is crucial for

understanding the Twin Transition adaptability in a rural Indonesian context.

Demographic Category	Classification	Frequency (N=25)	Percentage (%)	Role in Study
Gender	Female	18	72%	Primary Producers / Artisans
	Male	7	28%	Logistics / Technical Operators
Age Group	20–35 years	5	20%	Early Adopters (Digital Focus)
	36–55 years	14	56%	Core Producers (Mechanical Focus)
	>55 years	6	24%	Traditional Wisdom / Mentors
Education Level	Primary School	8	32%	Practical/Artisanal Insight
	Secondary School	12	48%	Operational Management
	Higher Ed/Diplomas	5	20%	Community Leaders / Tech Liaison
Business Longevity	<5 Years	4	16%	Start-up / Growth Phase
	5–15 Years	15	60%	Established / Scaling Phase
	>15 Years	6	24%	Legacy Producers
Digital Literacy	Low (Offline)	10	40%	Focus: Physical Standardization
	Moderate (Social Media)	12	48%	Focus: Marketing Adoption
	High (Web-literate)	3	12%	Focus: Web-based Maintenance

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The demographic data reveal a high participation rate of women (72%), highlighting the role of MSME industrialization in Women's Economic Empowerment. Furthermore, the dominance of the 36–55 age group underscores the need for Appropriate Technology over high-tech robotics, as this middle generation requires tools that enhance their traditional skills rather than replace them with complex programming. The inclusion of the 2022 University of Brawijaya student cohort served as the Digital Bridge, ensuring that even participants with Low digital literacy could benefit from the web-based marketing expansion.

The analysis identified three core themes that define the success of the rural Twin Transition. These themes illustrate how physical technology serves as the foundation for digital trust and health resilience.

### Theme 1. Technical-Capacity Decoupling (Scaling the Handmade Constraint)

The primary bottleneck identified was the physical limit of manual labor. The transition to the *Sarmiler* printing machine allowed MSMEs to decouple their growth from human fatigue. By achieving a 20x capacity increase, the enterprise shifted from a household hobby to a standardized industry.

**Table 1.** Technical Capacity & Scale (Physical Transition)

Code Word/Phrase	Context in Research	Thematic Significance
Peak Scale	Reaching the peak scale of production.	Indicates the transition from micro-subsistence to industrial volume.
20 Times	20x capacity compared to manual methods.	Quantitative proof of the efficiency of Appropriate Technology.
Hand Made	The previous, limited production method.	Serves as the Baseline of technical constraints in rural settings.
Printing Machine	The specific mechanical intervention tool.	Represents the Appropriate Technology (AT) physical anchor.

### Theme 2. Quality Consistency as a Health Proxy

Consistency was found to be more than an aesthetic requirement. In the post-pandemic market, uniformity in product dimensions directly correlates with food safety (even frying, moisture control, and hygiene). The machine acts as a stabilizer for health by reducing human contact and ensuring standardized thermal processing.

**Table 2.** Quality, Health & Market Standards

Code Word/Phrase	Context in Research	Thematic Significance
Quality Consistency	Ensuring product uniformity for the user.	The bridge between mechanical output and consumer trust.
Health Insurance	Guaranteeing consumer health post-pandemic.	Elevates the product from a snack to a healthy alternative.
Diversification	Expanding product lines via technology.	Shows how AT enables SMEs to explore new, higher-value market segments.
Market Response	The market's positive reaction to quality.	Validates that consistency is a high-demand market signal.

### Theme 3. The Digital-Physical Trust Feedback Loop

Digital marketing (the web-based) succeeded only because the physical product was standardized. The Expertise Transfer from university students created a professional digital signal, while the mechanical intervention ensured the signal was truthful.

**Table 3.** Digital Synergy & Expertise Transfer

Code Word/Phrase	Context in Research	Thematic Significance
Web Base	UB students developed the digital portal.	Represents the Virtual side of the Twin Transition.
Extraordinary	Results (growth) are beyond expectations.	Proof of the Multiplier Effect when digital meets physical readiness.
Expertise	The role of lecturers in practical solutions.	Highlights the University-Community bridge (Sejiwa-Senyawa).
Good Relationship	Building long-term market relationships.	Shows that digital tools foster Relational Capital rather than just one-time sales.

## DISCUSSION

### Mechanical Intervention and Industrial Quality Consistency

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The primary empirical finding of this research demonstrates a profound paradigm shift in production performance, catalyzed by the transition from traditional, handmade artisanal methods to the systematic implementation of Appropriate Technology (AT). Prior to this mechanical intervention, the target village's *sarmiler* (cassava snack) production framework was characterized by high variability and operational fragmentation. Baseline physical audits revealed significant, unpredictable fluctuations in chip thickness, geometry, and surface texture. In the food processing literature, such morphological inconsistencies are well documented as inhibitors of structural stability; uneven dimensions directly compromise the predictability of shelf-life and restrict the product's compliance with stringent national health and sanitation standards (Trinugroho et al., 2022). Following the deployment of specialized mechanical printing machines and diversified processing tools, the enterprise achieved unprecedented optimization of its manufacturing scale, culminating in a 20-fold increase in monthly output volume compared to baseline manual methodologies.

However, within the context of rural industrialization, this quantitative surge in production volume is theoretically and operationally secondary to the concurrent advancements achieved in qualitative consistency (Imron, et al., 2025). The transition from manual slicing to mechanized fabrication effectively standardized the physical dimensions of the *sarmiler* chips. This structural uniformity is a critical operational prerequisite for optimizing subsequent thermal processing phases, particularly solar drying and deep frying. From a food engineering perspective, uniform chip thickness ensures a predictable, homogenous moisture desorption rate during drying and a balanced heat flux during frying. This thermodynamic equilibrium yields a vital health guarantee. Even heat distribution across the food matrix during thermal processing eliminates localized under-cooked zones, thereby significantly mitigating the risk of microbial survival and pathogen proliferation. Concurrently, uniform morphology prevents structural warping, which typically induces excessive oil absorption, thereby minimizing the formation of unhealthy, oil-saturated pockets prone to lipid oxidation and rancidity. Consequently, the mechanical transition does not merely represent a mechanism for volume maximization, but rather serves as a structural determinant for established frameworks of consumer health resilience and product safety standardization (Gera et al., 2025).

### The Digital Transition and Market Integration

As mechanized interventions elevated localized production capacity to industrial-scale outputs, the constraints of the traditional, localized

village market became an immediate bottleneck, rendering regional demand insufficient to absorb the newly generated surplus. This structural imbalance necessitated an immediate upgrade to the enterprise's marketing and distribution infrastructure. To address this friction, a collaborative initiative was established with the 2022 University of Brawijaya student cohort to design and execute a comprehensive, web-based marketing architecture. The empirical outcomes of this digital deployment extended far beyond conventional e-commerce metrics. Rather than functioning merely as a passive online catalog, the developed digital platform established a highly structured, disintermediated distribution channel that bridged the socio-spatial and economic chasm separating rural agricultural producers from affluent urban consumer segments (Scuotto et al., 2023).

Analysis of the operational data indicates that the success of this digital pivot was fundamentally contingent upon the rigorous physical and qualitative standardization achieved during the initial mechanical intervention phase. When analyzed through the lens of Signaling Theory, online consumers operating under information asymmetry rely heavily on extrinsic visual signals, digital product descriptions, and brand representations to infer product quality before purchase. Because the mechanical phase had already successfully standardized the physical properties of the *sarmiler* chips, the physical goods delivered to urban consumers matched the high-quality digital archetypes displayed on the web portal. This exact alignment between digital representation and physical reality minimized buyer dissonance, fostered robust market trust, and cultivated consumer loyalty, resulting in high repeat-purchase rates and the establishment of sustainable, long-term customer relationships. These findings provide strong empirical validation for the contemporary discourse on the Twin Transition, demonstrating that digital transformations in rural, resource-constrained environments achieve maximum efficacy only when tightly coupled with, and preceded by, the modernization of physical production assets (Jaswadi et al., 2015; Scuotto et al., 2023).

### The Sejiwa-Senyawa Model: A Framework for Collaborative Rural Innovation

Beyond its empirical implications for operational scaling and market expansion, this study makes a core theoretical contribution by conceptualizing and formulating the *Sejiwa-Senyawa* (Shared Vision and Integrated Interest) framework. This dual-axis model offers a novel paradigm for understanding the socio-academic dynamics of knowledge transfer, specifically regarding how higher education institutions can effectively interface with micro, small, and medium enterprises (MSMEs)

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without generating the friction typical of top-down development paradigms.

**Table 4.** Sejiwa-Senyawa Model Dimension

Dimension	Core Definition	Operational Manifestation in the Field
Sejiwa ( <i>Shared Vision</i> )	Cognitive alignment of divergent stakeholder goals	Merging the researcher's academic milestones (data collection, publication) with the MSME's commercial imperatives (profitability, survival).
Senyawa ( <i>Integrated Interest</i> )	Structural dissolution of expertise into daily routines	Transitioning from external advisory roles to co-creative execution, embedding academic knowledge into the physical operations of the village.

The first dimension, *Sejiwa* (Shared Vision), represents the deliberate cognitive and strategic alignment between the researchers' academic objectives, such as action research validation, knowledge dissemination, and student experiential learning, and the primary economic and survival imperatives of community-based MSMEs. Rather than imposing exogenous academic benchmarks, the intervention reframed technical progress as a shared existential goal, ensuring that all participating stakeholders operated with conceptual synergy. The second dimension, *Senyawa* (Integrated Interest), conceptualizes the operational and practical solution-finding process in which the academic expertise of university lecturers and engineers is organically integrated into the daily, granular operations of the community. Field observations revealed that the resultant transfer of technical and managerial expertise did not occur via asymmetric, top-down instruction. Instead, it materialized through a highly collaborative, iterative co-creation planning process.

By dismantling the traditional hierarchy often observed in rural development interventions, the *Sejiwa-Senyawa* approach significantly minimized agency costs, the economic and social frictions arising from asymmetric information, misaligned incentives, and divergent motivations between external experts (agents) and community beneficiaries (principals). Because the local producers were active co-designers of both the mechanical workflows and the digital interfaces, they developed a profound psychological ownership over the newly introduced technologies. This

high level of community agency mitigated the rejection risks commonly associated with technology adoption in traditional societies. Ultimately, the successful evolution of the enterprise from a fragmented Village of Laborers into a cohesive Village of Standardized Industry was structurally underpinned by this unique, deeply embedded socio-academic bond (Borah et al., 2021).

## CONCLUSION

This research demonstrates that the economic resilience of rural MSMEs in the post-pandemic era depends on the Twin Transition. The implementation of Appropriate Technology (the *Sarmiler* machine) ensured Quality Consistency, guaranteeing consumer health. At the same time, the Digital Transition (web-based marketing) provided the necessary market reach to sustain industrial-scale production. The study concludes that Physical Standardization is a prerequisite for Digital Trust. Without the mechanical ability to produce a consistent product, digital marketing efforts remain fragile and prone to failure due to the Expectation-Performance Discrepancy. While this study focused on cassava-based snacks, future research should explore the Twin Transition in other rural sectors, such as textiles or organic farming. This study offers a tripartite contribution to the sustainable growth of rural MSMEs. First, it informs policymakers that rural development funding must prioritize investment in Appropriate Physical Technology to ensure standardized production before scaling digital initiatives. Second, for academia, the study introduces the *Sejiwa-Senyawa* framework, advocating for a shift from transient community service toward Expertise-Led Industrialization, where universities provide sustained technical and digital support to village clusters. Finally, for MSMEs, the findings underscore that transitioning from artisanal methods to mechanized consistency is the essential pathway to meeting modern health-oriented consumer standards and securing long-term market resilience.

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