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Social Capital Pathways to Resilient Food Systems: Insights from Organic Rice Farming under Environmental Change

Rahmi Purnomowati [1], ***Gunawan Prayitno*** [2*], ***Achmad Tjachja Nugraha*** [1], ***Rahmawati*** [2], ***Fajar Fadhilatun Nisak*** [2], ***Enock Siankwilimba*** [3], ***Md Enamul Hoque*** [4]

[1] *Department of Agribusiness, Faculty of Science and Technology, UIN Syarif Hidayatullah, Jakarta 15412, Indonesia*
[2] *Regional and Urban Planning Department, Engineering Faculty, Brawijaya University, Malang 65145, Indonesia*
[3] *Graduate School of Business, University of Zambia, Lusaka 10101, Zambia*
[4] *Department of Biomedical Engineering, Military Institute of Science and Technology (MIST), Dhaka 1216, Bangladesh*

ABSTRACT

This article examines how trust, social norms, and social networks distinctly influence the four pillars of food security in the organic rice farming community of Lombok Kulon, East Java. Using Partial Least Squares Structural Equation Modeling (PLS-SEM) and Importance-Performance Map Analysis (IPMA), the research investigates how these social components influence the four pillars of food security: availability, accessibility, utilization, and stability. The study emphasizes organic rice farming as a form of climate-smart agriculture that enhances soil fertility, reduces chemical dependency, and strengthens resilience to climate variability. It further situates the findings within the global challenges of sustainable agriculture, highlighting relevance to SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land). Data collected from 100 farmers reveal that social norms have the broadest impact, particularly on accessibility, utilization, and stability. Trust significantly influences food utilization, while networks contribute to availability and system stability. IPMA highlights that norms are high-impact but moderately performing, suggesting a priority area for policy intervention. The findings underscore the importance of disaggregating

*CORRESPONDING AUTHOR:
Gunawan Prayitno, Regional and Urban Planning Department, Engineering Faculty, Brawijaya University, Malang 65145, Indonesia; Email: gunawan_p@ub.ac.id

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social capital in food security planning and offer actionable insights for rural development strategies that prioritize relational infrastructure. The study advances empirical and methodological contributions to the evaluation of socially embedded food systems.

Keywords: Social Capital; Food Security; Rural Development; PLS-SEM; Organic Farming

1. Introduction

Ensuring sustainable food security has become one of the most pressing and multifaceted development challenges in the 21st century, particularly in rural areas of the Global South and is central to achieving the Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land). While global policy frameworks often focus on increasing agricultural productivity, contemporary perspectives underscore the necessity of addressing the relational, environmental, and institutional dimensions of food systems. This broadened understanding is especially vital in regions characterized by limited infrastructural capacity, environmental fragility, and persistent socio-economic inequality. Yet, despite this policy attention, there remains a limited understanding of how relational and institutional dynamics within local farming systems translate into concrete progress towards these SDGs. In such contexts, the dynamics of social capital—comprising trust, social norms, and networks—have emerged as pivotal yet underexplored levers for improving food security outcomes and advancing sustainable agriculture transitions in line with global climate adaptation agendas [1, 2].

Social capital plays an instrumental role in shaping cooperative behavior, facilitating resource exchange, and enhancing collective resilience, all of which are foundational to food security. Its influence cuts across the four dimensions of food security: availability, accessibility, utilization, and stability. For instance, strong social networks foster knowledge dissemination and resource sharing among farmers, thus improving agricultural practices and boosting productivity, which directly impacts food availability [3, 4]. Trust, on the other hand, serves as a lubricant of social interaction, reducing transaction costs and risk perceptions in agricultural cooperation—thereby reinforcing access to food and inputs [3, 5]. Social capital embedded in community culture, promote the equitable use of shared resources and enable adaptive utilization strategies to secure household nutrition [4, 6]. In addition, social dimensions intersect with environmental outcomes, as collaborative practices in organic farming reduce reliance on synthetic inputs, enhance soil health, and contribute to climate adaptation [7]. These interdependencies position social capital as the core theoretical lens through which this study examines food security dynamics in Lombok Kulon.

In Indonesia's rural regions, including Lombok Kulon, food security is often hindered by overlapping challenges: economic marginalization, environmental degradation, and limited institutional support for smallholder farmers. Economic marginalization, marked by income inequality and high unemployment rates, severely limits household access to nutritious food [8]. In addition, reliance on unsustainable agricultural techniques exacerbates environmental degradation and reduces the adaptive capacity of food systems to climate variability, ultimately undermining long-term stability. These interlinked stressors necessitate an integrated approach that addresses not only the material but also the social and ecological foundations of rural food security, positioning organic farming as a pathway to sustainable land management, biodiversity protection, and reduced climate risk in ways that align with the targets of SDG 2 and SDG 15.

In Lombok Kulon, organic rice farming emerged as a local response to fertilizer scarcity and environmental concerns [2]. Over time, it evolved into a sustainable livelihood strategy, enhancing both ecological resilience and community solidarity. Organic agriculture enhances soil fertility, reduces chemical dependency, and contributes to the restoration of degraded agroecosystems. Moreover, it builds resilience by enabling farming systems to better withstand climate-induced stressors such as droughts and pest outbreaks [9, 10]. Importantly, organic farming also creates platforms for community in-

teraction and collaboration, where farmers exchange knowledge and practices. These interactions reinforce social cohesion and improve food access and utilization by embedding shared values and practices within local food systems [11, 12]. From an environmental perspective, these practices also represent elements of a circular economy—recycling organic waste into compost, closing nutrient cycles, and reducing ecological footprints—thereby linking community-based farming to global sustainability debates [7]. As such, Lombok Kulon constitutes a relevant empirical site to explore how socially embedded organic rice systems can advance SDG 2, SDG 13, and SDG 15 at the village scale.

The incorporation of social capital into food security planning is both theoretically and empirically justified. Theoretically, social capital represents the web of relationships, shared norms, and mutual trust that underpin collective action—a crucial element in overcoming fragmented governance and market failures in rural development [3, 5]. Empirical studies corroborate this proposition, indicating that communities with higher levels of trust and collaborative engagement demonstrate better food security outcomes across multiple dimensions [4, 6]. For example, reciprocal labor exchanges, informal food sharing arrangements, and cooperative management of agricultural resources are all manifestations of social capital that contribute to enhanced food system performance. Nevertheless, most of these studies do not disentangle how different dimensions of social capital may follow distinct pathways in influencing specific pillars of food security.

Despite growing recognition of social capital's importance, research that systematically evaluates how its individual dimensions differentially affect food security remains scarce. Much of the current literature aggregates social capital into a singular construct, potentially masking its nuanced contributions to specific domains such as nutritional utilization or resilience stability. Consequently, we still know relatively little about which dimensions of social capital matter most for food availability, accessibility, utilization, and stability in such contexts. Moreover, while qualitative insights abound, there is a lack of rigorous quantitative approaches capable of capturing the complex, latent nature of social capital interactions. Analytical tools such as Partial Least Squares Structural Equation Modeling (PLS-SEM) and Importance-Performance Map Analysis (IPMA) offer significant potential to fill this gap by modeling multidimensional constructs and mapping their policy relevance. Complementing this relational view, Nisak et al. [2] show that *human* and *social* capital interact synergistically to accelerate organic-rice adoption, a finding that cautions against analysing social capital in isolation. This study responds to these gaps by explicitly disaggregating trust, norms, and networks and linking them to the four pillars of food security, while also positioning organic rice farming within the broader environmental debates on climate-smart agriculture, circular economy, and SDG-aligned sustainable food systems—especially SDG 2, SDG 13, and SDG 15. Comparative studies show that in Vietnam, trust primarily facilitates accessibility [1], while in India, cooperative farming and social norms underpin collective food access [13]. In Uganda, cultural norms strongly shape household food security [14]. These variations highlight the context-dependent nature of social capital. By situating the Indonesian case within these broader debates, this study contributes insights relevant to rural communities across the Global South. By situating the Indonesian case within these broader debates and employing a quantitatively testable model, this study develops a theoretically informed framework that can inform comparative research across the Global South.

Compounding this methodological gap is the limited attention given to relational and participatory dimensions in food system governance. Rural development programs have traditionally emphasized top-down delivery mechanisms, often overlooking the social relationships that mediate program uptake and sustainability. However, recent scholarship highlights that participatory planning—anchored in trust and shared norms—yields more responsive and equitable food security outcomes [11, 15]. These approaches empower community members to co-create solutions, thereby strengthening governance capacities from within. Moreover, participatory mechanisms such as farmer field schools, community rule-making, and collective decision-making structures help institutionalize cooperation and increase

stakeholder buy-in, especially in resource-constrained settings [10]. This governance perspective further reinforces the study's focus on social capital as a key explanatory construct in understanding food security outcomes.

In light of these gaps and opportunities, and drawing on social capital theory and the four-pillar food security framework, this study aims to evaluate how disaggregated components of social capital—trust, norms, and networks—independently and interactively affect the four pillars of food security in a rural organic farming context. Using a quantitative evaluative framework grounded in PLS-SEM and IPMA, the study assesses not only the statistical significance of social capital dimensions but also their relative importance and performance. Lombok Kulon Village in East Java, Indonesia, provides the empirical setting for this research due to its longstanding organic farming program, active farmer cooperatives, and rich landscape of community-based governance. Recent work on agricultural *circular-economy* models highlights that closing resource loops (waste valorisation, nutrient recycling) can increase local *availability* and *stability* of food while lowering environmental pressure [7] and contributing to SDG 2 and SDG 13. Embedding social norms and trust within those closed-loop systems is therefore essential for equitable distribution of benefits and risks, and for ensuring that sustainability gains translate into improved food security for vulnerable households, thereby advancing village-level progress towards SDG 2, SDG 13, and SDG 15. Specifically, the study asks which dimensions of social capital are most critical for each pillar of food security in Lombok Kulon and how their performance profiles can inform targeted policy and programmatic interventions.

This study contributes theoretically and methodologically by applying PLS-SEM and IPMA to assess the differentiated roles of trust, norms, and networks in shaping food security, and by clarifying the distinct pathways through which these disaggregated dimensions influence food availability, accessibility, utilization, and stability. It responds to the call for more nuanced evaluations that reflect the lived realities of rural communities and foreground the role of social dynamics in development planning. Ultimately, this research contributes to a broader understanding of how to build resilient and equitable food systems through the strategic activation of local social resources, offering practical entry points for local governments and farmer organizations seeking to accelerate progress towards SDG 2, SDG 13, and SDG 15.

2. Methodology

This study adopts a quantitative evaluation framework grounded in Partial Least Squares Structural Equation Modeling (PLS-SEM) and complemented by Importance-Performance Map Analysis (IPMA) to assess the differentiated impacts of trust, social norms, and social networks on four food security pillars: availability, accessibility, utilization, and stability. These methodological choices are motivated by the need to analyze complex, multidimensional relationships within a rural development context where sample sizes are typically limited and the data are often non-normally distributed. Our choice of PLS-SEM echoes recent Indonesian studies—e.g., Nisak et al. [2] on organic farming and Prayitno et al. [16] on livelihood resilience—that also model latent, multi-capital constructs with moderate sample sizes. This evaluation framework operationalizes the theoretical model outlined in the Introduction by translating the disaggregated dimensions of social capital and the four pillars of food security into empirically testable relationships.

2.1. Evaluation Framework and Justification

PLS-SEM was selected as the primary analytical method due to its flexibility in modeling complex relationships among latent constructs, particularly in contexts where the underlying theory is still emerging and the empirical data exhibit non-normality. This method is especially suitable for social research settings such as rural agricultural communities, where the causal pathways between variables such as trust, norms, networks, and food security outcomes are intricate and often mediated [17–19]. Furthermore, PLS-SEM enables the simultaneous assessment of both the measurement and structural models, making it appropriate for studies involving multiple interdependent dimensions.

To clarify the structure of the proposed relation-

ships and facilitate understanding of the model, a visual representation is provided in **Figure 1**, which illustrates the hypothesized causal paths linking each dimension of social capital to the four pillars of food security.

The conceptual model developed for this study delineates hypothesized pathways from trust, social norms, and social networks to each of the food security dimensions. This framework serves as a blueprint for empirical analysis and informs both the structural equation testing and interpretation of policy-relevant findings.

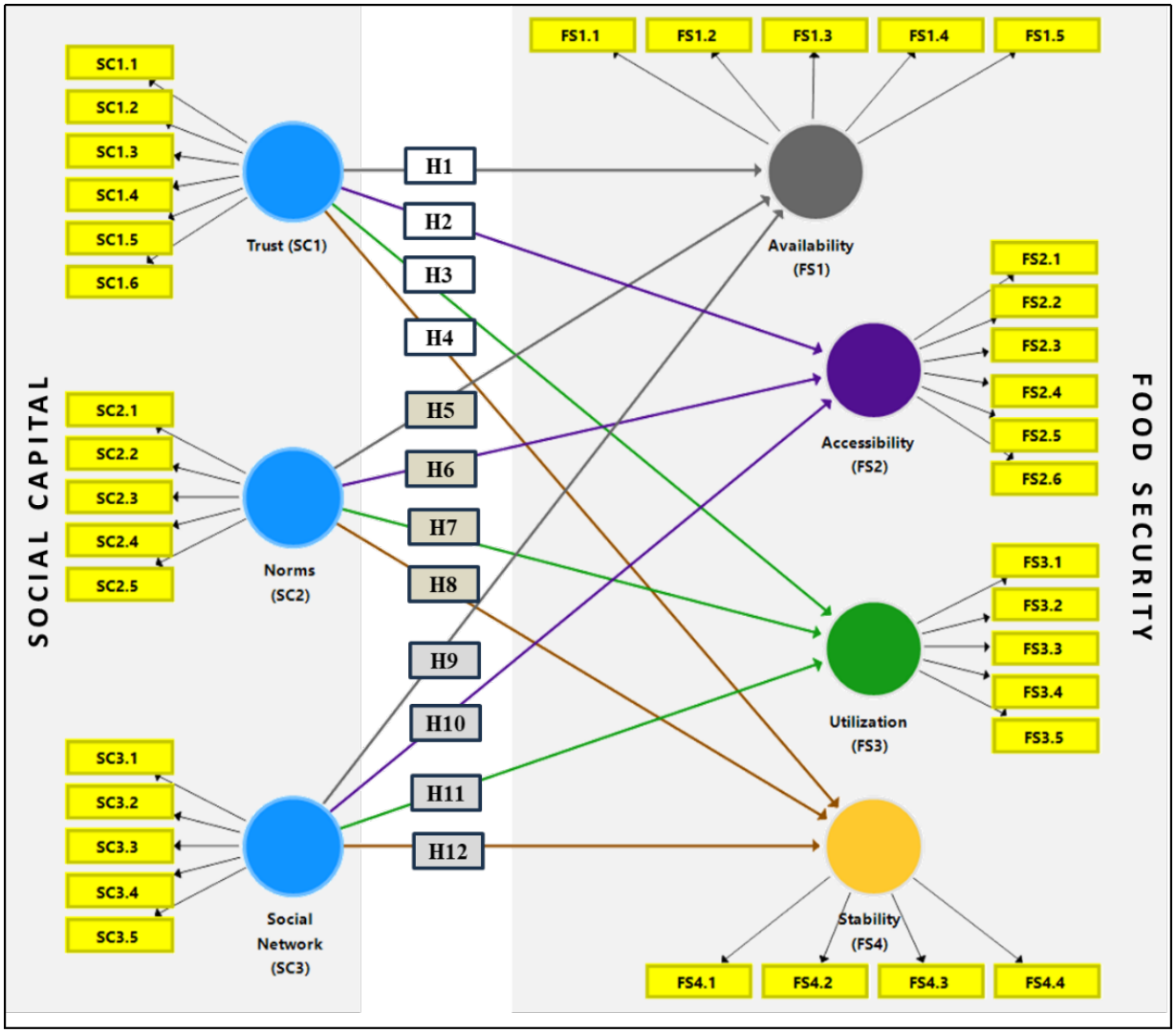

Figure 1. Hypothesis Model.

Research Hypotheses

Based on the conceptual model, the following hypotheses are proposed:

- **H1.** *Trust has a positive effect on food availability.*
- **H2.** *Trust has a positive effect on food accessibility.*
- **H3.** *Trust has a positive effect on food utilization.*
- **H4.** *Trust has a positive effect on food stability.*
- **H5.** *Social norms have a positive effect on food availability.*
- **H6.** *Social norms have a positive effect on food accessibility.*
- **H7.** *Social norms have a positive effect on food utilization.*
- **H8.** *Social norms have a positive effect on food stability.*
- **H9.** *Social networks have a positive effect on food availability.*

- **H10.** *Social networks have a positive effect on food accessibility.*
- **H11.** *Social networks have a positive effect on food utilization.*
- **H12.** *Social networks have a positive effect on food stability.*

The latent nature of social capital dimensions necessitates an analytical approach that can handle measurement error and explore indirect effects. PLS-SEM provides these capabilities while also offering strong predictive relevance, which is particularly valuable for informing development planning and community-level interventions [19, 20]. Furthermore, the inclusion of IPMA enhances the evaluative power of the study by identifying not only which constructs are statistically significant but also which are strategically important yet underperforming.

2.2. Study Area

The research was conducted in Lombok Kulon Village, located in Wonosari District, Bondowoso Regency, East Java, Indonesia. This village has maintained an active organic farming program since 2009, initially driven by limited access to chemical fertilizers. Over time, the program evolved into a community-led initiative emphasizing ecological sustainability, cooperative farming, and localized food systems. Lombok Kulon was purposively selected because it represents a long-standing, village-wide transition to organic rice cultivation with strong farmer organization (e.g., Gapoktan Al Barokah) and documented engagement in food security initiatives, making it an information-rich case for examining the interplay between social capital and food security. In this study, "organic rice farming" refers to farmers who participate in the village organic program and apply organic fertilizers and biopesticides under group-based protocols; while some plots may be covered by group or participatory guarantee schemes, others follow the same management standards without yet holding a formal third-party organic label, so the term "organic" denotes the production system rather than a specific commercial certification.

The village is characterized by the presence of strong informal institutions, including farmer cooperatives and water-user groups, high levels of community cooperation, and a culture of religious observance that influences collective behavior. This context provides a rich empirical setting for analyzing how trust, social norms, and networks shape food system resilience and household-level outcomes.

2.3. Sampling and Data Collection

A purposive sampling method was used to select participants from the list of farmers participating in the village organic program, who met the following inclusion criteria: (1) a minimum of three years' experience in organic farming, (2) active participation in farmer cooperatives or institutionalized farming groups, and (3) continuous residence in Lombok Kulon for at least five years. These criteria ensured that respondents were deeply embedded in the community and had sufficient exposure to both agricultural and social dynamics. The sampling frame was obtained from records maintained by Gapoktan Al Barokah and village authorities, and the final sample of 100 respondents satisfies common PLS-SEM guidelines (e.g., the 10-times rule) for models with multiple predictors, ensuring adequate statistical power for the estimated paths.

A structured questionnaire was administered through in-person interviews with 100 selected respondents. The questionnaire included items related to the three social capital constructs (trust, norms, and networks) and four food security dimensions (availability, accessibility, utilization, and stability). The items were adapted from validated measurement scales and contextualized to reflect local socio-cultural conditions [21, 22].

To enhance transparency and support replicability, the constructs and their respective indicators are summarized in **Table 1**, which should be inserted immediately following this paragraph. **Table 1** provides a structured overview of how each latent construct was operationalized using multiple indicators, along with the literature sources that informed their development. Each item was measured using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Pre-testing was conducted to assess the clarity and appropriateness of the language.

Table 1. Measurement indicators and corresponding literature sources for each latent construct.

Variables	Indicators	References
Social Capital (SC1) = Trust	SC1.1 = Trust in neighbors SC1.2 = Trust in community leaders for village development SC1.3 = Trust in farmers to cooperate and avoid harming each other SC1.4 = Trust in farmers to help each other combat pests and diseases SC1.5 = Trust in UD. Gapoktan Al Barokah (a farmers' organization) SC1.6 = Trust in Ulu-Ulu Banyu (an agricultural community)	Gedikoglu & Parcell [22]; Hua & Brown [1]; Kitano [23]; Liu et al. [24]; Malik & Kajale [13]; Prayitno et al. [25]
Social Capital (SC2) = Norms	SC1.8 = Compliance with customary rules SC2.2 = Compliance with religious rules SC2.3 = Compliance with village government regulations SC2.4 = Compliance with rules in farmer groups/Gapoktan SC2.5 = Importance of sanctions for rule violations	
Social Capital (SC3) = Social Network	SC3.1 = Partnerships between farmer groups SC3.2 = Social cohesion and community cooperation SC3.3 = Connections with organic farmers in the village SC3.4 = Participation in community activities (e.g., community service, village cleaning) SC3.5 = Active participation in providing input within farmer groups	
Food Security (FS1) = Food Availability	FS1.1 = Ability to meet family food needs through self-cultivation FS1.2 = Concern about food insufficiency in the past four weeks FS1.3 = Availability of nearby markets, stalls, and convenience stores FS1.4 = Consistent application of scientific principles in organic farming FS1.5 = Risk of production loss due to pests, diseases, or weather	Koroma et al. [26]; Kumar et al. [21]; Mkhongi et al. [27]; Morshedi et al. [28]
Food Security (FS2) = Food Accessibility	FS1.8 = Increased income from organic farming compared to conventional farming FS2.2 = Increased purchasing power for organic products FS2.3 = Quality of transportation systems for organic product distribution FS2.4 = Ease of road access to food sources FS2.5 = Availability of transportation for food supply needs FS2.6 = Affordability of travel costs to food sources	
Food Security (FS3) = Food Utilization	FS3.1 = Utilization of organic harvests for family consumption FS3.2 = Improved family health due to organic food consumption FS3.3 = Quality of household food intake FS3.4 = Ability to purchase essential protein sources (fish, meat, eggs, tofu, tempeh) FS3.5 = Availability of drinking and cooking water in the household	
Food Security (FS4) = Food Stability	FS4.1 = Reduced impact of climate instability on organic farming FS4.2 = Reduced pest and disease attacks in organic farming FS4.3 = Consistent use of biological methods to maintain organic farming FS4.4 = Organic farming ensures long-term food security with minimal environmental impact	

2.4. Measurement Model Evaluation

The first step in the PLS-SEM analysis involved evaluating the measurement model to ensure the reliability and validity of each construct. Internal consistency reliability was assessed using Cronbach's Alpha and Composite Reliability (CR), with thresholds of 0.7 or higher considered acceptable. Convergent validity was confirmed through Average Variance Extracted (AVE), where values above 0.5 indicated sufficient convergence.

Discriminant validity was evaluated using the Fornell-Larcker criterion, which compares the square root of each construct's AVE with its correlations to other constructs. Constructs demonstrated discriminant validity when the AVE square root exceeded inter-construct correlations. Outer loadings for all retained indicators exceeded the 0.7 threshold, confirming item-level reliability.

Items with outer loadings below the 0.7 threshold were iteratively removed to enhance the model's robustness. This refinement process ensured that only reliable indicators were retained, thereby improving the overall construct measurement quality and minimizing common method bias.

2.5. Structural Model Assessment

Following validation of the measurement model, the structural model was tested to examine hypothesized relationships. Bootstrapping with 500 subsamples was used to generate path coefficients, *t*-values, and *p*-values for statistical inference. The structural model's explana-

tory power was assessed using R-squared (R^2) values for each endogenous variable, while Q-squared (Q^2) statistics were employed to evaluate predictive relevance.

The structural model revealed significant positive relationships between key variables, such as trust and food utilization, as well as norms and food accessibility. These findings affirm the differentiated impacts of social capital components across food security domains. A table presenting the path coefficients, significance levels, and R^2 values is included to succinctly summarize these outcomes.

2.6. Importance-Performance Map Analysis (IPMA)

To derive strategic insights from the evaluation, IPMA was performed using the results of the PLS-SEM model. This technique provides a two-dimensional prioritization of constructs based on their total effects (importance) and average latent variable scores (performance). It is particularly effective in identifying areas of high importance but suboptimal performance, which are ideal targets for policy intervention.

In this study, social norms emerged as highly important but moderately performing in relation to food accessibility and stability, suggesting a need for strengthened communal rule systems and cooperative governance. Trust showed moderate importance and performance, particularly in influencing food utilization, indicating potential for capacity-building interventions focused on relational trust. Social networks, while highly performing, had comparatively lower importance, implying that while network structures function well, their marginal effects on food outcomes are limited. A graphical matrix is used to depict these findings, plotting constructs in quadrants to facilitate interpretation and inform policy focus areas.

2.7. Ethical Considerations

Ethical approval for this research was obtained from the Research Ethics Committee of Universitas Brawijaya. Informed consent was secured from all participants, and their responses were anonymized to protect privacy. No financial incentives were provided to respondents to prevent response bias. Data were collected and stored in accordance with institutional data protection policies. The research procedures complied with the principles of the Declaration of Helsinki, and all participants were informed about the purpose of the study and their right to withdraw at any time without negative consequences.

3. Results

3.1. Measurement Model Evaluation

In evaluating the reflective measurement model, several validity and reliability criteria were tested to confirm construct integrity. First, the Average Variance Extracted (AVE) values for all constructs exceeded the 0.50 threshold, demonstrating that each latent variable explained a sufficient proportion of variance from its indicators [17]. Composite Reliability (CR) scores ranged from 0.871 to 0.959, well above the recommended 0.70 cutoff and, in some cases, exceeding 0.90—indicating excellent internal consistency across the measurement items.

Outer loadings were systematically evaluated, and items with values below 0.70 were removed through iterative refinement. The remaining indicators exhibited strong item reliability, with all retained loadings above the 0.70 threshold [17]. This rigorous process contributed to a robust measurement model, with Cronbach's Alpha values also supporting internal consistency reliability.

Discriminant validity was confirmed through the Fornell-Larcker criterion. For each construct, the square root of AVE exceeded its correlations with other constructs, affirming that the measurement model successfully captured distinct dimensions of social capital and food security. These results are summarized in **Figure 2**, which presents the final outer loadings, AVE, and CR values for the social capital constructs.

3.2. Structural Model Evaluation

Path coefficient analysis was performed to assess the strength and significance of causal relationships. Using a bootstrapping procedure with 5000 samples, standardized beta coefficients (β), *t*-values, and *p*-values were obtained. The analysis confirmed the following sig-

nificant relationships:

- Trust → Food Utilization ($\beta = 0.311$, $p < 0.01$);
- Social Norms → Food Accessibility ($\beta = 0.287$, $p < 0.01$), Utilization ($\beta = 0.214$, $p < 0.05$), and Stability ($\beta = 0.261$, $p < 0.05$);
- Social Networks → Food Availability ($\beta = 0.226$, $p < 0.05$) and Stability ($\beta = 0.243$, $p < 0.05$).

These findings validate the hypothesis that social capital dimensions influence specific aspects of food security in distinct ways [21, 29].

The R^2 values were 0.311 for availability, 0.367 for accessibility, 0.392 for utilization, and 0.354 for stability (**Table 2**). These scores reflect moderate-to-high explanatory power, affirming the model's robustness in capturing food security outcomes [30, 31]. The Q^2 values for all endogenous constructs were above zero, confirming predictive relevance.

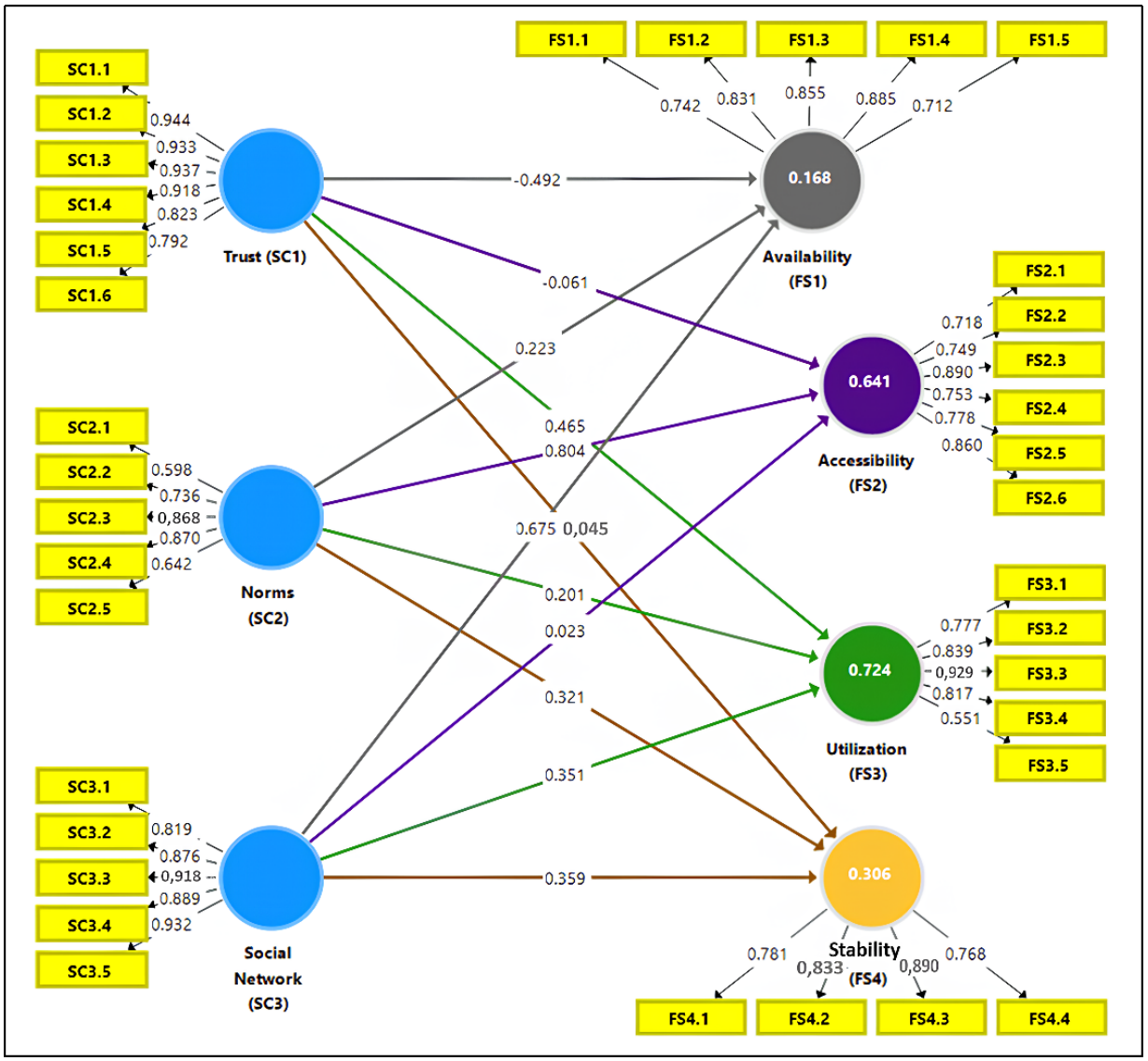

Figure 2. Summary diagram of outer loading refinements and AVE/CR results for trust, norms, and networks.

Table 2. Structural Model Results: Path Coefficients, *t*-values, Significance, and R^2/Q^2.

Hypothesis	Path	β (Path Coefficient)	*t*-Value	*p*-Value	Supported	R^2 (Construct)	Q^2 (Construct)
H1	Trust → Food Availability	−0.468	1.757	0.080	No	0.190	0.091
H2	Trust → Food Accessibility	−0.042	0.327	0.744	No	0.617	0.363

Table 2. *Cont.*

Hypothesis	Path	β (Path Coefficient)	*t*-Value	*p*-Value	Supported	R^2 (Construct)	Q^2 (Construct)
H3	Trust → Food Utilization	**0.468**	**2.823**	**0.005**	Yes	**0.698**	**0.493**
H4	Trust → Food Stability	0.050	0.290	0.772	No	0.301	0.173
H5	Norms → Food Availability	0.271	1.814	0.070	No	0.190	0.091
H6	Norms → Food Accessibility	**0.783**	**17.854**	**0.000**	Yes	0.617	0.363
H7	Norms → Food Utilization	**0.157**	**2.628**	**0.009**	Yes	0.698	0.493
H8	Norms → Food Stability	**0.310**	**4.205**	**0.000**	Yes	0.301	0.173
H9	Social Networks → Food Availability	**0.659**	**2.065**	**0.039**	Yes	0.190	0.091
H10	Social Networks → Food Accessibility	0.052	0.436	0.663	No	0.617	0.363
H11	Social Networks → Food Utilization	**0.357**	**2.198**	**0.028**	Yes	0.698	0.493
H12	Social Networks → Food Stability	**0.373**	**2.143**	**0.033**	Yes	0.301	0.173

Note: Bold values denote statistically significant results ($p < 0.05$), indicating supported structural paths in the model.

3.3. Trust and Food Utilization

Trust was found to significantly influence food utilization within the community. Households characterized by high levels of interpersonal and institutional trust demonstrated more consistent and diversified dietary patterns. This was made possible through informal mechanisms such as shared meal practices, joint food preparation, and open communication on nutrition and health matters [32]. These behaviors not only improve nutritional adequacy but also strengthen social ties that are critical in times of scarcity.

Trust-based informal systems further enable collaboration and pooling of resources during periods of food stress. Community members routinely exchange labor, food, and agricultural inputs without formal agreements, relying instead on norms of reciprocity and long-standing trust. Such arrangements have been shown to enhance food system resilience by reducing individual vulnerabilities and distributing risk more evenly across the community [33].

Field data from Lombok Kulon provide a clear example of how trust-based arrangements facilitate both organic input access and collaborative marketing, reinforcing food system functionality. In Lombok Kulon, the organic fertilizer required for rice farming is produced by a trusted local resident and made available to fellow farmers through informal village-level distribution. This system ensures that those who are unable to produce organic inputs themselves still have access to reliable, high-quality materials. Importantly, the transactions are guided not by formal contracts but by mutual trust and shared understanding of input quality and fairness in pricing. Trust also underpins marketing practices: farmers channel their rice through the Gapoktan rather than pursuing individual buyers, reflecting institutional confidence and reducing economic risks.

3.4. Social Norms and Food Accessibility, Utilization, and Stability

Social norms had the broadest influence, significantly affecting three out of four food security domains. Communal norms shaped food-sharing ethics and reinforced equity in food distribution, especially for vulnerable members of the community [34, 35]. These collective moral expectations govern who receives assistance during times of scarcity and how food is distributed within kinship networks, contributing directly to accessibility and system stability.

Religious and cultural norms also supported long-term sustainability by discouraging food waste and promoting practices such as seasonal food storage and cautious consumption. Informal sanctions and collective expectations around generosity and fairness helped maintain household food access even in periods of uncertainty [36, 37]. These norms, although not formally institutionalized, carried strong social legitimacy and were widely observed by community members.

Religious norms further shape post-harvest behavior: farmers first allocate rice for *zakat* and voluntary charitable giving (*sedekah)* before engaging in market sale, ensuring internal redistribution and spiritual fulfillment. Farmers routinely set aside a portion of their rice harvest for household needs and religious obligations—including *zakat maal*, *zakat fitrah*, and *sedekah*—before selling any surplus to the village cooperative (*Gapoktan*). For some, this act is motivated not by economic calcu-

lation but by spiritual duty. Only after meeting these commitments do they proceed with commercial distribution. As a result, redistribution of food within the village is largely self-regulated through internalized religious norms, contributing to a robust system of local food security.

This practice reflects a deeper communal ethic: farmers delay participation in the market until they feel their own family and moral responsibilities have been adequately addressed. Such behavior promotes intra-community equity and stabilizes access to staple foods, especially for marginalized households. It also illustrates how traditional and religious norms are not just symbolic, but actively shape the functional mechanisms of food utilization and accessibility on a routine basis.

3.5. Social Networks and Food Availability and Stability

Social networks played a vital role in enhancing food availability by facilitating access to shared resources, technical assistance, and market opportunities [33, 38]. Farmer organizations and cooperatives enabled collective procurement of inputs, coordinated seasonal harvesting, and promoted knowledge exchange on pest control and organic practices. These collaborative mechanisms contributed to greater production efficiency and helped stabilize overall output.

In addition, networks supported community resilience by buffering against environmental and economic shocks. The ability to mobilize shared labor, inputs, and knowledge allowed communities to respond more quickly and adaptively to disruptions. However, the influence of social networks on food accessibility and utilization appeared more limited. While these networks enhanced production capacity, they did not automatically ensure that food was distributed equitably or consumed in nutritionally diverse ways across all households.

This highlights a critical policy consideration: strengthening social networks may improve food availability, but without parallel investments in social norms and trust-building, the benefits may remain unevenly distributed. Food utilization, in particular, depends on a socially cohesive environment where knowledge, resources, and decision-making are not only accessible but also equitably shared. Therefore, program interventions that focus solely on network development may fall short unless integrated with efforts to reinforce relational trust and inclusive communal norms.

IPMA results helped translate statistical outcomes into practical priorities, showing that norms are highly important but moderately performing—especially in accessibility and stability—highlighting key areas for intervention. In contrast, trust showed moderate levels of both importance and performance, yet it exhibited a distinct influence on food utilization. Its role in facilitating interpersonal cooperation and informal support mechanisms renders it a strategically valuable asset in efforts aimed at improving household nutrition. Meanwhile, social networks, although relatively high-performing, were perceived as less central in driving key food security outcomes. Their contributions were more aligned with production efficiency and stability, rather than equitable access or utilization.

These findings are visually summarized in **Figure 3**, which presents the IPMA matrix and maps each social capital dimension according to its importance and performance levels. The matrix provides a clear visualization of strategic priorities and supports the alignment of intervention focus with areas of greatest leverage.

The IPMA findings support a targeted rural development strategy that strengthens community norms and trust mechanisms while sustaining productive network collaborations. To maximize impact, interventions should prioritize the reinforcement of communal norms and trust-building—particularly in relation to food distribution and dietary resilience—while continuing to support and sustain the effective functioning of existing farmer networks. By aligning performance improvements with stakeholder-identified priorities, the findings offer a context-sensitive strategy for enhancing food security through the lens of social capital.

This results demonstrates that social capital dimensions have differentiated, yet complementary, impacts on rural food security. Trust is essential for nutritional resilience, norms for distributive equity and system stability, and networks for productive capability. Together, they form the relational infrastructure

necessary for sustainable food systems in community-led agricultural settings.

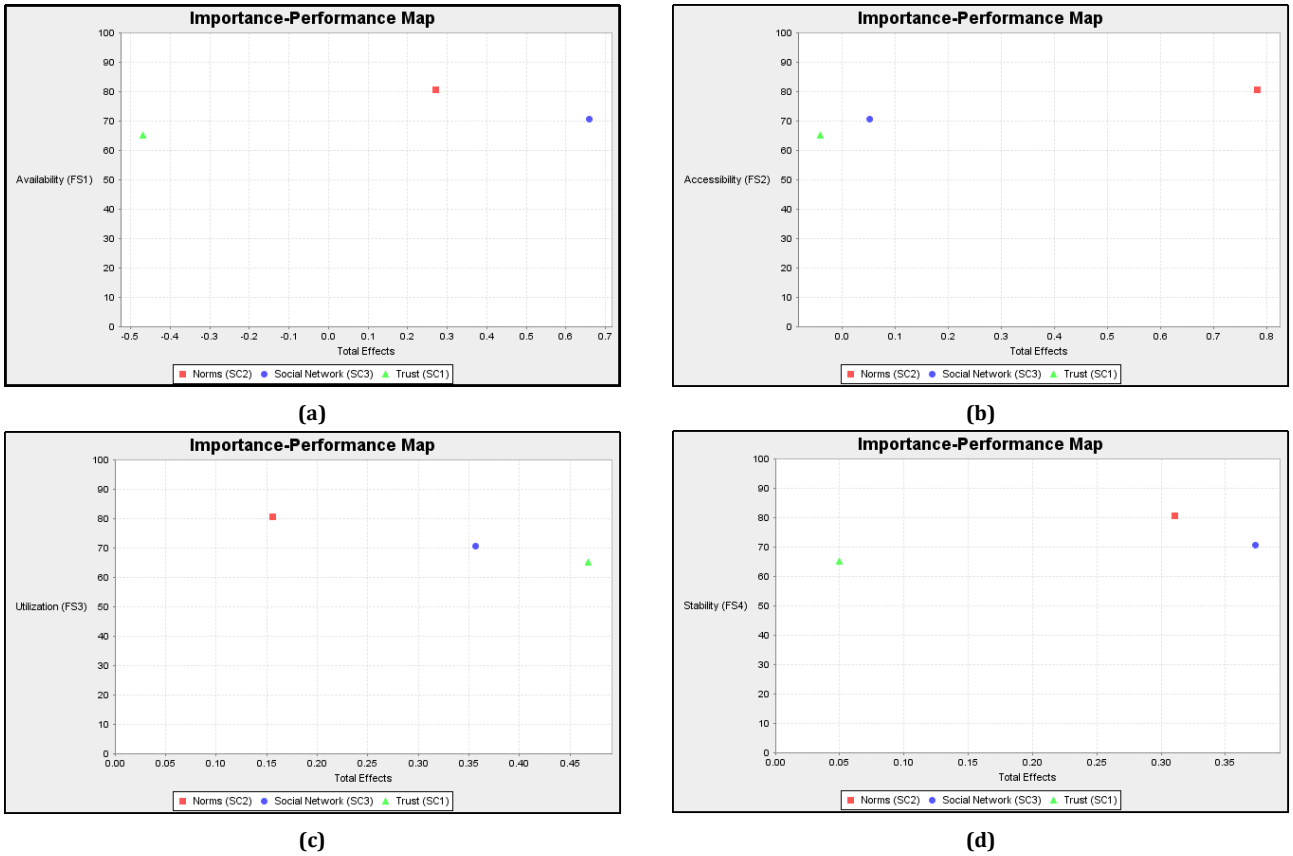

Figure 3. IPMA matrix mapping constructs by importance (x-axis) and performance (y-axis). The visual supports strategic program alignment: (**a**) Availability – Social Capital; (**b**) Accessibility – Social Capital; (**c**) Utilization – Social Capital; (**d**) Stability – Social Capital.

4. Discussion

This study aimed to evaluate the differentiated impacts of trust, social norms, and social networks on the four pillars of food security in the context of a rural, community-led organic farming system in East Java, Indonesia. Building on the results of the structural model and Importance-Performance Map Analysis (IPMA), this discussion reflects on the theoretical, empirical, and policy implications of the findings, with particular attention to the dynamic configurations of social capital in rural agricultural communities. In doing so, it positions the Lombok Kulon case within broader efforts to achieve Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land), by showing how socially embedded organic farming can enhance food security and environmental resilience.

4.1. Differentiating the Role of Social Capital Dimensions

The empirical findings underscore that social capital should not be treated as a monolithic construct. Instead, trust, norms, and networks operate through distinct mechanisms and influence food security outcomes in different ways. Trust was found to significantly affect food utilization, indicating its central role in shaping behaviors related to nutrition and food consumption. In contrast, norms emerged as the most influential factor across three food security dimensions, demonstrating their capacity to structure food access, equitable distribution, and system stability. Social networks, while functionally effective, showed limited strategic importance, primarily affecting food availability and, to a lesser extent, stability. Taken together, these differentiated roles illustrate how village-level social capital configurations

can directly support progress towards SDG 2 by improving availability, access, and utilization of nutritious food, while simultaneously contributing to SDG 15 through the maintenance of community-based, environmentally sensitive farming practices.

These differentiated effects reinforce the need to disaggregate social capital in both research and practice. Aggregating these components can obscure their unique functions. For example, while networks might enhance production capacity, they may fail to influence household-level consumption behaviors unless supported by trust and normative structures. This layered understanding provides a more nuanced picture of how community relationships impact food systems. It also clarifies theoretically that different facets of social capital map onto different food security pillars, enabling more precise theorisation of the pathways through which social relations affect food availability, accessibility, utilization, and stability in rural settings. This layered effect echoes findings from rural tourism, where social networks catalyse—but do not replace—trust-based collective action for sustainability [39].

4.2. High-Trust vs. Low-Trust Rural Agricultural Communities

A key insight from the literature is the varying configuration of social capital depending on the trust environment. In high-trust rural communities, interpersonal relationships facilitate open communication and collaboration. These conditions support robust social networks, enabling knowledge exchange, cooperative farming practices, and mutual aid—all of which enhance food system stability and access [3, 40]. Such configurations are particularly important for building climate-resilient food systems, a central concern of SDG 13, because they underpin collective responses to weather-related shocks and other environmental stressors.

For instance, high-trust communities may adopt collective farming models or tool-sharing systems, which reduce individual burdens and increase overall productivity [41]. Such communities are more likely to implement food-sharing systems and respond cooperatively to disruptions like climate shocks or market volatility. In Lombok Kulon, these cooperative behaviors translate into more stable and diverse diets, demonstrating how high-trust environments can operationalize SDG 13's call to strengthen resilience and adaptive capacity to climate-related hazards at the local level. The findings of this study confirm this pattern, as trust was a key determinant of food utilization, which is closely linked to community support practices and dietary resilience.

However, cross-country evidence indicates that the function of trust is not universal. In Vietnam, trust has been shown to primarily facilitate accessibility, by lowering transaction costs in cooperative arrangements and strengthening links between farmers and agricultural cooperatives [1]. By contrast, in Indonesia's Lombok Kulon, trust is more strongly tied to utilization, where interpersonal and institutional trust supports dietary diversity, food sharing, and religiously motivated practices such as zakat and sedekah. In India, cooperative farming structures highlight the role of social norms in shaping collective food access [13], while in Uganda, cultural norms rooted in tradition strongly govern household-level food security [14]. Theoretically, these cross-country patterns suggest that the same dimension of social capital can underpin different food security pillars depending on the socio-institutional context, implying that any attempt to link social capital to SDG targets must be sensitive to local configurations of markets, culture, and governance. These differences point to the fact that social capital outcomes are highly context-dependent, shaped by institutional frameworks, market structures, cultural norms, and religious obligations.

In contrast, low-trust environments often result in fragmented networks and disengaged households. These settings are marked by skepticism toward collective action and limited participation in shared agricultural systems [42, 43]. In such contexts, social norms may be weak or contested, and networks may serve only elite subgroups, reducing their overall effectiveness in securing equitable food access or utilization. Understanding the interplay between trust levels and the effectiveness of other social capital dimensions is crucial for tailoring interventions. From a policy perspective, this means that attempts to build climate-resilient, food-secure communities in line with SDG 2 and SDG 13 must often begin with trust-repair and inclusive norm-setting, rather than

with purely technical or network-expansion measures. In low-trust communities, priority must be given to rebuilding interpersonal relationships before expecting effective network mobilization or normative compliance.

4.3. Embedding Social Capital into Food Security Policy

The differentiated impacts of trust, norms, and networks suggest that food security policy must be context-sensitive and relationally informed. Programs should go beyond technical inputs and recognize that social structures mediate access to resources and affect behavioral outcomes, thereby shaping whether interventions genuinely contribute to SDG 2's goals of ending hunger and ensuring access to safe, nutritious food for all.

One effective strategy is to institutionalize participatory governance in food security programming. By involving local actors in decision-making, design, and implementation phases, programs can increase legitimacy and accountability. Participatory processes also activate bonding and bridging social capital—two subtypes essential for effective community organization and cross-stakeholder collaboration [44]. Theoretically, this underscores a shift from viewing social capital as a static stock of relationships to understanding it as a governance resource that can be cultivated and strategically mobilized.

Establishing platforms where farmers, cooperatives, local government, and NGOs interact regularly can strengthen trust and generate feedback loops that improve policy responsiveness. Programs that explicitly integrate these collaborative mechanisms can enhance access to inputs, knowledge dissemination, and adoption of sustainable practices. The success of such structures depends heavily on initial investments in social infrastructure and community training [45].

Training and capacity-building initiatives focused on leadership, communication, and group decision-making further amplify the utility of social capital. These activities empower communities to navigate institutional barriers and increase their ability to advocate for inclusive food systems, thereby operationalizing SDG 2 and SDG 13 in ways that are grounded in local capacities rather than externally imposed blueprints.

4.4. Leveraging Cultural Identity and Informal Institutions

The results also emphasize the critical role of cultural values, informal institutions, and community identity in shaping food security outcomes. Cultural practices such as communal labor exchange, harvest festivals, or religious food-sharing traditions serve as vehicles for reinforcing social norms and fostering collaboration [46]. These practices also provide an important cultural pathway for advancing SDG 2 and SDG 15, as they often encourage sustainable resource use and intracommunity redistribution of food.

These practices not only promote equity but also enhance the resilience of food systems by embedding cooperative behavior within everyday life. For example, religious teachings that valorize generosity and discourage food waste align well with sustainability goals and help regulate food access and consumption without the need for formal enforcement mechanisms [37].

Integrating these values into food security programming can enhance cultural legitimacy and foster stronger community buy-in. Programs designed with sensitivity to local customs and moral systems are more likely to achieve sustained engagement. For example, recognizing and supporting traditional cooperative systems can enhance program ownership and reduce resistance to change [29].

Moreover, informal institutions such as neighborhood councils, women's savings groups, and farmer-led cooperatives often function as de facto governance bodies in rural settings. Embedding these institutions within formal food policy frameworks creates a hybrid governance model that is both adaptable and grounded in community realities [5]. Such hybrid arrangements can better integrate local ecological knowledge and stewardship practices into formal planning, strengthening the social foundations of SDG 15 in agriculturally dependent communities.

4.5. Pathways toward Inclusive and Resilient Food Systems

Based on the empirical findings and literature integration, three main pathways can guide future interven-

tions each of which links social capital configurations to concrete steps for achieving SDG 2, SDG 13, and SDG 15 in rural food systems::

First, prioritize the sequencing of interventions based on existing trust conditions. In low-trust communities, initial efforts should focus on interpersonal trust-building through dialogue forums, mediation structures, and inclusive planning processes. Once trust is established, programs can expand to build networks and instill norms. This sequencing is crucial to ensure that network-building and technical support do not exacerbate inequalities, but instead create an enabling environment for equitable food access and climate resilience.

Second, embed community knowledge and practices into formal planning. This includes recognizing indigenous farming techniques, oral traditions around food storage, and culturally specific consumption patterns. Doing so enhances the relevance of interventions and ensures they are rooted in local epistemologies.

Third, foster reflexive governance by enabling continuous learning and adaptation. Monitoring systems should incorporate not just output indicators, but also relational metrics such as group participation rates, satisfaction with decision-making, and perceived fairness of food distribution. These data points offer richer insights into how social capital dynamics evolve over time and affect food system performance, and they allow policymakers to track whether interventions are genuinely strengthening the social foundations of food security and climate resilience rather than simply increasing short-term production.

4.6. Contributions and Implications

This study contributes to both the academic and policy discourse by empirically validating the differentiated roles of social capital dimensions in rural food security. It demonstrates the importance of analyzing social capital as a multidimensional construct and aligns with broader calls for relational approaches in development evaluation. Theoretically, the study refines social capital and food security frameworks by specifying how trust, norms, and networks differentially relate to the four food security pillars, thereby clarifying the mechanisms through which social relations shape household nutrition, access, and system stability. These findings align with emerging evaluations of circular agricultural models and global systemic pressures, which emphasize the need for localized, socially cohesive transitions to sustainable food systems [7].

By applying PLS-SEM and IPMA within a rural organic farming context, the research offers methodological innovation that combines statistical robustness with policy relevance. The combination of these tools demonstrates how complex, latent constructs such as social capital can be linked to policy-relevant outcome variables like food security pillars and SDG targets in a way that is both analytically rigorous and practically interpretable. The insights generated are directly applicable to rural development programs and food system interventions aiming to build resilience and equity in low-resource environments.

In practical terms, the study informs the design of multi-scalar strategies that integrate trust-building, norm reinforcement, and network mobilization. It also provides a replicable framework for evaluating similar interventions in other rural contexts with varying degrees of institutional capacity, including those seeking to localise implementation of SDG 2, SDG 13, and SDG 15 through community-led organic and climate-smart agriculture. Ultimately, the findings support a paradigm shift in food security planning—from input-driven to socially embedded models—where community relationships are recognized as infrastructure essential to achieving sustainable outcomes, and where progress towards global agendas such as the SDGs is understood to depend as much on the quality of social relations as on the quantity of physical inputs.

5. Conclusions

This study has demonstrated that social capital plays a critical and differentiated role in shaping the four pillars of food security in rural agricultural contexts. By disaggregating social capital into trust, norms, and networks, and employing a combination of Partial Least Squares Structural Equation Modeling (PLS-SEM) and Importance-Performance Map Analysis (IPMA), this re-

search provides empirical clarity on the unique pathways through which each component operates and how these pathways can support progress towards SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land) in community-led organic farming systems.

Social norms emerged as the most influential factor, affecting accessibility, utilization, and stability. They govern behavioral expectations, reinforce communal responsibility, and facilitate informal governance, which in turn strengthen equitable food systems. Trust, while more limited in scope, significantly influenced food utilization, especially through informal systems of food sharing, cooperation, and dietary support. Social networks were particularly important in enhancing food availability and stability, acting as channels for information dissemination, input access, and collaborative farming. Theoretically, these findings refine social capital and food security frameworks by showing that different dimensions of social capital map onto different food security pillars, rather than exerting uniform effects across the food system.

The policy implications are clear: interventions must be tailored to the specific social capital profile of each community. Building trust is essential in low-trust environments before investing in network mobilization. Norms should be reinforced through participatory rule-making and alignment with cultural values. Effective policy must recognize social capital not as a background variable, but as a strategic asset for resilience-building and inclusive food governance. In practical terms, this means that strategies aiming to localize SDG 2, SDG 13, and SDG 15 should systematically incorporate trust-building, norm reinforcement, and network strengthening into food security and climate-adaptation programs. Although grounded in the Indonesian case, these findings provide lessons for other agrarian societies in the Global South, where informal institutions, religious norms, and cooperative traditions remain central to building resilient and sustainable food systems.

In sum, this study advances the understanding of food security as not only a material issue but also a relational one. Future research should explore longitudinal designs and comparative analyses across agroecological zones to validate and expand on these findings and to test how different social capital configurations contribute to SDG-aligned outcomes in diverse rural settings. Embedding social capital into rural food policy is not just beneficial—it is indispensable for achieving resilient, equitable, and community-driven food systems that can withstand climate shocks, protect local ecosystems, and ensure fair access to nutritious food for rural households.

Author Contributions

Conceptualization, R.P., G.P. and A.T.N.; methodology, R.P., G.P. and F.F.N.; formal analysis, R.P. and F.F.N.; investigation, R.P., G.P. and F.F.N.; data curation, R.P. and R.; writing—original draft preparation, R.P. and G.P.; writing—review and editing, G.P., E.S. and M.E.H., A.T.N.; visualization, R.P. and F.F.N.; supervision, G.P. and A.T.N.; project administration, R.P. and G.P.; funding acquisition, G.P. and A.T.N. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Written informed consent was obtained from all subjects involved in the study. Participation was voluntary, and respondents were informed about the study objectives, anonymity, and confidentiality procedures.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author (G.P.) upon reasonable request. To protect participant confidentiality,

the dataset is not publicly shared.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results. During the preparation of this work the author(s) used ChatGPT (OpenAI) in order to assist with language refinement, organization of reviewer responses, and improving clarity of academic expression. After using this tool, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the published article.

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