

RESEARCH ARTICLE



Mocaf Flour for Food Security, Stunting Alleviation, and Creative Economy: A System Thinking Approach

Vita Sarasi¹, Dina Yulianti², Deny Saefulhadjar³

¹ Department of Management and Business, Faculty of Economics and Business, Padjadjaran University, Sumedang, 45363, Indonesia

² Department of International Relations, Faculty of Social and Political Sciences, Padjadjaran University, Sumedang, 45363, Indonesia

³ Department of Animal Husbandry, Faculty of Animal Husbandry, Padjadjaran University, Sumedang, 45363, Indonesia

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ABSTRACT

The rising dependence on imported wheat flour in Indonesia highlights the need for local alternatives such as Mocaf (modified cassava flour). This study explores the potential of Mocaf production in Sindangsuka Village, Garut, to strengthen food security, reduce childhood stunting, and promote the creative economy. A systems thinking approach was employed using a Causal Loop Diagram (CLD) to map and analyze the dynamic interconnections among these three domains. Data was gathered through literature review, focus group discussions (FGDs), and interviews with key local stakeholders. InsightMaker software was used to construct and simulate the CLD. The model identified reinforcing loops showing how increased Mocaf production improves local food access, supports child nutrition, and enhances household income through Mocaf-based enterprises. Triangulated validation confirmed key causal pathways linking innovation, nutrition programs, and creative economic activity. Policy leverage points include supporting agroecological practices, promoting maternal education, and expanding market access. Findings suggest that Mocaf production can simultaneously address public health and economic development goals. By integrating Mocaf into school feeding and micro-enterprise programs, communities can reduce stunting and boost income. The updated CLD also highlights potential risks such as market saturation and environmental degradation, underscoring the need for adaptive policies. This study contributes a validated systems model for rural development, offering practical insights for policymakers. It underscores that food system resilience requires coordinated strategies that address interconnected challenges across nutrition, agriculture, and livelihoods.

Introduction

The consumption of wheat flour in Indonesia has increased in line with the changing lifestyle of the younger generation, which now more frequently consumes wheat-based foods. In the 1970s, wheat flour consumption accounted for only about 3% of total staple food consumption, but this rose to 18.9% by 2010 and reached 28% by 2021. If this trend continues, wheat flour consumption is projected to reach 50% of staple food consumption by 2045 [1,2]. The rising demand for wheat flour poses a potential negative impact on the country's foreign exchange reserves. To reduce dependence on wheat flour imports, optimizing the use of local food sources is essential. Cassava (*Manihot esculenta*), a carbohydrate-rich crop abundantly available in Indonesia, offers a viable alternative. Indonesia is the world's largest producer of cassava, and cassava offers a solution to reduce dependence on wheat flour [3].

Sindangsuka Village in Cibatu, Garut, is an ideal location for optimizing cassava to enhance local food security. Adaptable and resilient to various conditions, cassava can be processed into modified cassava flour (Mocaf). The community service program in this village aims to process cassava into Mocaf, which can replace some of the wheat flour in various food products. Mocaf, produced from cassava fermented with lactic acid bacteria

Corresponding Author: Vita Sarasi  vita.sarasi@unpad.ac.id  Department of Management and Business, Faculty of Economics and Business, Padjadjaran University, Bandung, Indonesia.

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(LAB), has physicochemical properties similar to wheat flour and can be used in products such as bread, noodles, and cookies [4]. Research indicates that Mocaf production can reduce reliance on wheat flour and improve nutrition, particularly in efforts to address stunting in young children [5]. The development of nutritionally complete cassava varieties and their processing into Mocaf offers a solution to stunting while also promoting creative economic growth [1,6,7].

Using Causal Loop Diagram (CLD) within a System Thinking approach enables dynamic interaction analysis between food security, stunting alleviation, and creative economy. CLD helps understand how changes in one area impact others, both directly and indirectly, thereby supporting the formulation of integrated and effective strategies. It facilitates the design of more comprehensive and sustainable solutions by considering all factors and long-term impacts involved [8]. The urgency of this research is to provide practical and sustainable solutions for health and economic issues. The primary focus is on improving public health by addressing stunting in children through the use of local cassava for Mocaf production. Stunting affects children's growth and future quality of life, making it crucial to address [9]. By innovating with coconut sap fermentation, this research supports resource efficiency, enhances food security, and strengthens the local economy. It also explores new Mocaf production methods that add product value, open market opportunities, and improve nutritional quality. Marketing strategies and the use of Mocaf in the creative economy have the potential to drive local economic growth and create jobs.

This study contributes to the growing body of literature in Indonesia by offering a systems thinking perspective that links food security, stunting alleviation, and the creative economy within an integrated CLD model. While prior studies have addressed these issues separately, this research synthesizes them into a unified analytical framework. Such an approach is consistent with emerging trends in sustainable food systems research, where complex interdependencies across sectors are modeled to inform policy and community-based interventions [10–12].

To address the above challenges, this study aims to answer the following research question: What factors need to be considered in designing policies and strategies to maximize the benefits of Mocaf production for food security, public health, and local economic development? Accordingly, the objectives of this research are: (1) to explore the systemic relationships among Mocaf production, stunting alleviation, and the creative economy using a Causal Loop Diagram (CLD); (2) to validate the interconnections through stakeholder input and literature; and (3) to propose integrated strategies that support sustainable rural transformation.

Materials and Methods

Systems Thinking

The analysis technique used in this study is System Thinking, an approach for understanding complex systems by examining the relationships between various interrelated elements within the system. Unlike traditional analyses that isolate each element, Systems Thinking emphasizes patterns of interaction and feedback loops that shape the system's overall dynamics. This approach is particularly suitable for this study as it provides a comprehensive framework to link food security, stunting reduction, and creative economic development through Mocaf production. Systems Thinking, through tools such as the Causal Loop Diagram (CLD), helps map out these relationships, identifying both reinforcing and balancing loops [8], that reveal how increased Mocaf production can influence nutritional outcomes, food security, and local economic growth.

Systems Thinking also facilitates identifying underlying root causes of issues and developing effective policies and strategies by considering long-term impacts. By using CLD to map feedback loops, the study can show how improvements in nutrition through Mocaf can reduce stunting, boost productivity, and enhance local income via creative economic activities. Furthermore, Systems Thinking supports risk management by predicting the potential consequences of decisions in complex systems, allowing for proactive responses to challenges that may arise [13].

Systems Thinking begins with identifying the main elements and variables that interact within the system. Subsequently, relationships between these elements are mapped using a CLD, which depicts positive feedback loops (reinforcing loops) that amplify conditions, as well as negative feedback loops (balancing loops) that stabilize the system. Next, feedback patterns are identified to understand long-term behavior. Dynamic analysis is conducted to assess the impact of changes in one variable on other variables, leading to systemic changes. The creation of CLD is carried out in two stages. In the first stage, the CLD illustrates the current conditions.

In the second stage, the CLD is updated by adding new variables and relationships to propose scenarios, strategies, and solutions, as shown in Figure 1 [13]. The CLD modeling process followed a two-stage approach. In the first stage, a baseline CLD was constructed to represent the existing dynamics of Mocaf production, food access, and nutritional outcomes. In the second stage, additional variables were introduced based on stakeholder inputs to simulate scenarios and proposed interventions. The modeling was conducted using InsightMaker, an open-source system dynamics software, which allowed for dynamic feedback visualization and scenario-based analysis. We validated the model using a triangulation framework that drew on three sources: a review of relevant literature, focus group discussions with community members, and interviews with subject-matter experts. To keep track of the evidence, we developed a cross-reference matrix that linked each causal relationship to its origin, whether it came from expert judgment, field observations, or published studies. When the sources disagreed, we gave greater weight to field-based evidence and used secondary sources to fill any remaining gaps.

CLD Validation Approach

To test the reliability and contextual fit of the Causal Loop Diagram (CLD), we used a triangulation strategy that brought together expert reviews, community perspectives, and analysis of secondary data. Primary data came from focus group discussions (FGDs) and in-depth interviews with local stakeholders such as the village head, cooperative manager, cassava processors, women's groups, and micro-entrepreneurs involved in Mocaf production and marketing. Secondary sources included academic publications, government reports, and earlier studies on food security, stunting, and the creative economy. All proposed relationships between variables were validated through this multi-perspective process. A cross-reference matrix was also developed to map each causal relationship in the CLD to its source of evidence, expert opinion, community input, or literature. The results of this validation are summarized in Table 1.

Table 1. CLD variable validation sources, including triangulated inputs from literature, community FGDs, and expert opinion across food security, stunting, and creative economy domains.

Relationship in CLD	Source of evidence	Validation method	Notes
Mocaf ↑ → Stunting ↓	FGD with community health workers, literature [5,7]	FGD, literature review	Valid
Creative Economy ↑ → Household Income ↑	Interview with UMKM & cooperative, literature [14,15]	Interview, field observation	Valid
Cassava Production ↑ → Mocaf Supply ↑	Head of village, literature [3,4]	Expert judgement, data trend	Valid

The validation process helped refine feedback loops and ensured alignment with real-world stakeholder experiences. Revisions were made where stakeholder narratives indicated missing or misrepresented causal relationships. This validation strengthened the practical utility of the model in generating policy strategies.

Dynamic analysis is conducted to assess the impact of changes in one variable on other variables, leading to systemic changes. The creation of CLD is carried out in two stages. In the first stage, the CLD illustrates the current conditions. In the second stage, the CLD is updated by adding new variables and relationships to propose scenarios, strategies, and solutions, reflecting how interventions at different points in the system can lead to various outcomes over time. To better visualize this modeling process, the framework used to connect system goals, scenario development, strategic design, and simulation is presented in Figure 1.

To validate system thinking, the relationships between variables in the CLD must be consistent with reality. To test the reliability and contextual fit of the Causal Loop Diagram (CLD), we used a triangulation strategy that brought together expert reviews, community perspectives, and analysis of secondary data. Primary data came from focus group discussions (FGDs) and in-depth interviews with local stakeholders such as the village head, cooperative manager, cassava processors, women's groups, and micro-entrepreneurs involved in Mocaf production and marketing. Secondary sources included academic publications, government reports, and earlier studies on food security, stunting, and the creative economy.

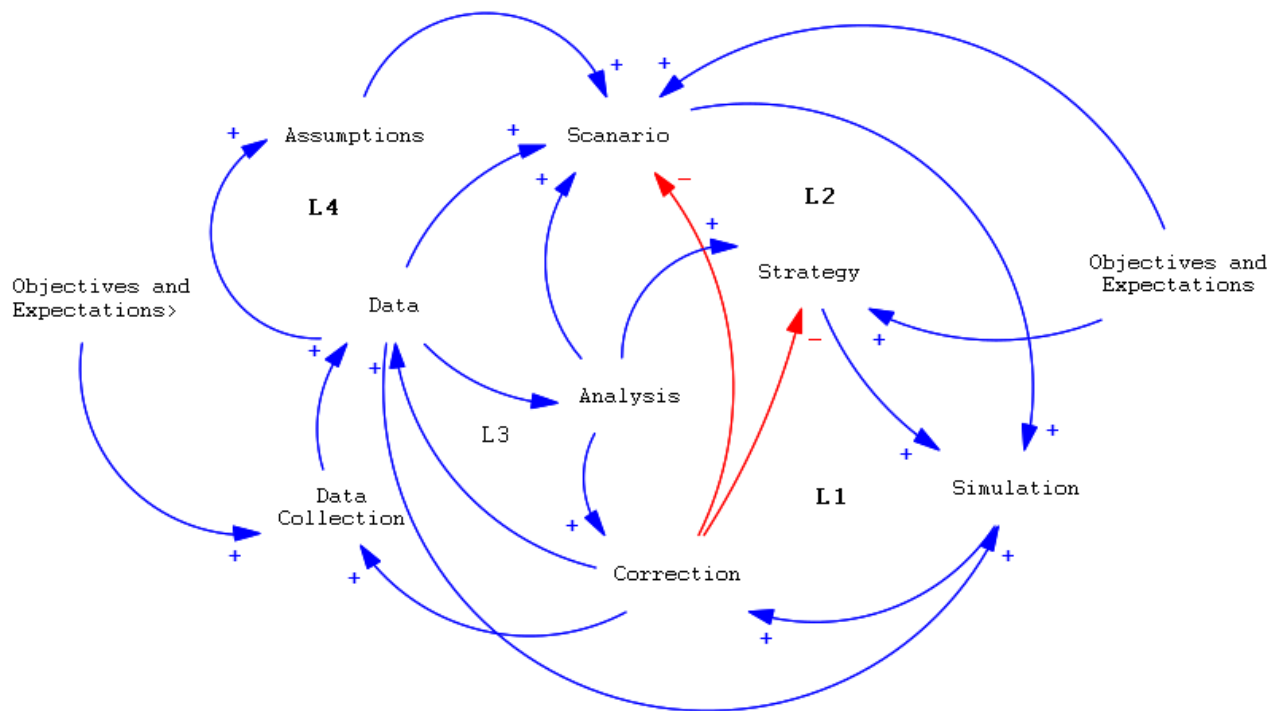


Figure 1. Framework illustrating the logical flow of systems thinking applied in this study, connecting research goals, scenario building, strategic policy design, and simulation planning to evaluate the systemic impact of Mocaf production.

Results and Discussion

Results

While this study employs a qualitative systems modelling approach through CLDs, empirical grounding is maintained through validation using field data, focus group discussions (FGDs), and expert interviews. The causal relationships identified in the model reflect observed dynamics within the community, such as the documented increase in household income following the adoption of Mocaf-based enterprises and community-reported improvements in child nutrition through school feeding programs. Rather than relying solely on theoretical assumptions, the feedback loops presented in the CLD are directly linked to practical outcomes observed in Sindangsuka Village. These insights strengthen the model's relevance and inform the formulation of context-specific policy strategies.

The first step involves defining the variables involved. The first variable is Food Security, which encompasses the availability, accessibility, and utilization of local food. Mocaf flour plays a crucial role in enhancing food security because cassava, as the raw material, can be processed into an alternative carbohydrate source that is more affordable and accessible. In the CLD, food security is represented by food availability, cassava production, and the use of Mocaf as a substitute for wheat flour [16].

The second variable is Stunting Alleviation, which pertains to the lack of nutritional intake in children. Nutrient-enriched Mocaf flour can improve the nutritional intake of undernourished infants, thereby helping to reduce stunting rates. In the CLD, stunting alleviation is linked to nutrition and the accessibility of affordable Mocaf products [17]. The third variable is Creative Economy, which contributes to food security while supporting the local economy through innovation and marketing of Mocaf products. Mocaf-based small enterprises in the village can boost income, create job opportunities, and strengthen the local economy. In the CLD, the creative economy is related to community income, innovation, and marketing [14]. Increased Mocaf production supports the creative economy through broader product distribution and enhanced community income [15]. After defining the variables, the next step involves relating Food Security, Stunting Alleviation, and the Creative Economy in a CLD to reflect the dynamic interactions in Mocaf flour production.

The CLD reveals several interconnected loops. The first loop illustrates how increased cassava production leads to higher Mocaf production, enhancing local food availability. This improved availability enhances

access to Mocaf flour, which boosts children's nutritional intake and reduces stunting. The subsequent reduction in stunting strengthens overall food security, which in turn increases the demand for Mocaf flour. This increased demand drives further Mocaf production, thereby completing the loop.

The second loop focuses on stunting alleviation. Higher Mocaf production, particularly of nutritionally enriched varieties, improves nutritional intake among children, which in turn reduces stunting. This reduction in stunting leads to better community well-being, increasing the demand for nutritional products. This heightened demand subsequently drives further Mocaf production, reinforcing the loop.

The third loop addresses the creative economy. Increased Mocaf production fosters product innovation, which enhances market competitiveness and boosts community income. The resulting improvements in food security and community income attract further investment in Mocaf production, thereby supporting additional product innovation and completing the loop.

Additionally, another loop highlights the economic impact. Increased Mocaf production leads to an expanded market reach, which enhances community income and improves food security. This improvement in food security and community income, in turn, supports higher production capacity and further market expansion, thereby reinforcing the cycle. These loops were not only developed conceptually but also validated through a structured triangulation process involving literature review, stakeholder interviews, and focus group discussions (FGDs).

The validation process confirmed that each relationship in the CLD was relevant and grounded in local conditions, with important contributions from village leaders, cooperatives, women's groups, and small business actors involved in Mocaf processing. These inputs guided adjustments to the causal links so the feedback loops accurately reflected the community's dynamics. The process also identified Mocaf production as a key driver connecting nutrition, local income, and food access. From a systems perspective, it revealed potential leverage points such as investment in innovation, expansion of community training, and targeted marketing, which policymakers can use to strengthen the system's resilience and effectiveness. Overall, the validation reinforced the study's theoretical foundation while confirming the practical value of the feedback structures in the community context.

These loops collectively demonstrate that Mocaf production initiates a series of positive feedbacks. The reinforcing effects include improved food availability and security, increased product innovation, boosted community income, and reduced stunting, all of which mutually support each other. However, potential balancing loops suggest that without continuous innovation or market expansion, market saturation could reduce income and weaken food security, underscoring the need for ongoing efforts to maintain balance and avoid negative outcomes (Figure 2).

To refine the solutions and strengthen the effectiveness of the Causal Loop Diagram (CLD), several strategic policy directions are proposed. The first priority is to encourage continuous innovation in Mocaf production by supporting research and development through grants, tax incentives, and collaborations between industry and universities. These initiatives can lead to better products and more ways to use Mocaf flour. Expanded market reach and market competitiveness are crucial and can be achieved by Mocaf production innovation and higher investment in Mocaf production, leading to a continuous increase in production capacity.

Nutrition-related programs on stunting reduction should also be improved. Integrating nutritionally enriched Mocaf flour into children's nutritional intake and access to Mocaf flour into the program will help increase community well-being, enhance demand for nutritional products, and strengthen food security.

The proposed strategic policies are designed not only to respond to current challenges but also to activate key reinforcing loops identified through the validated CLD model. By targeting leverage points such as innovation, nutrition access, and market expansion, these strategies help sustain long-term improvements in food security, stunting alleviation, and community income. Moreover, scenario-based interventions derived from systemic feedback ensure that Mocaf flour production contributes to resilient rural development while anticipating risks such as market saturation and environmental degradation. The integration of these strategies and variables is illustrated in the updated CLD model presented in Figure 3.

Figure 3 illustrates the updated Causal Loop Diagram (CLD), which incorporates scenario-based interventions into the core system dynamics of Mocaf production. This model shows how contributions of innovation policies, nutrition programs, and market expansion policies become backbones of the feedback loops that link food security, stunting reduction, and the community incomes through Mocaf production. As results, advances in Mocaf production development will increase some values of the production, create higher

market competitiveness, and generate higher incomes of the community. In turn, this income growth encourages further investment by the community in Mocaf production and distribution.

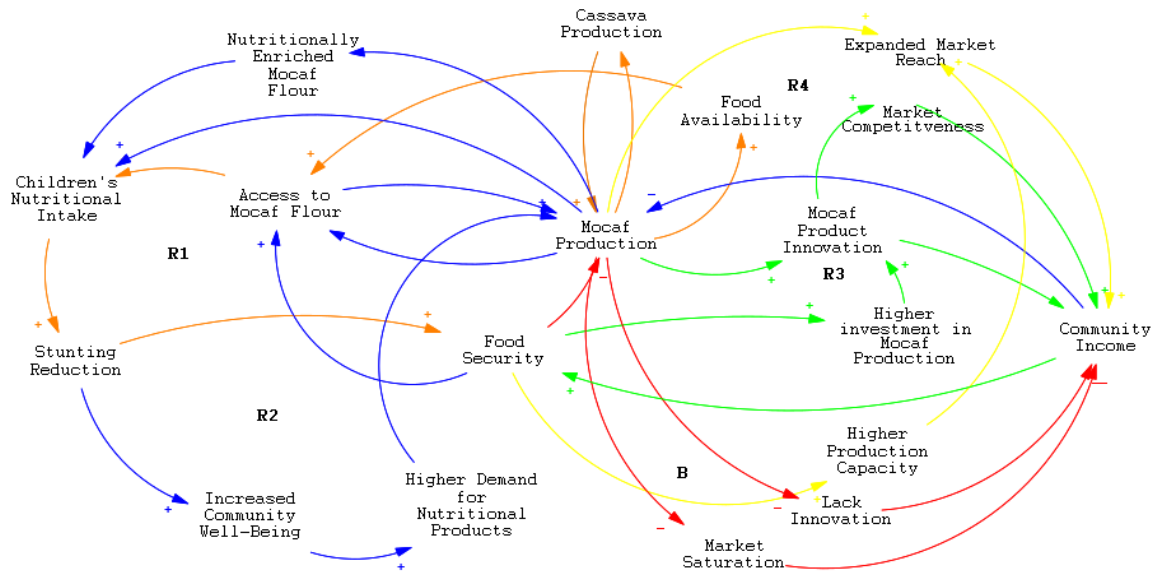


Figure 2. The baseline Causal Loop Diagram (CLD) illustrates the relationships among food security, stunting reduction, and the creative economy under existing conditions. The reinforcing loops depict positive feedback mechanisms identified and confirmed through community validation.

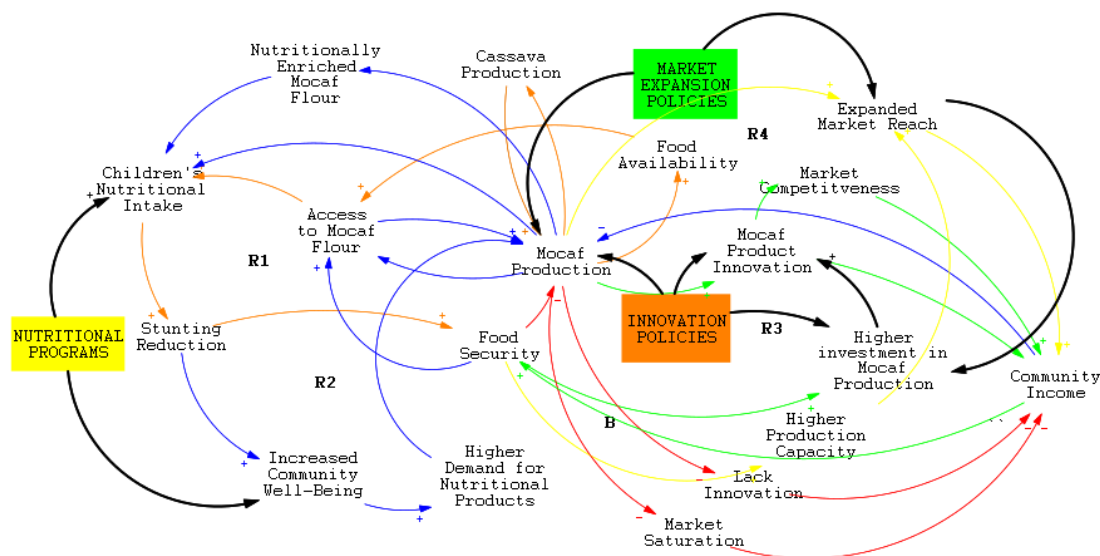


Figure 3. The revised Causal Loop Diagram (CLD) integrates scenario-based interventions such as innovation policies, nutritional programs, and market expansion policies.

Expanding the CLD Model by Incorporating Social, Economic, and Environmental Dimensions

The CLD Model can be further scrutinized by incorporating social, economic, environmental, and policy dimensions. Considering food security, there are some aspects that need to be analyzed. For instance, the quantity of food production also depends on the quality of the cassava seeds, the frequency of crops rotation, and the sufficiency of water for irrigation [18]. Sustainability of the food production is strongly dependent on land management, since land degradation leads to a reduction in soil fertility and, finally, a decline in agricultural productivity over time [19]. Using nature-based farming methods can accommodate these

problems. At the same time, fluctuating global market prices can impact food availability and production costs in local areas, especially if they rely on international markets [20].

The model outlines two crucial feedback loops. In the negative loop, land degradation reduces cassava yields, leading to lower food security and increased economic pressure on the community. This financial pressure in turn limits investment in sustainable farming practices, which further worsens land degradation. In the positive loop, government support for agroecological practices improves soil health, boosts cassava yields, and increases food availability, which strengthens food security. Incorporating these variables allows the model to capture the more complex and interconnected dynamics that shape food security at both local and global scales.

In efforts to alleviate stunting, several additional factors need to be considered. Environmental quality, such as air pollution and poor water quality, can worsen children's health conditions and increase the risk of stunting [21,22]. Additionally, access to healthcare services is crucial, as the availability of health facilities and nutrition programs significantly affects stunting rates, especially among mothers and children. The role of education is also critical; educating mothers about child nutrition can strengthen stunting alleviation programs. Maternal education levels and access to health education programs are relevant for improving understanding of nutrition [23].

The model shows two main feedback loops. In the negative loop, poor healthcare access can lead to increased stunting, which in turn reduces the productivity of future generations and decreases family income. This results in a decreased ability to purchase nutritious food, exacerbating stunting. Conversely, in the positive loop, the presence of educational programs can improve knowledge about child nutrition, leading to better nutritional practices. This will reduce stunting rates and produce healthier workers, improving productivity and ultimately increasing family income and access to nutritious food. The model clarifies how interventions in pollution, healthcare access, and education can significantly improve stunting conditions.

In the context of Mocaf-based creative economy, supply chain development becomes a critical variable. For the creative economy to develop effectively, a strong supply chain needs to be established, encompassing raw material access, processing, and distribution [24]. Transportation infrastructure, market accessibility, and logistical capacity are central to strengthening the supply chain. Equally important is innovation in derivative products, including packaged foods, cosmetics, and nutritional goods, which can drive the growth of the creative economy [25].

Digitalization, particularly through e-commerce and social media, offers new opportunities to expand and improve market access [26]. Strengthening the creative economy also requires collaboration among communities, government, NGOs, and the private sector, for example through the formation of cooperatives or joint business groups [27]. The model depicts two key feedback loops. In the negative loop, inadequate infrastructure reduces supply chain efficiency, limits market access, and results in low income from the creative economy. In turn, in the positive loop, investment in digital platforms improves market access, increases community income, and stimulates further investment in innovation. Overall, these two loops illustrate the dynamics that shape innovation-based community economy growth.

For the growth of Mocaf-based green economy, strong government support on agroecological practices is essential. The support will improve soil health in one side as well as reduce potential of rural poverty in another side. In the other perspective, the government policy will increase investment in Mocaf production and Mocaf product innovation, which furthermore strengthen food availability.

Environmental issues raise in the form of land degradation resulting in cassava yield and suffering food security. Overcoming the problem should pay much attention on enhancing the investment in sustainable practices of Mocaf production. Another environmental handicap comes from climate change disturbances on cassava planting schedules and crop yields, which in turn impact on Mocaf production. The changes of climate parameters such as rainfall often reduce water availability for the planting and decrease cassava production yields.

The model includes two main feedback loops. In the negative loop, climate change leading to extreme weather events reduces cassava yields, resulting in decreased food availability and increased food prices. This ultimately reduces food access and lowers food security. On the other hand, in the positive loop, effective adaptation strategies improve resilience to climate change and promote sustainable cassava farming practices. This results in stable or increased cassava yields, which enhances overall food security. The model illustrates how climate change and mitigation strategies can affect agricultural yields and food security (Figure 4).

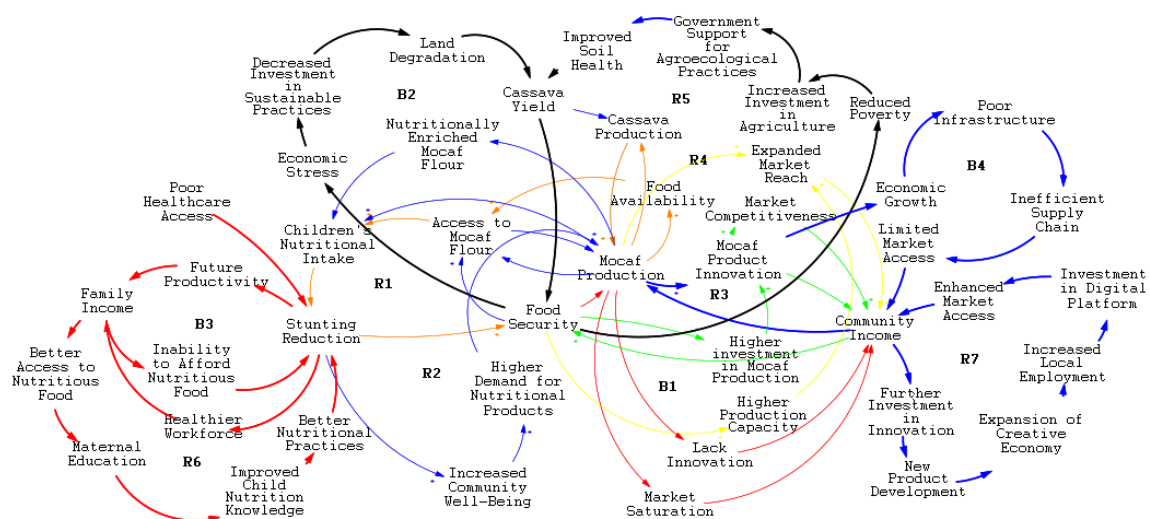


Figure 4. Expanded CLD with environmental, social, institutional, and climate variables, demonstrating how broader systemic factors, such as land degradation, maternal education, and climate adaptation, affect food system outcomes.

Figure 4 expands the previous model by capturing broader external variables that influence the effectiveness and sustainability of Mocaf-based systems. It illustrates how climate resilience, institutional support, ecological practices, education, and digital infrastructure collectively shape the long-term dynamics of food security, nutrition, and economic development. This expanded model reflects the real-world complexity of rural development and offers a holistic framework that can be adapted to other contexts with similar characteristics. It further reinforces the need for cross-sectoral collaboration and long-term systems-based policy planning.

Discussion

Critical Points of the Research

Recent studies highlight the effectiveness of systems thinking in addressing complex issues such as food security and stunting reduction, offering a holistic approach that examines the interconnectedness within food systems and community health. For instance, Quinteros-Reyes et al. [11] utilized community-based system dynamics to explore the drivers of malnutrition, including stunting, in Peru. This study engaged stakeholders to develop causal loop diagrams that revealed feedback loops between drivers of stunting and overweight issues, emphasizing the importance of understanding local contexts when designing interventions that address multiple health challenges simultaneously [11]. Similarly, Malard-Adam et al. [28] used a socioeconomic system dynamics model coupled with a crop growth model to examine how climate change and policy actions impact food security in indigenous communities in Guatemala. This approach identified feedback loops between environmental and human factors, providing a realistic representation of how climate policies affect food production and, consequently, food security [29]. These studies underscore the value of systems thinking in crafting integrated strategies that target root causes and promote sustainable improvements in food security and stunting reduction.

In the context of Mocaf production, a systems thinking approach offers valuable insight into how food security, stunting reduction, and creative economic development are interconnected. Using a causal loop diagram (CLD), this study has identified three main feedback loops: the Food Security, the Stunting Reduction, and the Creative-based Community Economy. The Food Security Loop showed that Mocaf, as locally made from cassava, provided an affordable food alternative and thus strengthened the security of food for the local community. The Stunting Reduction Loop demonstrated that nutrient-enriched Mocaf flour can improve the availability of nutritional food for children, which can be obtained or accessed locally by the rural community. Creative-based Community Economy Loop showed innovation can lead to enhancement of market access, which in turn widens market competitiveness and increases further investment in innovation of the Mocaf production and product innovation.

These three loops, as validated through literature review, stakeholder engagement, and FGDs, reflect dynamic interdependencies among the system components reflecting real conditions in rural communities.

As such, enhanced food security will support improved nutritional intake for children resulting stunting reduction, while economic growth of the rural community from Mocaf-related products will strengthen food availability and sustain the food demand, thereby reinforcing the system's positive loops.

Several studies have shown that Mocaf can both improve food security and boost the economy. In Indonesia, research has shown that fortified Mocaf products can enhance children's nutrition and help reduce stunting rates by offering an accessible, nutrient-rich food source [29]. At the same time, Mocaf production supports economic resilience in rural areas by creating market opportunities for value-added products such as Mocaf-based noodles and snacks, which have potential in both domestic and export markets. This economic activity not only boosts income for farmers and SMEs but also promotes local food security, demonstrating Mocaf's transformative role in both the food system and local economies. These findings align with the CLD framework developed in this study, reinforcing the strategic role of Mocaf in achieving food system resilience, improved health, and inclusive economic development. These findings underscore Mocaf's critical contribution to sustainable development goals related to food security, public health, and economic growth [12,30].

Strategic Policy Recommendations

Addressing challenges within the Mocaf production system requires a coordinated policy approach that tackles agricultural productivity, infrastructure, and access to financing. Research indicates that climate change and soil degradation pose significant threats to cassava yields, emphasizing the need for adaptation strategies, such as the development of drought-resistant cassava varieties and improved irrigation techniques [31]. Policies focused on agricultural subsidies and access to advanced farming technologies are essential to ensure a consistent and sustainable cassava supply for Mocaf production. Additionally, infrastructure improvements, including road networks and distribution channels, are necessary to facilitate the movement of Mocaf products to wider markets, thereby increasing accessibility and enhancing economic viability.

To support stunting reduction, nutrition programs that incorporate fortified Mocaf should be prioritized in regions with high stunting rates. Collaborations between the government and private sector can help develop Mocaf products enriched with essential nutrients, such as vitamins and minerals, ensuring these reach vulnerable populations. Educational campaigns in health centers and media outreach can further raise awareness of Mocaf's nutritional benefits, enabling better-informed food choices that contribute to improved health outcomes.

Expanding the creative economy through Mocaf production also requires policies that enhance access to capital and encourage innovation. Microcredit initiatives and digital marketing platforms can empower SMEs to innovate and reach broader markets, while business incubation programs for Mocaf-based products support product diversification and boost competitiveness. Trade agreements, such as the Indonesia-United Arab Emirates Comprehensive Economic Partnership Agreement (IUAE-CEPA), could open international market access, creating opportunities for local producers to expand beyond national borders [32]. Such economic policies provide the infrastructure for a thriving Mocaf industry and support sustainable growth within the creative economy.

To avoid market saturation, strategic partnerships among public, private, and community sectors can ensure Mocaf's continued relevance and sustainability. Regulations that protect agricultural land and promote agroforestry practices contribute to environmental sustainability and long-term productivity. Partnerships that drive technological advancements, such as digitalizing supply chains, can enhance efficiency and reduce costs, making Mocaf production more resilient to environmental and economic fluctuations. In addition, policy coherence across sectors, including agriculture, health, education, and environment, is essential to maintain synergies within the system. This ensures that interventions in one area (e.g., nutrition programs) are reinforced by parallel efforts (e.g., maternal education, clean water access, and sustainable farming).

In conclusion, implementing these policy solutions strengthens the systemic impact of Mocaf production, addressing challenges across food security, stunting reduction, and creative economic development. Through targeted agricultural support, infrastructure improvements, and policies promoting economic empowerment, Mocaf production can achieve sustainable outcomes that enhance community resilience, economic growth, and public health. These systemic strategies, grounded in the CLD framework, provide a practical roadmap for rural transformation and resilience-building in Indonesia and similar developing contexts.

Conclusions

This study addressed the research question by applying a systems thinking approach using a validated Causal Loop Diagram (CLD) to understand the interconnections between Mocaf flour production, food security, stunting alleviation, and the creative economy. The model revealed reinforcing feedback loops where innovation, improved nutrition, and household income support one another. Empirical validation through FGDs and field data confirmed that interventions such as nutrition-focused school programs, SME support, and cassava-based innovation can enhance system resilience. Key leverage points, such as increasing market access, supporting agroecological practices, and integrating maternal education, were identified to maximize impact. These findings provide a concrete framework for local governments and stakeholders to design integrated rural development strategies that are both sustainable and community-driven. Future research could expand this model with quantitative simulations or explore its applicability in other rural contexts to support broader policy formulation.

Author Contributions

VS: Conceptualization, Methodology, Analysis, Writing - Original Draft, Writing - Review & Editing; **DY:** Data Collection, Validation, Writing - Review & Editing; **DS:** Literature Review, Modelling, Writing - Original Draft.

Conflicts of Interest

There are no conflicts to declare.

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