Journal of General Education and Humanities
Vol. 5, No. 4, August 2026, pp. 4705 – 4720, https://doi.org/10.58421/gehu.v5i4.1435
ISSN 2963-7147

Policy Literacy and Farmer Capacity as Determinants of Corn Productivity: An Educational Governance Perspective from Gorontalo

Merita Ayu Indrianti[1], Dewa Oka Suparwata[2], Moh. Muchlis Djibran[3], Nurlia Ripo[4]
[1,2,3,4]Universitas Muhammdiyah Gorontalo, Gorontalo, Indonesia

Article Info

Article history:

Received 2026-04-18
Revised 2026-05-21
Accepted 2026-07-20

Keywords:

Administrative Exclusion
Digital Bureaucratic Violence
Digital Citizenship
Food Sovereignty
Prospective Structural Analysis
Technocratic Justice

ABSTRACT

The digitalization of agricultural governance in Indonesia has created new challenges in the implementation of fertilizer subsidy policies, particularly for farmers with limited technological capacity. This study aims to analyze the influence of socio-digital literacy, administrative accessibility, and intergenerational support on corn productivity in the Gorontalo Regional Hub following the implementation of Presidential Regulation No. 6 of 2025. The study also examines the relative contribution of policy literacy compared to conventional governance factors in supporting food sovereignty outcomes. This research employed a Sequential Explanatory Mixed-Methods design involving quantitative and qualitative approaches. Quantitative data were collected from 150 corn farmers in the Limboto and Limboto Barat Districts using structured questionnaires, while qualitative data were collected through interviews with policymakers, extension coordinators, and youth intermediaries. Data analysis included descriptive statistics, thematic analysis, and Prospective Structural Analysis using the MICMAC method to identify key systemic variables. The results indicate that socio-digital literacy (LITE_X4) was one of the most influential variables in the governance system, with an influence score of 264 in the MICMAC analysis. Intergenerational support recorded the highest governance score (4.51), while the spatial-digital synchronization variable (P11) showed the lowest score (3.14), indicating persistent administrative barriers in the digital subsidy system. The findings also revealed a positive association between understanding of digital policy and productivity outcomes ($r = 0.397$, $p < 0.01$), although the study does not claim direct causation. Qualitative findings showed that youth intermediaries played an important role in helping senior farmers navigate digital administrative systems. This study concludes that digital literacy and administrative accessibility are important components of contemporary agricultural governance. The findings suggest the need for more adaptive digital governance models, participatory extension services, and inclusive policy mechanisms to reduce administrative exclusion in agricultural subsidy systems.

Corresponding Author:

Merita Ayu Indrianti
Faculty of Sciences and Computer Science, Universitas Muhammadiyah Gorontalo
Email: ayusutarto@umgo.ac.id

1. INTRODUCTION

Food sovereignty refers to the right of communities to access healthy and culturally appropriate food produced through sustainable agricultural systems [1], [2], [3]. In Indonesia, corn (Zea mays L.) has been positioned as a strategic commodity for strengthening national food resilience, particularly in production regions such as Gorontalo [4]. To support agricultural productivity, the government has long implemented fertilizer subsidies as a fiscal mechanism to reduce production costs and maintain farmer competitiveness [5]. Along with the increasing digitalization of agricultural governance, subsidy distribution systems are now transitioning from conventional administrative mechanisms toward integrated digital-based governance models [6], [7].

This transformation became more significant following the enactment of Presidential Regulation (Perpres) No. 6 of 2025 [8] and Minister of Agriculture Regulation (Permentan) No. 15 of 2025 [9]. These regulations introduced the "7T" governance framework, which extends the previous "6T" principles by adding "Right Recipient" (Tepat Penerima) as a key criterion in subsidy allocation. The implementation of this framework relies on digital systems such as the Electronic Group Needs Definitive Plan (e-RDKK) and the i-Pubers application, which integrate farmer identity data, land verification, and spatial mapping to improve accountability and targeting accuracy [10]. Previous studies have shown that digital transformation in agriculture can improve efficiency and transparency; however, the success of implementation strongly depends on farmer readiness, technological literacy, and supporting infrastructure [6], [11], [12].

Several recent studies provide important insights into the challenges of digital agricultural governance. Syahriyanda et al. [5] found that fertilizer subsidy effectiveness contributes to technical efficiency among corn farmers, although implementation barriers remain at the administrative level. Ripo et al. [13] reported that fertilizer availability alone does not guarantee access because rigid digital validation mechanisms can create administrative obstacles for farmers. Similarly, Azis and Suryana [14] emphasized that agricultural digitalization in Indonesia often shifts governance challenges from logistics toward administrative and cognitive dimensions. International studies by Smidt and Jokonya [11] and Zhang et al. [12] also confirmed that education level, digital skills, and institutional support highly influence digital adoption among smallholder farmers.

Despite these findings, several important gaps remain unresolved. Previous studies primarily focused on rural agricultural areas and emphasized logistical or technical dimensions of subsidy distribution [5], [13]. Limited attention has been given to how urban and peri-urban agricultural typologies respond differently to the 2025 digital governance reforms. In addition, the relationship between policy literacy, intergenerational social support, and corn productivity has not been comprehensively analyzed using a prospective systems approach. Existing studies also rarely compare the contribution of socio-digital capacity with that of conventional physical inputs to influencing agricultural productivity outcomes.

Based on these gaps, this study investigates the determinants of corn productivity in the Gorontalo Regional Hub following the implementation of the 2025 digital fertilizer governance reforms. Specifically, this study addresses the following research questions: (1)

How does policy literacy influence corn productivity? (2) What is the relative contribution of policy literacy compared to physical agricultural inputs? (3) How do urban and peri-urban typologies shape the effectiveness of digital agricultural governance? Moreover, (4) What mechanisms can reduce administrative exclusion within digital fertilizer governance systems?

This study adopts a Sequential Explanatory Mixed-Methods design combined with Prospective Structural Analysis using the MICMAC approach to identify key systemic drivers and governance interactions. Unlike previous cross-sectional studies, this research applies a forward-looking analytical framework to examine how socio-digital literacy, youth intermediation, and governance structures influence future outcomes of food sovereignty. The study also integrates perspectives from governance theory, human capital theory [18], and agricultural extension studies [19], [20] to explain how technological readiness affects policy implementation and productivity performance.

The expected contribution of this research is both theoretical and practical. Theoretically, the study expands discussions on food sovereignty and digital agricultural governance by emphasizing the importance of policy literacy as a strategic component of modern agricultural systems. Practically, the findings are expected to support policymakers, extension institutions, and local governments in developing more adaptive and inclusive digital governance models. By identifying systemic barriers and enabling factors, this research is expected to contribute to the formulation of agricultural policies that improve both administrative accessibility and corn productivity in developing regions.

2. METHOD

2.1. Research Design and Framework

This study adopts a Sequential Explanatory Mixed-Methods design, which combines quantitative mapping with qualitative deep-dives to provide a comprehensive understanding of complex agrarian transitions [16]. To transcend beyond static correlation, the design is augmented with Prospective Structural Analysis using the MICMAC (Matrix of Cross-Impact Multiplications Applied to Classification) method. This approach allows for the identification of "hidden drivers" within the food sovereignty system, moving from descriptive observations to predictive governance modeling [17]. The research evaluates the systemic shift from the "*6T*" logistical principles to the "*7T*" (adding *Right Recipient* / *Tepat Penerima*) technocratic framework mandated by Presidential Regulation (Perpres) No. 6 of 2025 [8] and Minister of Agriculture Regulation (Permentan) No. 15 of 2025 [9].

2.2. Study Area and Geographic Typology

The research was conducted in the Gorontalo Regional Hub, Indonesia, specifically focusing on the Urban district of Limboto and the Peri-Urban district of Limboto Barat. This selection represents a strategic expansion of the rural baseline study by Ripo et al. [13], which focused on the Pulubala district ($N = 99$). By integrating urban, peri-urban, and rural typologies, this study provides a multi-sectoral lens on how varying levels of infrastructure and "human capital investment" [18] influence the adoption of digital agricultural policies. Limboto represents an urban profile with 74.6% secondary-to-tertiary education, while Limboto Barat exhibits a peri-urban 'low-education trap' with 80% primary-level graduates,

creating a stark contrast in technological absorptive capacity. These locations were selected as 'critical cases' because they represent the maximum variance in socio-technical readiness within the region, providing a robust test for the 2025 reforms.

2.3. Population and Sampling Procedures

The study used a stratified purposive sampling approach to obtain diverse socio-digital profiles.

1. For the quantitative strand, 150 ($n = 150$) corn farmers ($N_{Urban} = 75$; $N_{Peri-Urban} = 75$) were surveyed for primary data between January-March 2026. Sample size was estimated using Slovin's formula with a margin of error of 7%. The sample size reflected adequate power for the regional level following the expansion of the digital fertilizer subsidy system. The urban-peri-urban gradient captured the socio-digital divide.
2. Qualitative Strand: We employed a stratified purposive sampling technique to select three key stakeholders representing the "Triple Helix of Governance": (S1) a Senior Agricultural Policy Administrator, (S2) a Field Extension Coordinator, and (S3) a Youth Intermediary (Millennial Farmer). These informants provided the narrative depth required to contextualize the "Administrative Exclusion" observed in the field. The selection of three key informants followed the principle of 'intensity sampling,' focusing on actors with maximum information richness within the governance hierarchy. Methodological rigor was ensured through iterative coding, which yielded deep insights into the P11 anomaly. Saturation, in this focused context, was achieved when the narratives consistently identified the same systemic frictions, thereby providing the necessary contextual validation for the quantitative trends despite the focused sample size.
3. Regional Synthesis: The analysis synthesized the current $N = 150$ dataset with the $N = 99$ baseline from Pulubala [13], resulting in a comprehensive regional evaluation ($N = 249$) to identify "Governance Paradoxes" across different geographic landscapes.

2.4. Research Instruments and Operationalization

Two primary instruments were deployed to capture the complexity of corn productivity determinants:

1. Structured Questionnaire: A 5-point Likert scale instrument organized into seven dimensions: Effectiveness of *7T* Governance (A-C), Digital Policy Literacy (D-E), Socio-Theological Stewardship (F), and Intergenerational Support (G). We conducted face validity and reliability testing on the structured questionnaire (Cronbach's Alpha > 0.70) before full deployment to ensure internal consistency [8].
2. Semi-Structured Interview Guide: Developed to explore the "Administrative Exclusion" phenomenon and the informal role of "Socio-Digital Intermediaries [15]. This instrument was designed to "stress-test" the quantitative findings through direct field narratives.

2.5. Data Analysis and Prospective Modeling

The analytical workflow proceeded through three rigorous phases:

1. Descriptive and Comparative Analysis: Quantitative data were processed to map disparities in technological readiness and policy understanding between urban and peri-urban hubs.
2. Thematic Qualitative Coding: Interview transcripts were analyzed using thematic frameworks to contextualize the "P11 anomaly" (Administrative barriers) and the transformation of extension workers into "Policy Translators" [14], [19].
3. Prospective Structural Analysis (MICMAC): An Expert-Based Matrix of Direct Influences (MDI) was constructed by a panel of five experts (policy researchers, digital governance specialists, and regional coordinators) selected via purposive sampling. To ensure the stability of the matrix, consensus was reached through two rounds of Delphi-inspired consultation. The MICMAC software then processed these validated inputs to calculate indirect influences, effectively identifying which variables, such as LITE_X4 or YOUT_G, function as the 'systemic engine' across the urban-peri-urban landscape.

2.6. Data Transparency and Ethics

In alignment with Open Science standards, the research instruments, quantitative datasets, and qualitative transcripts have been assigned persistent identifiers and archived in the Zenodo repository (DOIs: 10.5281/zenodo.20096702 (Research Instruments (Appendix A & B)); 10.5281/zenodo.20096830 (Quantitative Dataset N=150 (Appendix C)); 10.5281/zenodo.20097212 (Qualitative Interview Transcripts (Appendix D)). Crucially, the study protocol was reviewed and approved by the Institutional Ethics Committee of Universitas Muhammadiyah Gorontalo (Protocol No. UMG-2025-042). All participants provided written informed consent prior to data collection, with guaranteed anonymity and the right to withdraw at any stage, ensuring compliance with the Declaration of Helsinki.

3. RESULTS AND DISCUSSION

3.1. Socio-Demographic Typology and Regional Digital Disparities

The empirical findings from the Gorontalo Regional Hub (Limboto and Limboto Barat) indicate substantial differences in educational attainment and technological readiness between urban and peri-urban farmers. As presented in Figure 1, the Urban district (Limboto) demonstrates a relatively stronger educational profile, with 74.6% of respondents completing secondary or tertiary education. This condition is accompanied by higher ownership of digital communication devices, particularly smartphones, as shown in Figure 2. In contrast, the Peri-Urban district (Limboto Barat) is dominated by farmers with primary and junior high school educational backgrounds (80%), and many respondents rely on regular mobile phones or have no digital devices at all.

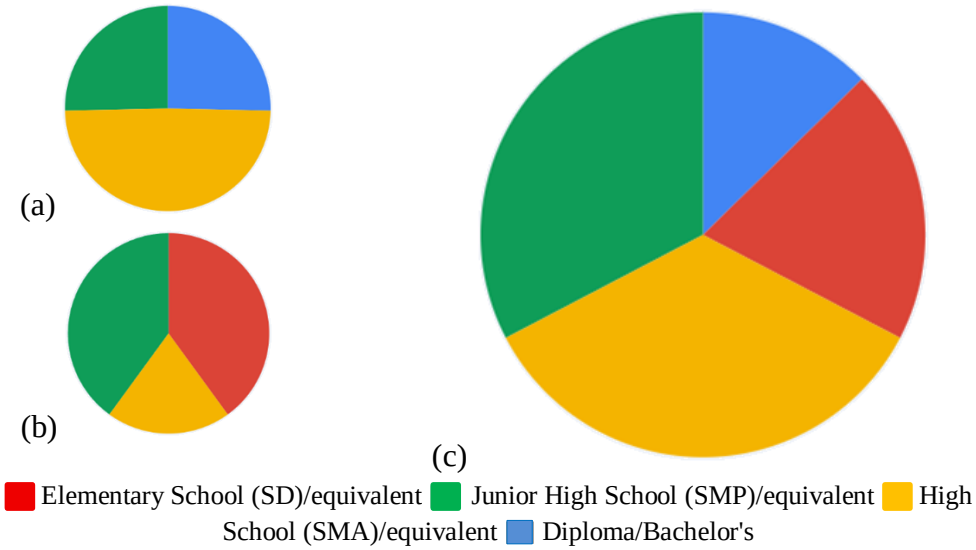

Figure 1. Distribution of education level of Corn Farmers in Limboto (a), West Limboto (b), and (c) Combined

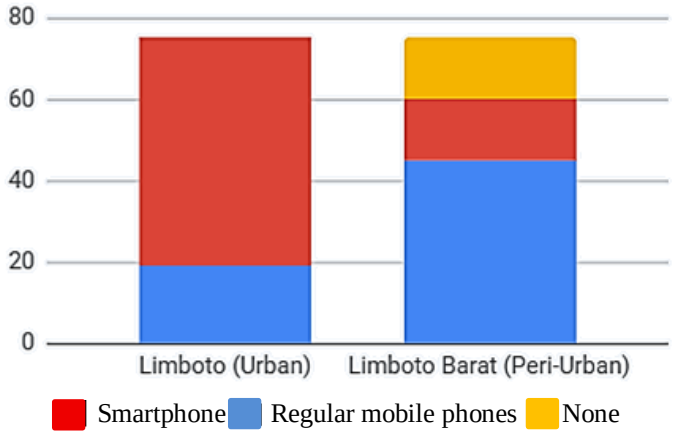

Figure 2. Distribution of ownership of digital communication devices for corn farmers in Limboto and West Limboto Districts

These findings indicate that the Gorontalo Regional Hub consists of heterogeneous socio-digital conditions rather than a uniform agricultural landscape. Based on Schultz's human capital theory [18], higher educational attainment may increase farmers' absorptive capacity for adopting digital governance systems and agricultural innovations. The observed relationship between education level and digital device ownership also supports previous findings that technological adoption among smallholder farmers is closely associated with literacy, infrastructure, and institutional support [11], [12]. However, the relationships identified in this study should be interpreted as associative rather than causal.

The data further suggest that standardized digital governance policies may produce varying implementation outcomes across different regional typologies. Farmers in peri-urban areas with limited digital access may face greater difficulties in adapting to

administrative systems that rely heavily on online verification and spatial synchronization. This interpretation aligns with previous studies emphasizing that unequal technological readiness can contribute to disparities in access to agricultural services [6], [7].

3.2. Governance Performance: The 'Digital Enclosure' of Subsidized Resources

The P11 variable, representing the spatial-digital synchronization between on-ground GPS coordinates and central polygon maps, scored significantly low (3.14). Theoretically, the P11 anomaly signifies a 'Digital Enclosure', a modern iteration of historical land dispossession where farmers are geographically present but administratively invisible due to algorithmic rigidities. When the *i-Pubers* application fails to synchronize GPS coordinates with central polygon maps, it effectively cordons off the farmer's access to state support. This 'Spatial-Digital Mismatch' is not a mere technical glitch; it constitutes 'Digital Bureaucratic Violence', where the burden of technological fallibility is shifted entirely onto the subject. For the senior farmer, the P11 anomaly, the mismatch between soil and software, triggers a sense of 'technological alienation,' where a GPS coordinate devalues their lifelong expertise. In this regime, the 'Right to Produce' is no longer dictated by soil fertility or labor, but by the ability to bypass an uncompromising digital lock, rendering the digitally illiterate 'administratively vanished.'

Table 1. Evaluative Dimensions of Fertilizer Subsidy Governance

Dimension	Mean Score	Interpretation
G. Intergenerational Support	4.51	Very High (Primary Social Capital)
H. Food Sovereignty (Productivity)	4.31	High (Collective Optimism)
D. Digital Policy Understanding	3.70	Low/Moderate (The Structural Bottleneck)
F. Stewardship (Anomaly P11)	3.14	Low (Administrative Exclusion)

This disparity in scores (4.51 vs 3.70) quantifies a 'Cognitive Gap,' illustrating a systemic state where aspirations for agricultural productivity are hindered by the complexity of the digital-bureaucratic interface, despite strong intergenerational support. Furthermore, the low score for item P11 (3.14), representing the 'Spatial-Digital Mismatch' where GPS coordinates on the *i-Pubers* application fail to synchronize with polygon maps, highlights a perceived sense of 'cognitive injustice' among farmers. As noted by Azis and Suryana [14], the transition to digital governance in Indonesia often shifts the burden of proof from the state to the farmer, creating a new layer of "administrative barricades" [13].

Interestingly, Table 1 shows that Socio-Theological Stewardship (F) scored 3.14, indicating that while the religious value of 'earth-keeping' remains present, it is currently 'muted' by the overwhelming pressure of digital compliance. This suggests that the cold logic of algorithmic accountability is displacing the spiritual dimension of farming.

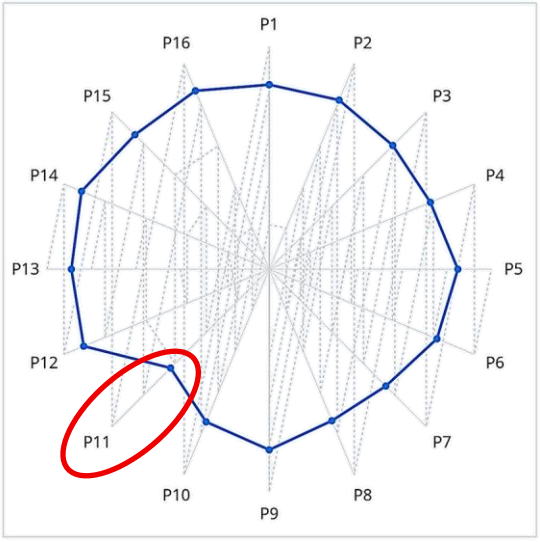

Figure 3. Fertilizer Subsidy Policy Governance Performance

The governance performance data indicate that digital agricultural policies require adaptive implementation mechanisms that consider local socio-digital conditions. In this context, extension services and institutional assistance remain important to ensure that administrative procedures do not become structural barriers for farmers with limited technological capacity.

3.3. Multistakeholder Perspectives: The "Humanized" Policy Narrative

This analysis revealed three dominant clusters that contextualize the quantitative findings:

3.3.1 The Technocratic-Administrative Burden

The Senior Agricultural Policy Administrator (S1) confirms that while Perpres 6/2025 and Minister of Agriculture Regulation (Permentan) 15/2025 enhance transparency, they introduce a "digitized complexity." The integration of spatial data (polygons) has transformed the state's role. Field Extension Coordinators (S2) reported that 70% of their time is now dedicated to "app troubleshooting" rather than agronomic guidance. This shift validates the transformation of extension workers into "Policy Translators" [19], [20].

3.3.2 Digital Bureaucratic Violence and Exclusion

Interviews regarding the P11 anomaly reveal that the "Digital Lock" mechanism of the *i-Pubers* application, which automatically freezes quotas if GPS coordinates do not match the central database, is perceived as "Digital Bureaucratic Violence." Senior farmers in Peri-Urban areas feel "punished" by a system that prioritizes algorithmic precision over biological planting cycles [15]. This qualitative finding provides a human face to the quantitative P11 anomaly; the 'Digital Lock' is not merely a technical error but a systemic barrier that formalizes the exclusion of digitally marginalized subjects from their right to subsidies.

3.3.3 The Youth as "Socio-Digital Intermediaries"

The most resilient component of the system is the informal role of the youth (S3). Without intergenerational intervention, the majority of senior farmers would be "administratively vanished" from the subsidy system. This confirms that the Triple Helix of Governance in Gorontalo relies not on formal institutions but on a Socio-Digital Intermediation model in which the younger generation serves as the functional interface between the farmer and the state [15].

3.4 Prospective Structural Analysis: Deciphering "The Literacy Engine"

The MICMAC (Matrix of Cross-Impact Multiplications Applied to Classification) analysis validates the "hidden drivers" of the system (Table 2).

Table 2. Indirect Influence and Dependence Classification (MII)

Rank	Label	Variable Name	Influence (*Sum of Row*)	Dependence (*Sum of Col*)
1	REGU25	Regulatory Reform 2025	307	19
2	LITE_X4	Socio-Digital Literacy	264	120
3	YOUT_G	Youth Intermediary	229	30
4	TARG_X1	Targeting Precision	83	197
5	STEW_F	Socio-Theology Stewardship	83	18
6	LOGI_X2	Logistical Reliability	33	169
7	FISC_X3	Fiscal & Quality Compliance	31	180
8	PROD_Y	Food Sovereignty Outcome	0	416

The Power Triangle: Regulation, Literacy, and Youth

The Indirect Influence Map (Figure 4) provides a sophisticated visualization of the system's power dynamics, moving beyond simple linear correlations. The most critical finding is the positioning of Socio-Digital Literacy (LITE_X4) as the primary "Engine" of the system. In MICMAC terminology, LITE_X4 is a Determinant Variable with the highest power of contagion across the network.

This suggests that the pursuit of Food Sovereignty (PROD_Y) is no longer a logistical challenge but a cognitive one. While the 2025 Regulatory Reform (REGU25) provides the legal mandate, LITE_X4 is the strategic intervention variable; a minor improvement in literacy yields an exponential increase in system-wide stability. Conversely, neglecting the 'Literacy Engine' ensures that even the most robust fiscal subsidies remain trapped in a state of governance paralysis. The MICMAC analysis mathematically validates that for corn productivity to be resilient, the state must pivot from a 'Control-Oriented' technocracy to a 'Literacy-Driven' empowerment model. Literacy is not merely a technical skill in this framework; it is the *sine qua non* of modern agrarian citizenship and food sovereignty. The positioning of LITE_X4 as a determinant variable suggests that 'Digital Literacy' functions as the new 'Social Infrastructure' of the 2025 reforms.

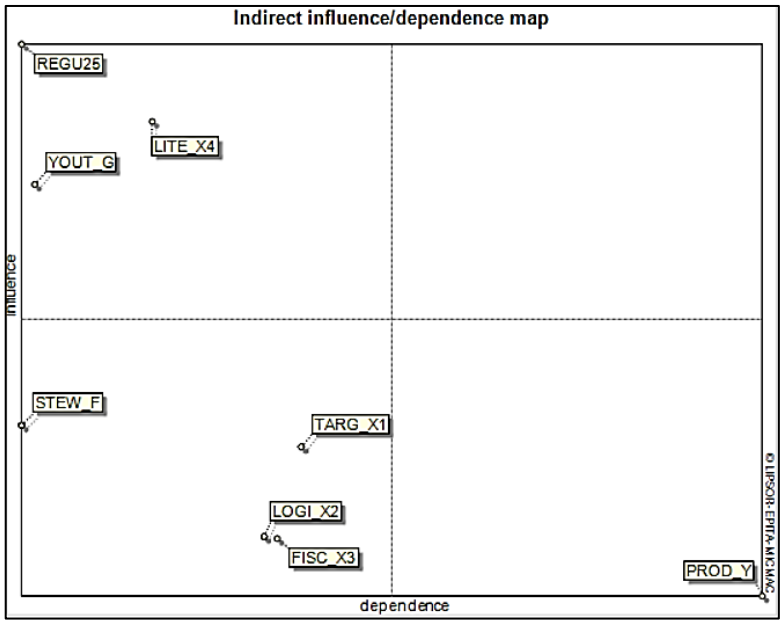

Figure 4. Indirect Influence/Dependence Map

The Indirect Influence Graph (Figure 5) illustrates the "neural pathways" of the policy. The thickest influence lines flow from REGU25 → PROD_Y (Direct Regulatory Pressure) and LITE_X4 → PROD_Y (Cognitive Mediation). This indicates that the success of the digital fertilizer reform is no longer dependent on logistical reliability (LOGI_X2) but is now "held hostage" by beneficiaries' cognitive capacity. If digital literacy fails, the entire regulatory framework collapses before it can impact productivity.

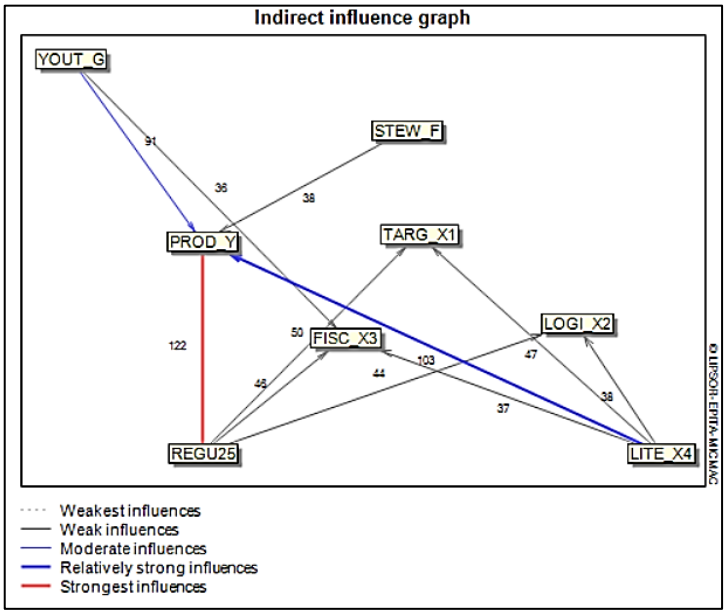

Figure 5. Indirect Influence Graph

System Evolution: The Displacement Map

The Displacement Map (Figure 6) shows a significant shift in variables. Factors such as Targeting Precision (TARG_X1) and Fiscal Compliance (FISC_X3) have shifted from

being autonomous to highly dependent. This evolution suggests that in the post-2025 digital era, "Getting the Target Right" is no longer a management task; it is a direct byproduct of Digital Literacy.

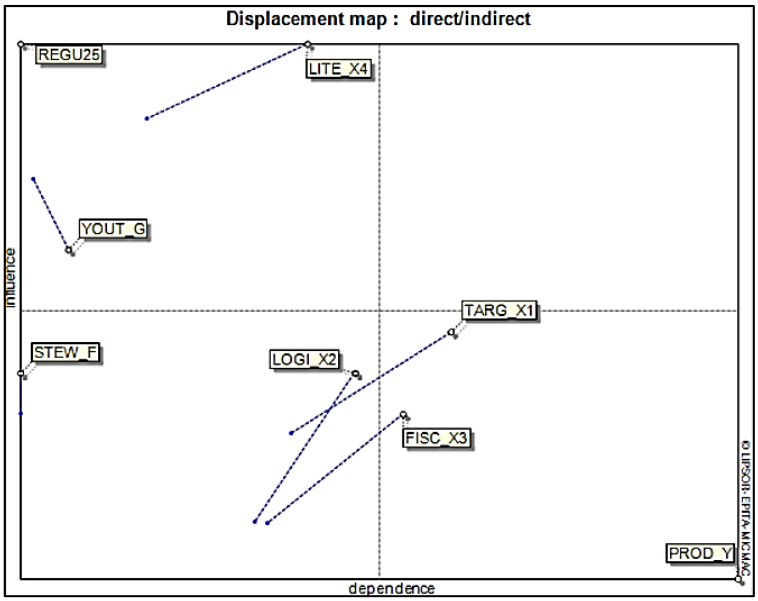

Figure 6. Displacement Map: Direct/Indirect Influences

This finding aligns with Antwi-Agyei and Stringer [21] and Choruma et al. [6], who argue that digitalization without human capital investment creates a "governance mirage", a system that appears efficient in central dashboards but remains inaccessible to the grassroots. The absence of variables in Quadrant II (Linkage) indicates a stable but linear system: it is a highly efficient "machine" when triggered by literacy but is prone to total paralysis if the digital-bureaucratic interface is disrupted.

3.5 Critical Discussion: Synthesizing Food Sovereignty and Technocratic Justice

The Gorontalo case study exposes the Governance Paradox first identified by Ripo et al. [13]. Physical fertilizer availability is no longer the primary determinant of food sovereignty; rather, Administrative Accessibility has emerged as the new gatekeeper.

In the context of La Via Campesina's [3] definition of food sovereignty, the current Indonesian *7T* framework risks violating the "right of peoples to healthy and culturally appropriate food" by imposing technocratic barriers that exclude traditional farming populations. The high dependence of Productivity (PROD_Y) on Literacy (LITE_X4) confirms that the "Agroecological Revolution" [1] cannot be achieved through top-down digitalization alone. It requires a "humanized" approach that formalizes the role of Youth Intermediaries [15] and mitigates the Administrative Exclusion (Anomaly P11) felt in peri-urban typologies. The P11 anomaly, the spatial-digital mismatch, is not merely a technical glitch; it is a form of 'Digital Enclosure', where farmers are geographically present but administratively invisible due to GPS inaccuracies.

Ultimately, if the goal is true food sovereignty, the digital policy must evolve from a "Digital Lock" mechanism to an "Inclusionary Enabler." This necessitates a shift from purely

technocratic audits to a participatory extension model that prioritizes investment in human capital [18], [19]. The findings suggest that digitalization, when divorced from critical literacy, acts as a new form of enclosure. To humanize this interface, the state must treat the farmer as a knowledge-bearing subject rather than a data point in a centralized dashboard.

While the 'Literacy Engine' is a critical driver in urban and peri-urban hubs, its effectiveness depends on basic infrastructure. In remote 'zero-connectivity' zones, the Governance Paradox may escalate into 'Total Systemic Invisibility,' where the digital state effectively ceases to exist. In such contexts, humanizing policy requires not just literacy, but the maintenance of non-digital 'safety-valve' protocols to prevent the complete erasure of marginalized smallholders.

To bridge the gap between systemic drivers and the resulting food security outcomes, the structural interactions between policy mandates, cognitive readiness, and social intermediation are synthesized into a conceptual framework. The Triple Helix Model of Digital Fertilizer Governance, as illustrated in Figure 7, provides a holistic visualization of how these pillars converge to drive regional food sovereignty.

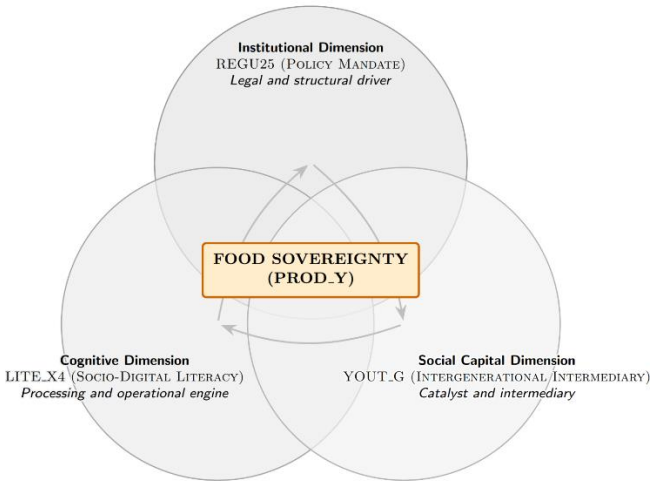

Figure 7. The Triple Helix Model of Digital Fertilizer Governance

The model depicts the convergence of state-led regulatory mandates (REGU25), individual cognitive capacity (LITE_X4), and intergenerational social capital (YOUT_G). The ‘Bold Gold Center’ represents the achievement of Food Sovereignty (PROD_Y) as a direct result of synergistic interactions, effectively mitigating the administrative exclusions identified in the peri-urban landscapes.

4. CONCLUSION

This research provides a critical evaluation of the systemic transition in subsidized fertilizer governance within the Gorontalo Regional Hub following the 2025 technocratic reforms. A Sequential Explanatory Mixed-Methods and Prospective Structural Analysis (MICMAC) study shows how moving from a “logistical” (*6T*) to a “data-driven” (*7T*) logic has transformed the determinants of corn productivity. The results generate three important conclusions:

We start by recognizing LITE_X4 as ‘The Literacy Engine’ and the systemic driver. Presidential Regulation (Perpres) No. 6 of 2025 serves as a regulatory trigger, while the socio-digital literacy of the targets determines the program's effectiveness. The MICMAC analysis confirms that literacy is not merely a supportive variable but the "engine" that determines whether regulation translates into productivity or collapses into administrative inertia. Without significant investment in human capital, echoing Schultz’s [18] thesis, the digitalization of agriculture remains a ‘governance mirage’ where physical abundance is rendered inaccessible by cognitive barriers. Ultimately, this study asserts that, in the contemporary technocratic landscape, food sovereignty is no longer merely a matter of soil and seed but is fundamentally predicated on ‘Inclusionary Digital Justice.’ We argue that the ‘Right to Produce’ remains hollow without the recognized ‘Right to Digital Inclusion’; thus, ‘Digital Literacy’ must be repositioned not merely as a technical skill, but as a fundamental human right and a cornerstone of modern agrarian citizenship.

Second, the manifestation of a ‘Governance Paradox’ through Administrative Exclusion. The stark digital divide between Urban and Peri-Urban landscapes reveals that technocratic rigidities, such as the spatial-based ‘Digital Lock’ of the *i-Pubers* application, inadvertently penalize the very populations they aim to protect. The findings suggest that food sovereignty is currently threatened not by logistical scarcity but by ‘Digital Bureaucratic Violence,’ in which senior farmers are marginalized by algorithmic precision. This paradox illustrates that modern food sovereignty is inseparable from the right to be digitally recognized by the state.

Third, the emergence of the ‘Triple Helix of Governance’ as a resilience mechanism. The system's stability is sustained by a recursive interplay among Regulation, Literacy, and Youth Intermediaries. The informal role of youth as ‘Policy Translators’ serves as a vital safety net, navigating the digital-bureaucratic interface to prevent the total exclusion of aging farming populations, thereby shifting ‘Targeting Precision’ from a top-down administrative outcome to a byproduct of intergenerational social capital. The study confirms that the Triple Helix of Governance in the digital era is no longer a top-down administrative flow but a recursive interaction in which youth serve as the indispensable 'functional bridge' between an uncompromising digital state and an aging agrarian workforce.

Theoretically, this study advances the discourse on food sovereignty by asserting that the "Right to Produce" must now encompass the "Right to Digital Inclusion." It confirms that technocratic reforms in emerging economies require a paradigm shift toward "technocratic justice," in which digital tools align with biological cycles rather than rigid audit requirements. In practice, the research advocates a transition from "control-oriented" digital policies to "enabler-oriented" frameworks that humanize the digital-agrarian interface.

To ameliorate the identified systemic frictions, this study proposes a three-tiered strategic roadmap:

1. National Level (Ministry of Agriculture): Implementation of *"Safety Valve"* Protocols. The government must introduce a Humanized Digital Protocol that incorporates a mandatory manual override mechanism. This *"Safety Valve"* allows for offline verification and temporary quota release during peak planting seasons

when spatial validation (polygons) fails due to cloud cover, GPS inaccuracies, or system *downtime*, ensuring that technocratic audits do not disrupt biological cycles [20], [21].

2. Regional Level (Local Government): Institutionalizing the *"Millennial Digital Envoy."* Transition from informal family assistance to a structured governance asset by establishing a formal program that subsidizes and trains young digital intermediaries. These envoys should be deployed to peri-urban hubs to bridge the 'Cognitive Gap' and resolve 'Digital Lock' issues at the grassroots level [22].
3. Operational Level (Extension Services): Typology-Based Extension Models. Extension activities must shift from purely agronomic guidance to Digital Troubleshooting. In peri-urban areas, the extension focus should prioritize correcting *NIK-Spatial* residues and ensuring administrative synchronization, thereby reducing the 'Administrative Barricades' faced by senior farmers [23].

While this study provides a robust mapping of urban and peri-urban dynamics within the Gorontalo Hub, the exclusion of remote rural zones characterized by "zero-connectivity" and minimal infrastructure may limit the generalizability of the findings. This limitation implies that the *"Administrative Exclusion"* identified here might manifest as *"Total Systemic Invisibility"* in more isolated hinterlands, where the digital state ceases to exist. Future research should critically investigate these 'digital vacuums' to determine if *"Socio-Theology Stewardship"* functions as a dominant informal regulator and moral controller where digital surveillance fails [24], [25]. Furthermore, longitudinal studies are required to evaluate whether the current reliance on youth intermediaries is a sustainable long-term solution or merely a temporary buffer against a deepening intergenerational digital divide [5].

ACKNOWLEDGEMENTS

The authors express their profound gratitude to the Head of the Agribusiness Study Program in the Faculty of Science and Computer Science for the institutional support and facilities provided during this research. Special appreciation is extended to the accompanying researcher at Universitas Muhammadiyah Gorontalo—Ivan Taslim, MT.—whose intellectual rigor, critical insights, and unwavering guidance were instrumental in shaping the structural analysis and theoretical framework of this study. We also sincerely thank the Government of Limboto and Limboto Barat District, along with the local farming groups, for their exceptional cooperation and transparency during the field data collection. Finally, the authors acknowledge the strategic utilization of Artificial Intelligence (AI) tools to enhance academic productivity. We credit Gemini for assisting with structural analysis, synthesis, and drafting, and Paperpal for linguistic refinement and ensuring technical clarity. These tools were used ethically as supportive instruments to augment the human analytical process.

REFERENCES

[1] M. A. Altieri and V. M. Toledo, "The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants," *J. Peasant Stud.*, vol. 38, no. 3, pp. 587–612,

Jul. 2011, doi: 10.1080/03066150.2011.582947.
[2] T. Garner Gruber, "'Fixing' hunger in the 21st century: How food sovereignty might turn agriculture 'Right-side Up,'" *Appetite*, vol. 47, no. 3, p. 390, Nov. 2006, doi: 10.1016/J.APPET.2006.08.023.
[3] V. Campesina, "Food Sovereignty : A Future without Hunger," 1996.
[4] A. Bisma, Z. Sirajuddin, and A. Anisa, "Diversifikasi Usahatani Petani Jagung Gorontalo dan Determinannya," *Perbal J. Pertan. Berkelanjutan*, vol. 14, no. 1, pp. 95–107, Feb. 2026, doi: 10.30605/perbal.v14i1.7138.
[5] A. M. Syahriyanda, E. Fauziyah, D. R. Hidayati, F. F. Muhsoni, M. Z. Alfisuma, and S. A. A. Taridala, "The Impact of the Effectiveness of Fertilizer Subsidy Policy Implementation on the Technical Efficiency of Corn Farmers in Pamekasan Regency," *Agrisocionomics J. Sos. Ekon. Pertan.*, vol. 9, no. 3, pp. 631–652, Nov. 2025, doi: 10.14710/agrisocionomics.v9i3.25667.
[6] D. J. Choruma *et al.*, "Digitalisation in agriculture: A scoping review of technologies in practice, challenges, and opportunities for smallholder farmers in sub-saharan africa," *J. Agric. Food Res.*, vol. 18, p. 101286, Dec. 2024, doi: 10.1016/j.jafr.2024.101286.
[7] Y. Yuan and Y. Sun, "Practices, Challenges, and Future of Digital Transformation in Smallholder Agriculture: Insights from a Literature Review," *Agriculture*, vol. 14, no. 12, p. 2193, Nov. 2024, doi: 10.3390/agriculture14122193.
[8] Republik Indonesia, *Peraturan Presiden Republik Indonesia Nomor 6 Tahun 2025 Tentang Tata Kelola Pupuk Bersubsidi*. 2025.
[9] Kementerian Pertanian Republik Indonesia, *Peraturan Menteri Pertanian Nomor 15 Tahun 2025 Tentang Peraturan Pelaksanaan Peraturan Presiden Nomor 6 Tahun 2025 Tentang Tata Kelola Pupuk Bersubsidi*. 2025. [Online]. Available: https://peraturan.bpk.go.id/Details/319663/permentan-no-15-tahun-2025
[10] Kementerian Pertanian Republik Indonesia, *Peraturan Menteri Pertanian Republik Indonesia Nomor 1 Tahun 2024 Tentang Perubahan Atas Peraturan Menteri Pertanian Nomor 10 Tahun 2022 Tentang Tata Cara Penetapan Alokasi Dan Harga Eceran Tertinggi Pupuk Bersubsidi Sektor Pertanian*. 2024.
[11] H. J. Smidt and O. Jokonya, "Factors affecting digital technology adoption by small-scale farmers in agriculture value chains (AVCs) in South Africa," *Inf. Technol. Dev.*, vol. 28, no. 3, pp. 558–584, Jul. 2022, doi: 10.1080/02681102.2021.1975256.
[12] X. Zhang, Q. Yang, A. Al Mamun, M. Masukujjaman, and M. M. Masud, "Acceptance of new agricultural technology among small rural farmers," *Humanit. Soc. Sci. Commun.*, vol. 11, no. 1, p. 1641, Dec. 2024, doi: 10.1057/s41599-024-04163-2.
[13] N. Ripo, M. A. Indrianti, D. O. Suparwata, and M. M. Djibran, "Dynamics of Fertilizer Subsidy Implementation: A Systemic Evaluation of the 6T Principles on Corn Productivity in Gorontalo," *Pop. J. Penelit. Mhs.*, vol. 5, no. 1 SE-Articles, pp. 82–90, Mar. 2026, doi: 10.58192/populer.v5i1.4209.
[14] M. Azis and E. A. Suryana, "Komparasi dan Implementasi Kebijakan Digitalisasi Pertanian: Peluang dan Tantangan," *Risal. Kebijak. Pertan. dan Lingkung.*, vol. 10, no. 3, pp. 179–198, 2023, doi: 10.24244/jkebijakan.v10i3.51083.
[15] M. S. Sheikh and L. Berenyi, "E-Governance in Agriculture: A Framework on Digital Technology Adaptation by Smallholder Farmers," in *Central and Eastern European eDem and eGov Days 2023*, New York, NY, USA: ACM, Sep. 2023, pp. 78–83. doi: 10.1145/3603304.3603341.
[16] J. R. Fraenkel, N. E. Wallen, and H. H. Hyun, *How to Design and Evaluate Research in Education*, 8th ed. New York, NY 10020: McGraw-Hill, 2012. [Online]. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://digilib.upnb.ac.id/files/original/8/975/jack_fraenkel_norman_wallen_helen_hyun-how_to_design_and_evaluate_research_in_education_8th_edition_-mcgraw-hill_humanities_social_sciences_languages2011.1.
[17] M. Godet, *Creating Futures: Scenario Planning as a Strategic Management Tool*, I. France: Economica Ltd, 2006.
[18] T. W. Schultz, "Investment in Human Capital," *Am. Econ. Rev.*, vol. 51, no. 1, pp. 1–17, May 1961, [Online]. Available: http://www.jstor.org/stable/1818907
[19] J. Mariyono *et al.*, "Farmer field school: Non-formal education to enhance livelihoods of Indonesian farmer communities," *Community Dev.*, vol. 52, no. 2, pp. 153–168, Mar. 2021, doi: 10.1080/15575330.2020.1852436.
[20] C. S. Prajapati *et al.*, "The Role of Participatory Approaches in Modern Agricultural Extension: Bridging Knowledge Gaps for Sustainable Farming Practices," *J. Exp. Agric. Int.*, vol. 47, no. 2, pp. 204–222, Feb. 2025, doi: 10.9734/jeai/2025/v47i23281.
[21] P. Antwi-Agyei and L. C. Stringer, "Improving the effectiveness of agricultural extension services in supporting farmers to adapt to climate change: Insights from northeastern Ghana," *Clim. Risk Manag.*, vol. 32, p. 100304, Jan. 2021, doi: 10.1016/j.crm.2021.100304.

[22] A. Jabbar, W. Liu, Y. Wang, J. Zhang, Q. Wu, and J. Peng, "Exploring the Impact of Farmer Field Schools on the Adoption of Sustainable Agricultural Practices and Farm Production: A Case of Pakistani Citrus Growers," *Agronomy*, vol. 12, no. 9, p. 2054, Aug. 2022, doi: 10.3390/agronomy12092054.

[23] G. W. Norton and J. Alwang, "Changes in Agricultural Extension and Implications for Farmer Adoption of New Practices," *Appl. Econ. Perspect. Policy*, vol. 42, no. 1, pp. 8–20, Mar. 2020, doi: 10.1002/aepp.13008.

[24] S. Chaudhuri, M. Roy, L. M. McDonald, and Y. Emendack, "Reflections on farmers' social networks: a means for sustainable agricultural development?," *Environ. Dev. Sustain.*, vol. 23, no. 3, pp. 2973–3008, Mar. 2021, doi: 10.1007/s10668-020-00762-6.

[25] K. Valujeva, E. K. Freed, A. Nipers, J. Jauhiainen, and R. P. O. Schulte, "Pathways for governance opportunities: Social network analysis to create targeted and effective policies for agricultural and environmental development," *J. Environ. Manage.*, vol. 325, p. 116563, Jan. 2023, doi: 10.1016/j.jenvman.2022.116563.