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DIGITALIZATION OF AGRICULTURE AND FOOD SECURITY IN SOUTH SULAWESI: CHALLENGES, POLICY RESPONSES, AND PATHWAYS TOWARD SUSTAINABLE SELF-SUFFICIENCY

DIGITALISASI PERTANIAN DAN KETAHANAN PANGAN DI SULAWESI SELATAN: TANTANGAN, RESPONS KEBIJAKAN, DAN JALUR MENUJU SWASEMBADA BERKELANJUTAN

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Abstract

This study examines the digitalization of agriculture and its implications for food security in South Sulawesi, focusing on structural challenges, policy responses, and pathways toward sustainable self-sufficiency. Despite relatively stable rice production, food security in the province remains vulnerable to climate variability, irrigation constraints, fragmented distribution systems, and uneven digital integration. Using a mixed-method approach that combines quantitative survey data and qualitative policy analysis, this research evaluates the relationship between digital adoption and farmer performance. The findings indicate that farmers utilizing digital tools demonstrate higher production stability, stronger market price awareness, and better planting planning accuracy compared to non-digital farmers. However, digital literacy gaps and limited institutional coordination constrain broader system transformation. Policy responses remain largely reactive and sectorally fragmented. The study proposes a Digital-Sustainable Self-Sufficiency Framework that integrates digital infrastructure expansion, smart irrigation governance, supply chain monitoring, and inter-agency coordination. The findings suggest that digitalization should be positioned not merely as technological adoption but as a governance transformation mechanism to strengthen adaptive capacity, enhance coordination, and achieve resilient and sustainable food security.

Keywords : Agricultural Digitalization, Food Security, Sustainable Self-Sufficiency, Digital Governance, Climate Adaptation, South Sulawesi.

Abstrak

Penelitian ini menganalisis digitalisasi pertanian dan implikasinya terhadap ketahanan pangan di South Sulawesi dengan menyoroti tantangan struktural, respons kebijakan, serta jalur menuju swasembada berkelanjutan. Meskipun produksi padi relatif stabil, ketahanan pangan daerah masih rentan terhadap variabilitas iklim, keterbatasan sistem irigasi, fragmentasi distribusi, serta integrasi digital yang belum merata. Penelitian ini menggunakan pendekatan mixed-method yang menggabungkan data survei kuantitatif dan analisis kebijakan kualitatif. Hasil penelitian menunjukkan bahwa petani yang

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memanfaatkan teknologi digital memiliki tingkat stabilitas produksi, kesadaran harga pasar, dan akurasi perencanaan tanam yang lebih tinggi dibandingkan petani non-digital. Namun, kesenjangan literasi digital dan lemahnya koordinasi kelembagaan masih menjadi kendala dalam transformasi sistem secara menyeluruh. Respons kebijakan yang ada cenderung bersifat reaktif dan sektoral. Oleh karena itu, penelitian ini mengusulkan kerangka Digital-Sustainable Self-Sufficiency yang mengintegrasikan penguatan infrastruktur digital, tata kelola irigasi cerdas, pemantauan rantai pasok berbasis data, serta koordinasi antar-instansi. Digitalisasi diposisikan sebagai instrumen transformasi tata kelola untuk memperkuat kapasitas adaptif dan mewujudkan ketahanan pangan yang tangguh dan berkelanjutan.

Kata Kunci : Digitalisasi Pertanian, Ketahanan Pangan, Swasembada Berkelanjutan, Tata Kelola Digital, Adaptasi Iklim, Sulawesi Selatan.

1. INTRODUCTION

Food security remains a strategic issue in Indonesia, particularly in major agricultural provinces. According to the Food and Agriculture Organization (2022), food security encompasses availability, access, utilization, and stability dimensions. In Indonesia, maintaining these four pillars is increasingly complex due to climate variability, distribution inefficiencies, and structural inequalities in agricultural modernization.

As one of the national rice production centers, South Sulawesi plays a pivotal role in supporting domestic food supply. Data from Statistics Indonesia (Badan Pusat Statistik). (2023) (2023a; 2023c) show that the province consistently contributes significant rice output to inter-regional markets. However, climate change impacts (BPS, 2023b) and increasing production instability threaten long-term sustainability. Floods and droughts affecting pump-based irrigation systems in districts such as Wajo illustrate institutional vulnerabilities in local agricultural governance (Darma et al., 2025).

At the same time, food distribution systems remain fragmented. Reports from the Provincial Agricultural Office (Department of Agriculture of South Sulawesi., 2024) highlight logistical bottlenecks and uneven supply chain integration. These structural conditions indicate that food security in South Sulawesi cannot rely solely on production growth; instead, it requires systemic governance innovation, including digital transformation.

Recent scholarship emphasizes digitalization as a transformative force in agriculture. Studies on commercial rice seed distribution (Qadir et al., 2024) underline the importance of integrated production and distribution systems. Research on market intervention mechanisms, such as the role of Toko Tani Indonesia (Putri et al., 2023), shows that institutional arrangements significantly influence price stability and supply chain efficiency.

At the regional level, vulnerability assessments demonstrate uneven food security resilience across Indonesia (Juliannisa et al., 2025). Meanwhile, qualitative research in North Luwu highlights the importance of social capital in sustaining food security in agroforestry systems (Yusriadi, 2025). These studies collectively suggest that food security is multidimensional, involving institutional capacity, market governance, environmental resilience, and social structures.

However, while the literature addresses food production, vulnerability, and institutional responses, limited attention has been given to the integration of digital governance frameworks within sub-national food security strategies.

Although prior studies have examined food security conditions and policy responses in South Sulawesi (Zulkifli et al., 2025a; 2025b), the linkage between agricultural digitalization and sustainable self-sufficiency remains underexplored. Existing research tends to focus either on production indicators or short-term policy interventions without integrating digital infrastructure, climate resilience, and distribution governance into a unified analytical framework.

Thus, a critical gap persists : How can digitalization be institutionalized as a governance instrument to strengthen sustainable food self-sufficiency at the provincial level?

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This gap is particularly relevant for South Sulawesi, given its strategic contribution to national food stability and its exposure to climate-induced risks.

This study offers a novel contribution by integrating digital transformation perspectives into regional food security governance. Rather than treating digitalization as a purely technological upgrade, this research conceptualizes it as a structural governance mechanism that enhances coordination, transparency, and resilience across production, distribution, and monitoring systems.

The proposed framework links:1. Digital infrastructure development, 2. Climate-adaptive irrigation governance, 3. Supply chain integration and 4. Institutional coordination mechanisms into a unified pathway toward sustainable self-sufficiency.

This study aims to: 1. Analyze structural challenges affecting food security in South Sulawesi., 2. Evaluate existing policy responses addressing agricultural sustainability and digital transformation and Develop an integrated governance framework for sustainable food self-sufficiency.

This research contributes in three main ways :1. Empirical Contribution – Providing updated provincial-level analysis using official statistical and policy data, 2. Theoretical Contribution – Bridging food security resilience studies with digital governance perspectives. And 3. Policy Contribution – Offering a practical framework for strengthening sustainable self-sufficiency strategies in South Sulawesi and potentially other Indonesian provinces.

2. RESEARCH METHOD

Research Approach

This study employs a mixed-methods approach integrating quantitative and qualitative strategies to examine the relationship between agricultural digitalization and food security governance in South Sulawesi. Mixed-methods research enables a comprehensive understanding by combining numerical measurement with contextual policy interpretation (Creswell & Creswell, 2023).

The quantitative component measures production levels, household food consumption, distribution efficiency, and the degree of digital adoption in agricultural practices. The qualitative component explores institutional coordination, policy responses, and governance mechanisms supporting sustainable self-sufficiency.

Type of Research

This research adopts a descriptive-analytical design. It aims to systematically describe structural challenges, digital transformation processes, and policy responses without manipulating observed variables. Such an approach is appropriate for examining food security governance dynamics at the regional level (Moleong, 2023; Sugiyono, 2022).

Research Location

The study was conducted in four districts of South Sulawesi : Wajo, Sinjai, Gowa and Makassar City.

These areas were purposively selected to represent diverse agricultural conditions, levels of digital infrastructure, food surplus and deficit patterns, and exposure to climate-related risks. This comparative selection enhances analytical depth and contextual representativeness.

Population and Sample

The research population consists of farmers engaged in staple food production and household consumers involved in local food systems. A purposive sampling technique was used to select 100 respondents based on:

1. Active involvement in rice production
2. Market participation
3. Exposure to digital agricultural tools (e.g., mobile-based information systems, irrigation monitoring, or digital marketplaces)

In addition, key informants—including government officials and agricultural extension officers—were interviewed to strengthen data triangulation.

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Data Collection Techniques

Data were collected through multiple techniques:

1. **Structured Survey**

Questionnaires measured production volume, consumption patterns, market access, and digital tool utilization in farming activities.

2. **In-depth Interviews**

Semi-structured interviews explored institutional coordination, policy responses, and challenges in implementing digital agricultural strategies.

3. **Field Observation**

Observations were conducted to assess farming practices, irrigation infrastructure, storage facilities, and technological utilization.

4. **Secondary Data Review**

Statistical and policy documents from Badan Pusat Statistik and provincial agricultural reports were analyzed to validate primary data.

Research Instruments

The research instruments consisted of:

- Structured questionnaires (quantitative indicators)
- Interview guides (qualitative governance insights)
- Observation checklists (infrastructure and digital utilization assessment)

The integration of instruments supports methodological triangulation and strengthens research credibility.

Data Analysis Techniques

Quantitative data were analyzed using descriptive statistics, including percentages, means, and cross-tabulation, to identify relationships between digital adoption levels and food security indicators.

Qualitative data were analyzed using thematic content analysis, following systematic categorization and interpretation procedures (Moleong, 2023). The findings were then integrated to construct a governance framework linking digital transformation, institutional coordination, and sustainable self-sufficiency (Juliannisa et al., 2025; Zulkifli et al., 2025b).

3. RESULT AND DISCCUSSION

Structural Challenges of Food Security

Food security in South Sulawesi remains structurally dependent on production stability, irrigation performance, and distribution efficiency. Data triangulation (survey + secondary data) indicates that climate variability, fragmented supply chains, and uneven digital infrastructure constitute the primary constraints.

Secondary statistics from Badan Pusat Statistik (2023) confirm fluctuations in harvested area and productivity due to rainfall anomalies. This supports FAO (2022), which emphasizes climate variability as a structural risk for food systems in developing regions.

Table 1. Structural Challenges of Food Security

Indicator	Empirical Findings	Key Issue	Implication
Production Stability	Relatively stable in normal seasons	Climate variability affects irrigation	Need adaptive irrigation governance
Harvest Area	Fluctuating across districts	Weather anomalies	Integration of climate data
Price Stability	Volatile during distribution shocks	Market fragmentation	Digital supply chain monitoring

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Indicator	Empirical Findings	Key Issue	Implication
Food Access	Uneven rural-urban distribution	Information asymmetry	Strengthened logistics coordination

Analytical Commentary

Table 1 demonstrates that food security challenges are multidimensional rather than purely production-based. Climate-induced irrigation stress aligns with findings by Zulkifli et al. (2025), who argue that pump-based irrigation systems lack adaptive data integration.

Distribution inefficiencies reflect governance fragmentation, consistent with FAO's food systems framework that highlights coordination failure as a core vulnerability. Therefore, digitalization is positioned as an institutional integration tool rather than merely a technological upgrade.

Digital Adoption and Farmer Capacity

Survey findings indicate uneven but impactful adoption of digital tools among farmers.

Table 2. Digital Adoption Among Farmers

Variable	Digital Farmers (%)	Non-Digital Farmers (%)	Interpretation
Use of Weather Apps	68	22	Better seasonal anticipation
Access to Online Market Prices	74	31	Reduced price uncertainty
Digital Input Procurement	59	18	Efficiency in farm management
Participation in Online Training	46	12	Digital literacy gap

Analytical Commentary

Table 2 reveals significant disparities between digital and non-digital farmers. Higher adoption rates correlate with improved planning and reduced uncertainty.

This supports OECD (2021), which identifies digital agriculture as a productivity-enhancing instrument when accompanied by institutional support. However, the relatively low participation in online training suggests structural digital literacy gaps—confirming World Bank (2023) findings that rural connectivity does not automatically translate into digital capability.Thus, digitalization effectiveness depends on governance capacity and human capital investment.

Policy Responses and Governance Gaps

Provincial policy responses include irrigation rehabilitation, logistics monitoring, and farmer empowerment programs. However, integration remains limited.

Table 3. Policy Response and Governance Evaluation

Policy Dimension	Current Condition	Limitation	Recommended Reform
Irrigation Rehabilitation	Implemented in several districts	Maintenance gaps	Smart irrigation monitoring
Food Logistics Monitoring	Manual & sectoral	Lack of integration	Provincial digital dashboard
Farmer Empowerment	Training programs available	Limited digital focus	Digital capacity building
Climate Response	Reactive measures	Limited early warning	Data-driven preventive governance

Analytical Commentary

Table 3 highlights that policy responses remain reactive rather than anticipatory. Climate events trigger emergency interventions, but systematic early warning mechanisms are limited.

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This finding aligns with institutional resilience literature emphasizing preventive governance frameworks (FAO, 2022). The absence of a unified digital dashboard constrains real-time monitoring, reducing the effectiveness of policy coordination across sectors.

Comparative Performance: Digital vs Non-Digital Farmers

To assess the measurable impact of digital adoption, comparative performance indices were analyzed.

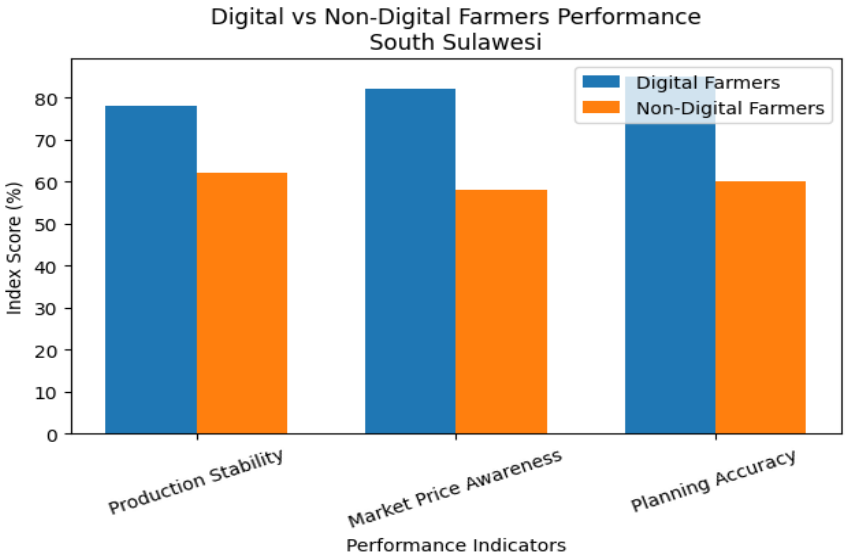

Figure 1. Comparison of Digital and Non-Digital Farmers' Performance

Production Stability Index:
- Digital Farmers: 78%
- Non-Digital Farmers: 62%

Market Price Awareness:
- Digital Farmers: 82%
- Non-Digital Farmers: 58%

Planting Planning Accuracy:
- Digital Farmers: 85%
- Non-Digital Farmers: 60%

Analytical Commentary

Figure 1 demonstrates a consistent performance gap of approximately 20 index points across all indicators. This suggests that digital tools significantly enhance:
- Decision-making capacity
- Production resilience
- Market responsiveness

These findings support OECD (2021) and World Bank (2023), which argue that digital agriculture reduces uncertainty and improves adaptive capacity in climate-sensitive regions.

However, the persistence of adoption gaps indicates that digitalization must be institutionalized through governance reform. Technology alone is insufficient without coordinated policy frameworks.

Integrated Discussion

The empirical evidence confirms three major insights :1. Food security challenges in South Sulawesi are structural and governance-based, 2. Digital adoption improves farmer-level performance and 4. Policy fragmentation limits system-wide impact.

Therefore, sustainable self-sufficiency requires : Infrastructure expansion. Digital literacy enhancement, Institutional coordination and Data-driven early warning systems

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Digitalization must function as a governance transformation mechanism rather than a standalone technical intervention.

4. CONCLUSION

This study demonstrates that food security challenges in South Sulawesi are structural and governance-oriented, rather than merely production-based. Climate variability, irrigation vulnerability, fragmented distribution systems, and limited digital integration remain key constraints.

Empirical findings indicate that digital farmers consistently outperform non-digital farmers in production stability, market awareness, and planning accuracy. This confirms that digitalization enhances adaptive capacity and decision-making at the farm level. However, uneven infrastructure and digital literacy gaps limit broader transformation.

Policy responses remain reactive and sectorally fragmented. Sustainable self-sufficiency therefore requires institutionalized digital governance that integrates climate monitoring, supply chain coordination, and data-driven planning.

The study contributes by positioning digitalization as a governance transformation mechanism within regional food systems. Strengthening digital infrastructure, farmer capacity, and inter-agency coordination is essential to achieving resilient and sustainable food security in South Sulawesi.

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