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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Unraveling Farmer Empowerment: The Role of Socioeconomic and Institutional Factors in Sustainable Agriculture

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Abstract

Empowering farmers is essential for achieving sustainable agriculture, particularly in rural regions who depend on this sector as their primary means of subsistence. Given the increasing challenges in the agricultural sector, such as the dynamic market conditions and limited access to modern technology, there is a pressing need to identify and implement strategic interventions that enhance farmer empowerment. This study seeks to elucidate the impact of diverse elements, such as farmer motivation, local resources, cultural context, infrastructure, subsidy programs, agricultural cooperatives, the role of facilitators, and coffee-livestock integration on the degree of farmer empowerment. The analysis involved 168 farmers as respondents and using the fuzzy-set Qualitative Comparative Analysis (fsQCA) approach to discover factor combinations that correlate with varying levels of empowerment by evaluates the interaction among the determinant factors and determines the unique configurations that drive either high or low levels of empowerment. The findings indicate that the integration of appropriate local resources, the presence of active agricultural cooperatives, and a well managed crop-livestock integration system positively influences farmer production and economic stability. Robust infrastructure and focused subsidy policies enhance farmer competitiveness in the agriculture industry. Nonetheless, the influence of facilitators is not universally predominant, as there are instances where farmers attain significant empowerment despite minimal facilitator engagement. This study emphasizes the significance of a multi-faceted strategy in formulating more successful tactics for farmer empowerment. These findings are anticipated to provide a reference for policymakers and stakeholders in formulating policies that better align with farmers' demands, therefore enhancing the resilience and sustainability of the agricultural industry over the long term.

Keywords: Farmers' empowerment, Sustainable agriculture, Socio-economic, Institutional factors, fsQCA

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1. Introduction

Agriculture is a crucial industry for the economies of developing countries, particularly in Indonesia, where a significant portion of the people relies on it for their livelihoods (Salendu, 2021). In this environment, farmers play a vital role in ensuring the nation's food security. Currently, food security is not just dependent on the existence of farmers; rather, the empowerment of farmers is acknowledged as a means to enhance welfare and production (Asadullah and Kambhampati, 2021; Ibrahim and Yanti, 2019). Farmer empowerment encompasses access to tangible resources like land and capital, and intangible resources that enhance social, economic, and institutional capacities, thereby equipping farmers to confront difficulties in an increasingly complex environment (Bahua et al., 2016; Friis-Hansen and Duveskog, 2012; Ton et al., 2014). Moreover, in conjunction with the issues of environmental degradation, climate change, and global market dynamics, a sustainable and integrated strategy is essential for enduring agricultural resilience (Durant et al., 2023; Munir and Fadhilah, 2023).

Crop-Livestock Integration (CLI) has emerged as a pertinent sustainable approach in recent years (Purnomo et al., 2021; Sekaran et al., 2021; Swastika et al., 2024). CLI is a suitable method due to its capacity to combine crops and livestock into a single ecosystem. Altieri et al. (2017) asserted that CLI can enhance resource efficiency by diminishing reliance on progressively variable external inputs. Furthermore, CLI serves as a form of immunity inside the agricultural system while confronting environmental catastrophes (Bonaudo et al., 2014). This technology enables the conversion of crop waste into animal feed and livestock manure into organic fertilizer, hence enhancing soil fertility and plant productivity (Esen et al., 2022). The adoption of CLI is influenced not just by technical features but also by other socio-economic, policy, and institutional issues that affect its success (Costa et al., 2018; Sekaran et al., 2021). Additionally, elements including farmer motivation, local resources, cultural context, infrastructure, subsidy programs, the influence of cooperatives, and facilitators play a part in farmer empowerment. The motivation of farmers is a crucial factor in the adoption of new technology and the transformation of farming practices towards greater sustainability (Meijer et al., 2015). The availability of land, water, and animal feed is crucial in an integrated farming system (Pretty et al., 2018). Moreover, local culture influences agricultural practices, affecting the adoption of new technologies and perhaps hindering agricultural innovation (Beckford et al., 2007). Alongside social and cultural variables, supporting infrastructure such as market access, amenities, and irrigation systems plays a crucial role in enhancing farmer competitiveness (Moussa et al., 2021). Government-targeted subsidy policies promote sustainable agriculture systems (Nasrullah and Ovitasari, 2022). Moreover, cooperatives' role in enhancing access to production and financing can bolster farmers' positions across the agricultural supply chain (Bernard et al., 2022). The involvement of facilitators in delivering training, technical guidance, and disseminating sustainable insights and information can enhance farmers' capabilities (Yanfika et al., 2024).

Numerous technical and non-technical elements have been recognized as pivotal in farmer empowerment; however, the majority of studies primarily concentrate on individual factors, neglecting the intricate interactions among these elements that influence the overall level of farmer empowerment (Wossen et al., 2015). Moreover, while numerous studies examine the elements contributing to farmer empowerment, the methodologies frequently emphasize the isolated mapping of these factors, neglecting the interplay of socio-economic and institutional dynamics that underpin the sustainability of agricultural systems (Mariyono, 2024) Factors including farmer motivation, local resources, cultural context, infrastructure, subsidy policies, agricultural cooperatives, facilitator roles, and crop-livestock integration are frequently examined in isolation, neglecting the interrelationships and synergies among these elements that can either enhance or impede farmer empowerment. Farmer empowerment arises not from a singular source, but from the intricate interplay of multiple interrelated components within a complex agricultural environment. The government's subsidy strategy may only be effective if complemented by sufficient infrastructure and agricultural cooperatives capable of efficiently managing resource distribution. Similarly, facilitators' effectiveness in delivering technical support to farmers can be enhanced by fostering robust social awareness within the agricultural community to embrace change and innovation. Consequently, a gap persists in comprehending how the interplay of these factors might jointly establish optimal conditions for farmer empowerment.

This study aims to address the research gap by examining how the interplay of these elements influences the degree of farmer empowerment, while offering comprehensive insights into measures to enhance the sustainability

of farming systems at the individual farmer level. This study seeks to comprehensively examine the influence of critical aspects, including farmer motivation, local resources, cultural context, infrastructure, subsidy programs, agricultural cooperatives, facilitator roles, and crop-livestock integration, on farmer empowerment. This study employed the fuzzy-set Qualitative Comparative Analysis (fsQCA) method to find the configuration of elements that influence high or low levels of farmer empowerment. This study aims to enhance the comprehension of the dynamics of farmer empowerment aspects within integrated farming systems, a topic that has not been extensively addressed in prior research. This study aims to deliver more effective policy recommendations to enhance farmer empowerment and promote the adoption of the CLI system, thereby contributing to food security and agricultural sustainability in Indonesia. This study aims to address two primary questions in accordance with the research objectives: (1) How might the interplay of farmer incentive factors, local resources, local culture, infrastructure, subsidy policy, agricultural cooperatives, facilitator roles, and crop-livestock integration foster conditions conducive to significant farmer empowerment? (2) What are the primary impediments to enhancing farmer empowerment, and what is the appropriate method to address them? This study aims to elucidate how the fsQCA-based methodology may determine the optimal configuration of elements that facilitate sustainable farmer empowerment by addressing these concerns. Moreover, comprehending the arrangement of these components enables this study to offer more precise policy recommendations to enhance farmer empowerment more efficiently. Consequently, the findings of this study are anticipated to offer theoretical insights by elucidating the intricate dynamics of farmer empowerment, along with practical implications for the development of more effective empowerment policies and practices within the realm of sustainable agriculture.

2. Materials and Methods

2.1. Material

2.1.1. Farmers' Empowerment for Sustainable Agriculture

Empowering farmers is essential for establishing a sustainable and efficient agricultural system. This empowerment pertains to enhancing the capabilities of farmers in multiple dimensions, including social, economic, and technical, so enabling them to exert greater control over the administration of their agricultural enterprises (Abidin and Prasetyani, 2021). The sustainability of agriculture is significantly contingent upon farmers' access to resources, technology, and institutional assistance. Numerous studies have demonstrated that farmer involvement in groups and agricultural cooperatives yields substantial advantages, particularly in enhancing access to knowledge, technology, and broader market prospects (Addai et al., 2022; Bhattacharyya et al., 2021). Furthermore, the use of technical advancements like precision agriculture and renewable energy sources significantly contributes to enhancing resource efficiency and mitigating adverse environmental effects (Konfo et al., 2024). Consequently, farmer empowerment seeks to enhance crop yields while also securing their long-term welfare through the establishment of a more autonomous and competitive agricultural system.

Nonetheless, initiatives to empower farmers within sustainable agriculture encounter numerous challenges, including restricted access to technology and legislation that are insufficiently supportive of small-scale farmers (Choruma et al., 2024; El Bilali et al., 2021). Moreover, social and cultural variables frequently impede the adoption of agricultural innovations at the local level (Barth et al., 2021). Furthermore, prior studies indicate that training and human resource development initiatives significantly influence farmers' preparedness to embrace sustainable agriculture methods (Cooreman et al., 2021). Agricultural cooperatives play a crucial role not just in supplying agricultural inputs but also in serving as a more equitable and sustainable distribution system for agricultural goods (Bernard et al., 2022). In addition, the integration of technology into production and marketing processes has been shown to increase farmers' competitiveness in the global market. For example, digital applications that facilitate the rental of agricultural equipment can improve operational efficiency and reduce production costs for small-scale farmers (F. Zhang et al., 2021). Therefore, empowering farmers in sustainable agricultural systems must include a comprehensive approach, covering economic, technological, social, and institutional aspects, in order to create a more resilient agricultural system that is able to adapt to future challenges.

2.1.2. Farmers' Motivation

The motivation of farmers substantially propels their empowerment, since this element dictates the degree to which they may enhance their ability and autonomy in managing sustainable agricultural enterprises (Pandey et

al., 2024). Robust farmer motivation stimulates increased engagement in knowledge acquisition, training participation, and the adoption of more efficient and adaptive agricultural innovations (Slimi et al., 2021). Farmer motivation is linked to personal fulfillment, pride, and the dedication of farmers to their agricultural enterprises as integral components of their social and cultural identity (Nguyen and Drakou, 2021). Furthermore, farmer motivation is associated with income enhancement opportunities, accessibility, and governmental support in fostering greater farmer ability (Hagen et al., 2022). Empowered farmers exhibit more adaptability to change and demonstrate increased receptiveness to interventions designed to enhance productivity and competitiveness (Clarkson et al., 2022). Consequently, motivation serves as both a personal impetus in managing a farming enterprise and a catalyst for communal empowerment within the agricultural community.

2.1.3. Local Resources

The empowerment of farmers in promoting sustainable agriculture is significantly contingent upon their successful utilization of local resources (Boix-Fayos and de Vente, 2023). Human resources, including skills, knowledge, and experience, are the primary determinants in enhancing farmers' ability to run agricultural enterprises more efficiently and to respond to environmental fluctuations and market dynamics (Pandey et al., 2024). Natural resources, such as land, water, and biological ecosystems, are significant; nevertheless, without effective management and technical assistance, their potential is frequently underutilized (Obaisi et al., 2022). Consequently, measures for farmer empowerment should emphasize local resource-based methods to reduce reliance on external inputs and enhance the sustainability of their agricultural enterprises. Moreover, Candemir et al. (2021) indicates that social capital, including mutual cooperation and collaboration within farmer groups, significantly enhances the competitiveness of small farmers and fortifies their economic resilience. The presence of agricultural cooperatives and suitable government subsidy programs might alleviate capital limitations and enhance market access for farmers (Deng et al., 2021). The integration of human, environmental, and social capital enhances farmers' prospects for sustainable welfare and productivity improvement.

Nonetheless, the execution of local resource-based empowerment programs encounters numerous obstacles in practice. Current agricultural policies are predominantly top-down, failing to consider the unique conditions and requirements of local farmers (Atisa et al., 2021). Furthermore, some farmers remain hesitant to embrace modern agricultural technologies due to limited access to knowledge and a reliance on traditional practices that have persisted for centuries (Kamal and Bangladesh, 2023). The function of agricultural assistants or facilitators is crucial as intermediaries between farmers and various stakeholders, including the government, academia, and the corporate sector. Klerkx and Proctor (2013) assert that effective assistance enables farmers to access knowledge, technology, and broader commercial networks. Consequently, initiatives to empower farmers must extend beyond mere subsidies or aid; they also require educational programs, training, and support that foster farmer autonomy. A participatory and regionally oriented approach would enhance farmers' capacity to confront obstacles, augment production yields, and attain sustainable food security for their communities.

2.1.4. Local Cultures

Local cultures significantly contributes to empowering farmers, particularly in establishing a sustainable and community-oriented agricultural system. In numerous agricultural regions of Indonesia, cultural elements such as mutual collaboration, local wisdom, and generational farming methods serve as fundamental pillars in enhancing farmer competitiveness (Widayati et al., 2021). A tangible manifestation of local culture's role in empowering farmers is the collaborative practice among community members in resource sharing, encompassing knowledge, agricultural implements, and labor. In an integrated agricultural system with coffee plants and goats, the culture of mutual collaboration enables farmers to enhance the efficiency of both crop and animal management (Ahado et al., 2021). Moreover, robust social interactions enable farmers to receive knowledge regarding new agricultural technologies, marketing techniques, and other advances that can enhance their productivity (Fitri et al., 2024; Llones and Suwanmaneepong, 2021). Consequently, local culture not only enhances social cohesion among farmers but also augments their ability to adapt to change and capitalize on available opportunities.

Furthermore, local culture significantly influences farmers' perspectives and attitudes on their economic empowerment. Numerous agricultural communities in Indonesia regard farmland and livestock as integral components of their social identity and indicators of prosperity (Sterzer and Azizah, 2021). In many regions, coffee and goats serve as both economic assets and hold significant cultural significance, particularly in traditional rites

or customs that reinforce social bonds among farmers (Ginting et al., 2025). This tradition frequently serves as a motivating factor for farmers to continue their agricultural endeavors, despite economic difficulties and climatic change. By incorporating local culture into farmer empowerment initiatives, governments and stakeholders can formulate policies that align more effectively with the needs and values of local communities. These initiatives may encompass community-oriented training programs, facilitating market access that considers cultural preferences, and mentorship that honors local traditions (Klerkx and Proctor, 2013). This method to farmer empowerment emphasizes not just enhancing productivity but also fortifying the identity and socio-economic sustainability of agricultural communities, thus fostering more inclusive and self-sufficient farming systems.

2.1.5. Infrastructure

Adequate infrastructure is crucial in empowering farmers, particularly in fostering the sustainability of agricultural enterprises that integrate coffee cultivation and goat husbandry (Sumantra and Wijaya, 2024). The presence of sufficient facilities and infrastructure, including highways, transportation systems, and effective distribution networks, significantly influences farmers' access to markets and agricultural technology. Robust infrastructure enables farmers to expedite the transportation of their agricultural products to markets, hence enhancing the competitiveness of agricultural products in both local and worldwide markets (Stepanova et al., 2021). Shamdasani (2021) demonstrate that infrastructure quality, particularly in roads and transportation, directly influences farmers' success in product distribution and operational cost reduction. This is crucial for coffee and goat farming enterprises that necessitate effective management to uphold quality and output while enhancing farmer welfare.

Furthermore, sufficient infrastructure enhances farmers' access to essential services, including training, agricultural loans, and the provision of suitable crop materials (Davis et al., 2021). The presence of supporting infrastructure in coffee and goat farming enhances the acquisition of excellent animal feed and the implementation of contemporary agricultural techniques. An effective infrastructure encompasses not just physical transportation but also the establishment of agricultural amenities, including market connectivity, irrigation systems, and agricultural product processing facilities (Aoyagi et al., 2022). With sufficient infrastructure, farmers may more readily access the diverse resources and information necessary to enhance output capacity and diminish reliance on restricted distribution channels. Consequently, farmer empowerment facilitated by sufficient infrastructure can enhance their ability to run coffee and goat farming enterprises more efficiently, sustainably, and economically, thereby promoting local economic growth and the overall welfare of farmers.

2.1.6. Subsidy Policies

Subsidy policy are crucial in empowering farmers by offering financial assistance that enables them to acquire the resources necessary to enhance the production and efficiency of their agricultural enterprises (Zhang et al., 2021). Local government agricultural subsidies, including those for fertilizers, seeds, and farming equipment, facilitate farmers' access to essential inputs at a reduced cost. Bai et al. (2022) shown that effective subsidy programs can alleviate the economic strain on farmers, enabling them to concentrate on enhancing agricultural productivity and managing their farming operations sustainably. These subsidies diminish farmers' reliance on external finance while simultaneously incentivizing the adoption of innovative technologies and more efficient agricultural methods. Subsidies for the acquisition of high-quality fertilizers or seeds can enhance yields in coffee and goat farming, thereby motivating farmers to adopt novel practices and improve their agricultural management capabilities (Brown et al., 2021). Thus, subsidy policies can enhance farmers' competitiveness in a progressively competitive market. Moreover, subsidy support from local governments facilitates farmers' access to technical help and resources essential for the development of their agricultural enterprises (Zhang et al., 2021). Quiroga et al. (2024) indicates that government subsidies can serve as a catalyst for transformation in agricultural systems by enhancing farmers' ability to adapt to market and technical shifts. Subsidy policies targeting the agricultural sector, particularly regarding accessible financial and technical support, enable farmers to enhance both the quality and quantity of their output, thereby bolstering their economic resilience. This is crucial in the realm of coffee and goat farming, where investment in superior technology and infrastructure is essential for sustained success. Consequently, effectively executed subsidy policies not only promote agricultural sustainability but also expedite farmer empowerment, enhance their welfare, and fortify the agricultural sector overall.

2.1.7. Agricultural Cooperatives

Agricultural cooperatives play a vital role in empowering farmers by improving access to essential resources, markets, and financial support (Zhu and Wang, 2024). Acting as intermediaries, cooperatives help farmers acquire seeds, fertilizers, and equipment at lower costs while also serving as distribution agents that enhance efficiency and product quality (Li and Ito, 2021). By organizing farmers into structured groups, cooperatives strengthen their bargaining power, reduce dependence on external suppliers, and provide access to market intelligence and innovative technologies (Candemir et al., 2021). Additionally, cooperatives facilitate financial support, offering low-interest or interest-free loans that enable farmers to invest in modern agricultural practices and expand production capacity. Beyond financial aid, cooperatives enhance managerial skills through training programs that equip farmers with strategic decision-making and financial management competencies (Alemu et al., 2021). These combined efforts foster greater economic independence and sustainability in agricultural enterprises. By bridging gaps in resources, finance, and knowledge, agricultural cooperatives create a structured support system that enhances productivity, strengthens market positioning, and promotes long-term agricultural resilience. Ultimately, their role extends beyond economic benefits, contributing to broader rural development and farmer well-being through sustainable agricultural practices and improved livelihoods.

2.1.8. Facilitator Role

Facilitators are essential in empowering farmers by offering ongoing assistance in the adoption of technologies that improve production and community welfare. Derived from governmental or community entities, they provide farmers with crucial technical and management competencies to enhance agricultural practices (Cooreman et al., 2021). Their function beyond mere training, as they use contemporary agricultural methods, including sustainable fertilizers (Mulyaningsih et al., 2021) and optimized irrigation systems (Yang et al., 2022), assisting farmers in surmounting obstacles such as insufficient knowledge and information access (Thomas et al., 2023). Furthermore, facilitators enhance farmers' managerial competencies, facilitating improved planning and decision-making (Ouerghemmi et al., 2024). They also cultivate knowledge-sharing networks, enhancing farmers' market access and resource availability (Lakner et al., 2021). Facilitators serve as change agents by connecting farmers with financial institutions, markets, and technology suppliers, thereby fostering collaboration and adaptability to market demands. Their planned assistance guarantees that farmers possess the essential skills and resources to enhance agricultural sustainability and economic resilience. Facilitators increase agricultural practices and contribute to the long-term improvement of farmer livelihoods by promoting self-sufficiency and creativity within farming communities.

2.2.8. Crop-Livestock Integration

Crop-Livestock Integration (CLI), which amalgamates crops and livestock waste, particularly coffee with goats, has demonstrated significant potential in enhancing productivity and sustainability of agricultural enterprises, particularly in optimizing the utilization of available resources (Ginting et al., 2025). The amalgamation of coffee cultivation and goat husbandry not only yields ecological advantages through the repurposing of waste from both agricultural enterprises but also enhances the economic resilience of farmers (Swastika et al., 2024). Byproducts from coffee cultivation, like shade tree pruning and coffee cherry harvest residues, can serve as animal feed, whereas correctly processed goat dung can function as organic fertilizer, enhancing soil fertility for coffee plants. This system endorses the principle of integration within an integrated farming system, wherein the utilization of local resources and waste that benefits both crops and livestock positively influences farmers' economic resilience and environmental sustainability. This strategy enhances farmers' revenue while simultaneously improving environmental quality through sustainable and eco-friendly agricultural techniques (Sekaran et al., 2021). The establishment of an integrated coffee plantation and goat farming system yields substantial economic and social advantages. Tesema (2021) assert that CLI is a cost-effective animal enterprise for farmers with limited capital, offering significant economic value it products, which can serve as fertilizer for plants. Driven by strong motivation to enhance family income and bolstered by supportive social environments and government initiatives, such as the blue economy policy implemented by the Ministry of Agriculture, the integration of coffee cultivation with goat farming enables farmers to operate their agricultural enterprises more efficiently and sustainably. This is demonstrated by the rise in coffee production resulting from the use of organic fertilizer derived from goat dung, which subsequently enhances both the quality and quantity of coffee agricultural outputs (Ginting et al., 2025).

The mutualistic symbiosis between these two agricultural enterprises is crucial for fostering farmer autonomy and enhancing their socio-economic well-being, while promoting the sustainability of farming operations in rural regions.

2.2. Proposition Development

The factors affecting farmer empowerment have garnered considerable focus in agricultural and rural development literature. Local resource-based capacity building is implemented to furnish farmers with diverse supportive experiences in the empowerment process (Hasdiansyah et al., 2021). An integrated farming system that incorporates coffee cultivation and goat rearing enhances farmer empowerment by improving agricultural efficiency and productivity (Sekaran et al., 2021). The success of farmer empowerment is attributable to three primary factors that promote farming sustainability: the availability of local resources, support for subsidy policies, and access to pertinent training facilities and guidance (Bai et al., 2022; Hu et al., 2022; Soni et al., 2022). These three variables can enhance farmer empowerment by augmenting their ability to manage agriculture more effectively and sustainably. The sustainability and contentment of farmers with their empowerment are significantly influenced by the adequacy of existing policies in addressing their requirements. Farmers' aspirations for meaningful empowerment will be realized when they are granted access to sufficient resources, favorable policy support, and facilitators capable of offering suitable assistance (Melchior and Newig, 2021; Prus and Sikora, 2021; Sood et al., 2024). This will affect their satisfaction and autonomy in managing their agricultural enterprises. Consequently, farmer empowerment, influenced by an integrated farming system that maximizes local resource utilization, favorable subsidy policies, and the ongoing involvement of facilitators in delivering training and support, can enhance farmer welfare and fortify food security and the local economy. Consequently, this study present the subsequent propositions:

Proposition 1: The presence of single factors of fostering the farmer empowerment (motivation, local resources, local culture, infrastructure, subsidy policy, agricultural cooperative, facilitator role, integrated agribusiness development) is insufficient to foster the high farmer empowerment.

Proposition 2: The absence of single factors of fostering the farmer empowerment (motivation, local resources, local culture, infrastructure, subsidy policy, agricultural cooperative, facilitator role, integrated agribusiness development) is insufficient to foster the low farmer empowerment.

2.3. Methodology

2.3.1. Sampling Technique and Data Collection Procedures

This study examines farmers that include coffee and goat farming into their agricultural enterprises in North Sumatra, Indonesia. This study employed a nonprobability sampling technique, specifically purposive sampling, to ascertain the appropriate sample size, as only farmers who integrate the two commodities can furnish pertinent and comprehensive information on the research topic. Data collection was executed through direct visits to farmers participating in the farming business development program, namely those supported by the Starbucks Farmers Support Center (SFSC), conducted in December 2024. This in-person visit was used to guarantee that farmers comprehended each item posed, hence minimizing the likelihood of bias in completing the questionnaire. This strategy aims to yield more accurate and representative data, allowing researchers to further elucidate study questions if necessary, hence enhancing the quality and validity of the acquired data.

2.3.2. Analysis Technique

This study employs the fuzzy-set Qualitative Comparative Analysis (fsQCA) approach to evaluate the suggested propositions and ascertain the configuration of characteristics that facilitate farmer empowerment. FsQCA was selected for its capacity to examine intricate interactions among multiple components inside non-linear connections (Pappas and Woodside, 2021), making it highly suitable for this study's objectives. The fsQCA analysis approach evaluates the sufficiency and necessity to discover the configuration of conditions required to attain high or low levels of farmer empowerment. Each component is evaluated to ascertain its contribution, lack thereof, or irrelevance in affecting empowering outcomes. In fsQCA, metrics like consistency, raw coverage, and unique coverage are employed to produce configuration options that align with the propositions presented in this study. Consistency denotes the extent to which a configuration of causal conditions dependably results in the

consequence, illustrating the dependable association between a specific configuration and elevated farmer empowerment, while coverage denotes the fraction of result occurrences elucidated by a configuration, signifying the empirical significance or relevance of the configuration within the dataset (Pappas and Woodside, 2021). By identifying multiple configurations, fsQCA offers profound theoretical and practical insights into the diverse demands and behaviors of farmers, hence facilitating the formulation of more targeted and successful policies for promoting sustainable agriculture.

3. Results and Discussion

3.1. Sample Demographics

This study involved 168 coffee farmers in North Sumatra who are members of the Starbucks Farmers Support Center (SFSC) mentoring program. The majority of farmers are in the 35 – 45-year age range (25% or 41 farmers), followed by the 46 – 55-year age group (44% or 74 farmers), while 18% or 30 farmers are > 55 years old, and only 13% or 23 farmers are < 35 years old, which shows that the participation of young farmers is still low. In terms of coffee land ownership, 46% or 77 farmers have land < 0.5 hectare, 38% or 64 farmers have land 0.5-1 hectare, while 16% or 27 farmers have land > 1 hectare, which shows that the majority of farmers are on a small scale. Coffee farming experience also varies, with 19% or 33 farmers having < 10 years of experience, 56% or 94 farmers having 10–20 years of experience, 24% or 41 farmers having > 20 years of experience. In terms of raising goats, 87% or 146 farmers have < 10 years of experience, 11% or 18 farmers have 10–14 years of experience, 2% or 4 farmers have > 15 years of experience, which shows that coffee-livestock integration is still in its early stages. Overall, these characteristics indicate that the majority of farmers have long experience in coffee farming, but with varying scales of land ownership and livestock farming experience, so further assistance is needed in optimizing the integrated farming system.

3.2. Calibration Selection and Truth Table

This study employs the fsQCA analytic method, commencing with data calibration, wherein data gathered using a 5-point Likert scale is transformed into a fuzzy set. A specified threshold assigns a value of "1" to denote complete non-membership, "3" to signify full membership, and "5" serves as a crossover point to verify adherence to the relevant technique (Pappas and Woodside, 2021; Ragin, 2023). The outcomes of this calibration serve as the foundation for constructing a truth table, which systematically delineates causal conditions, including motivation, local resources, local cultural, infrastructure, subsidy policies, agricultural cooperatives, facilitator role, and crop-livestock integration, all of which contribute to farmer empowerment. *Table 2* illustrates the utilization of fuzzy logic, emphasizing the impact of specific construct combinations on farmers' empowerment (FE) and enhancing the comprehension of sustainable agriculture. The fsQCA research identified six distinct configurations linked to high FE, highlighting various combinations of constructs including motivation, local resources, local culture, infrastructure, subsidy programs, farmer cooperatives, facilitator roles, and crop-livestock integration. The consistency scores for these setups varied from 0.995 to 1.000, demonstrating the reliability and predictive efficacy of the truth table. Configuration 5, which included all structures, proved to be the most robust, comprising 65 examples with a consistency score of 0.996, signifying optimal synergy among these elements in augmenting farmer empowerment. This conclusion indicates that although specific combinations produce best outcomes, alternative methods can also attain similar results, providing significant insights into enhancing farmer empowerment. Conversely, the examination of the low FE configuration revealed six unique routes, suggesting that the outcomes of these truth tables exhibit comparable variability to those of high FE. Among these, one configuration demonstrated elevated levels of low FE, whereas the other five displayed diminished levels of low FE. In contrast to the uniform pattern noted for high FE, these paths exhibited a more disjointed trend. Configuration six, which encompasses all constructs, produces a low FE, comprising 65 examples with a consistency score of 0.332. Conversely, Configuration 1, lacking infrastructure yet containing other constructs, demonstrates a low FE with a diminished consistency score of 0.853, based on a singular example. This variety highlights the intricate hurdles to farmer empowerment, where the lack or interplay of specific components can impede agricultural sustainability. This study offers a comprehensive view on overcoming problems in ensuring consistent empowerment and developing effective strategies for promoting sustainable agriculture by analyzing these configurations.

Table 1. Truth Table Analysis for High Results

FM	LR	LC	IF	SP	AC	FR	IA	Cases	High FE	Raw Consistency
Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	7	Yes	1.000
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	1	Yes	1.000
Yes	Yes	Yes	No	Yes	Yes	No	Yes	1	Yes	0.998
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	2	Yes	0.997
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	65	Yes	0.996
Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	1	Yes	0.995

Table 2. Truth Table Analysis for Low Results

FM	LR	LC	IF	SP	AC	FR	IA	Cases	Low FE	Raw Consistency
Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	1	Yes	0.853
Yes	Yes	Yes	No	No	Yes	Yes	Yes	1	No	0.796
Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	1	No	0.722
Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	2	No	0.657
Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	7	No	0.627
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	65	No	0.332

3.3. Necessity and Sufficiency Analysis

The examination of necessity conditions uncovered significant insights into the determinants of high and low FE. According to the criteria established by Pappas and Woodside (2021), a condition was deemed "necessary" if its consistency surpassed 0.90 and its coverage exceeded 0.50. For elevated FE, all essential elements, including motivation, local resources, local culture, infrastructure, subsidy policy, farmer cooperatives, facilitator function, and crop-livestock integration, satisfied the requisite thresholds. Consequently, farmer motivation exhibited remarkable consistency (0.965) and coverage (0.935), highlighting its essential function in promoting high FE. five findings affirm that elevated farmer empowerment is contingent upon the existence of five basic constructs, each of which is essential for fostering agricultural sustainability.

Table 3. Necessity and Sufficiency Results

Configuration	High FE		Low FE	
	Consistency	Coverage	Consistency	Coverage
FM	0.965	0.935	1.000	0.222
~FM	0.197	1.000	0.708	0.823
LR	0.973	0.928	1.000	0.219
~LR	0.182	1.000	0.676	0.852
LC	0.894	0.955	0.990	0.245
~LC	0.293	0.998	0.819	0.640
IF	0.868	0.936	0.965	0.246
~IF	0.321	0.976	0.858	0.600
SP	0.852	0.961	0.993	0.258
~SP	0.342	0.995	0.852	0.570
AC	0.912	0.967	0.996	0.242
~AC	0.285	0.998	0.867	0.696
FR	0.930	0.933	0.996	0.230
~FR	0.232	0.996	0.711	0.701
IA	0.962	0.970	1.000	0.231
~IA	0.238	1.000	0.873	0.842

The analysis for low FE revealed that none of the constructs independently satisfied the requirements for need. For instance, although the lack of farmer motivation (~FM) exhibited a considerable coverage (0.708), its consistency (0.823) fell short of the requirement. Likewise, different constructs had differing levels of impact, however none emerged as the exclusive factor contributing to low FE. This indicates that low FE results from particular combinations of absent or diminished variables, rather than from the absence of individual parts. These results underscore the intricate dynamics of diminished engagement in farmer empowerment, wherein the dimensions are interrelated. *Table 4* delineates these findings.

4.4. fsQCA Findings

Table 5 presents the findings of the fsQCA study concerning intermediate solutions, encompassing core and peripheral conditions, in relation to high and low FE. The results reveal three configurations associated with a "high" level of FE and one configuration indicative of a "low" level of FE (refer to *table 4*). Rihoux and Ragin (2009) assert that the consistency value for a "high" overall outcome must surpass 0.75, signifying a highly pertinent and acceptable amalgamation of causal elements. The overall solution consistency rating for high FE results is 0.989, and the overall solution coverage value is 0.806. Conversely, for the "low" FE outcomes, the overall consistency value is 0.853, and the overall solution coverage value is 0.854. The results provide improved predictions for "high" and "low" levels of FE regarding participation outcomes (refer to Figures 2 – 5).

Table 4. fsQCA Findings

Configuration	**High FE**			**Low FE**
	C1	**C2**	**C3**	**C4**
FM	●	●	●	●
LR	●	●	●	●
LC	●	●	●	●
IF		●	●	●
SP		●	●	●
AC	●	●	●	●
FR	●	●		●
IA	●		●	⊗
Raw Coverage	0.780	0.667	0.685	0.854
Unique Coverage	0.117	0.004	0.023	0.854
Consistency	0.991	0.994	0.995	0.853
Overall Solution Coverage		0.808		0.854
Overall Solution Consistency		0.989		0.853
Proposition		*P1: Confirmed*		*P2: Confirmed*

Notes: "●" represent presence; "⊗" represent absence; "blank space" represent don't care.

The results presented in the initial Configuration (C1) in Figure 2 for elevated farmer empowerment (FE) underscore the significance of farmers motivation, local resources, local culture, agriculture cooperative, facilitator role, and crop-livestock integration, alongside the negligible influence of infrastructure and subsidiary policy in promoting high levels of farmer empowerment. This configuration attains a coverage of 0.780 and a consistency of 0.991, underscoring the necessity of integrating these parameters to promote farmer empowerment. The second Configuration (C2) in Figure 3 exhibits a marginally reduced coverage of 0.667, yet demonstrates an elevated consistency of 0.994. It incorporates the elements of motivation, local resources, local culture, infrastructure, subsidy policy, agriculture cooperatives, and facilitator role, while categorizing crop-livestock integration as a "don't care" condition. The third configuration (C3), illustrated in Figure 4, exhibits a coverage of 0.685 and a consistency of 0.995. It encompasses motivational factors, local resources, local culture, infrastructure, subsidy policy, agriculture cooperatives, and crop-livestock integration, alongside the facilitator role's "don't care" condition.

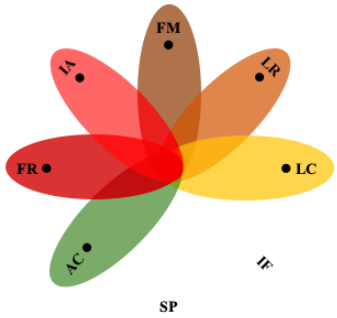

Figure 2. Configuration 1 – Normal ellipse represents "presence" condition and no ellipse represent "don't care" condition.

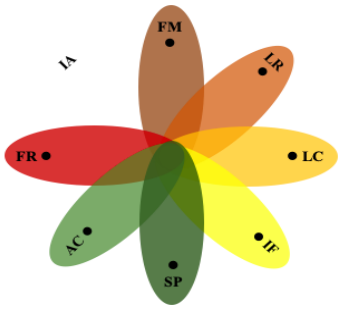

Figure 3. Configuration 2 – Normal ellipse represents "presence" condition and no ellipse represent "don't care" condition.

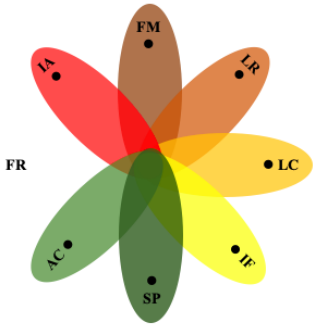

Figure 4. Configuration 3 – Normal ellipse represents "presence" condition and no ellipse represent "don't care" condition.

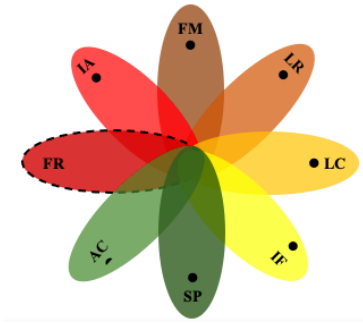

Figure 5. Configuration 4 – Normal ellipse represents "presence" condition; no ellipse represent "don't care" condition; and doted-line ellipse represents "absence" condition.

Moreover, the results for low FE present a conflicting notion. The fourth configuration (C4) depicted in Figure 5 indicates that the absence of IA (~IA) alone might result in low FE when the majority of the components (*FM, *LR, *LC, *IF, *SP, *AC, *FR) are present. This pathway demonstrates a consistency of 0.586 and a coverage of 0.758, highlighting the significant significance of IA in facilitating farmer empowerment. This configuration indicates that the absence of IA, despite the presence of certain variables, may hinder FE.

4.5. Discussion

This study offers significant insights into the diverse determinants of farmer empowerment, highlighting the critical role of supporting variables. This study elucidates four distinct configurations, encompassing both high and low variations, thereby emphasizing the multifaceted dynamic interactions arising from many sources of farmer empowerment that might facilitate agricultural sustainability. These findings enhance the understanding of

standard linear models by elucidating the dynamics of farmer empowerment and identifying the factors contributing to varying levels of empowerment.

The initial configuration of high FE highlights the significance of the interplay among motivation, local resources, agriculture cooperative, local culture, facilitator role, and crop-livestock integration in empowering farmers. This finding aligns with the prior research which highlighted that farmers empowerment in support agricultural sustainability relies on a synergy of effectively managed local resources (Hu et al., 2022), social engagement via cooperatives and farmer organizations (Ma et al., 2023), and sufficient subsidy support (Adam et al., 2022). Moreover, Kernecker et al. (2021) underscored that external facilitation through mentoring by empowerment institutions significantly enhances the adoption of sustainable agriculture techniques. The crop-livestock integration system, as demonstrated in the study by Puech and Stark, (2023), has been shown to enhance land efficiency and productivity by optimizing nutrient cycles between crops and cattle. This conclusion demonstrates that high farmer empowerment relies not on a singular factor, but on the synergy of multiple elements that foster an environment conducive to farmers' economic and social development. Nonetheless, despite this method demonstrating efficacy in enhancing farmer empowerment, the primary problem resides in ensuring the widespread implementation of these features. Moreover, the absence of robust governmental support and access to infrastructure is a substantial limitation (Havemann et al., 2022; Mhlanga, 2021). This study emphasizes that policies aimed at enhancing crop-livestock integration and improving resource accessibility for farmers are essential measures that must be reinforced to promote long-term sustainable farmer empowerment.

The second configuration (C2) presents a synthesis of motivational factors, local resources, local culture, infrastructure, subsidy policy, agriculture cooperatives, and the facilitators role, whereas crop-livestock integration growth is categorized as a "don't care" situation. The results suggest that while crop-livestock integration growth can enhance farmer empowerment, there are alternate avenues where other factors significantly influence farmer welfare improvement. In this environment, cooperative assistance and the role of facilitators function as the primary mechanisms that connect farmers to capital, technology, and markets, hence enhancing farmer productivity and income. Nonetheless, while this configuration highlights the significance of multiple factors in promoting farmer empowerment, the lack of a substantial impact from crop-livestock integration growth suggests that not all farmers depend on crop-livestock integration systems to enhance their agricultural potential. Nusrathali and Nikzaad (2023) indicates that the execution of a crop-livestock integration system necessitates robust infrastructural preparedness and policy backing for effective operation. Consequently, while this method yields favorable outcomes for farmer empowerment, the primary difficulty is ensuring the sustainability of interactions among these components over the long run. Future policies aimed at enhancing infrastructure and market access are anticipated to augment the efficacy of a more inclusive agribusiness-oriented farmer empowerment paradigm.

Third, these findings yield a composite configuration of motivational factors, local resources, cultural context, infrastructure, subsidy policies, farmer cooperatives, and crop-livestock integration, while the facilitator role is classified as a “don’t care” condition in promoting farmer empowerment. This indicates that whereas facilitators can aid many empowerment processes, there exist alternate avenues where structural and institutional elements significantly enhance farmer welfare. The incorporation of local resources and agricultural systems bolsters economic resilience by maximizing the utilization of animal waste for farming, resulting in heightened production and land efficiency. Furthermore, integrating internal elements, including motivation and local culture, with infrastructure and agriculture cooperative enhances farmers' autonomy in embracing agricultural advances and diminishes their reliance on external aid. While this technique yields favorable outcomes, the lack of a facilitator function in this framework suggests that its impact is not inherently vital in all instances of farmer empowerment. In some agricultural contexts, farmers depend more on formal infrastructure and institutional frameworks, such as cooperatives and subsidy programs, instead of external facilitation. Simultaneously, crop-livestock integration serves as a fundamental catalyst for sustainable agriculture, linking the crop and livestock sectors into a symbiotic system. The facilitator position may not always be decisive, however it can be significant in particular circumstances, especially when farmers encounter difficulties in accessing markets and technology.

Finally, the fsQCA analysis results reveal that a low level of farmer empowerment is associated with the lack of crop-livestock integration, which considerably impedes farmer empowerment despite the presence of other determinants. This discovery validates that the amalgamation of agricultural and livestock is essential for establishing sustainable farming enterprises by enhancing resource utilization and productivity. In this context, crop-livestock integration systems enhance resource efficiency by utilizing livestock waste as organic fertilizer, hence improving soil fertility and crop yields. The lack of this integration suggests that farmers may encounter

constraints in effective resource management, particularly regarding cost efficiency and sustainable production. This indicates that empowerment initiatives concentrating solely on a single facet, such as legislative support or enhancing farmer ability, may prove insufficient without a comprehensive strategy that incorporates crop-livestock integration. Consequently, a more holistic strategy is required, encompassing policy support that promotes the adoption of crop-livestock integration systems, incentives for farmers utilizing sustainable practices, and enhanced access to technology and markets to guarantee optimal and sustainable farmer empowerment.

5. Conclusions

This study offers theoretical and practical insights into farmer empowerment within sustainable agriculture. Theoretically, it illustrates that empowerment is influenced not only by technical factors like infrastructure and agricultural implements but also by social and institutional components, including farmer motivation, access to local resources, agricultural cooperatives, and crop-livestock integration. This study employs a configurational approach with fsQCA, demonstrating that empowerment arises from many combinations of components rather than a singular pathway, hence underscoring the necessity for a context-specific methodology. The findings provide essential insights for policymakers and stakeholders in formulating integrated policies to enhance farmer resilience. Enhancing agricultural cooperatives can improve access to capital, technology, and markets, while facilitators play a crucial role in facilitating knowledge transfer and assisting farmers in adopting innovative techniques. While certain farmers attain empowerment autonomously, facilitators are essential for maintaining enduring progress. Nevertheless, this study is geographically limited to North Sumatra, Indonesia, which may potentially impact the generalizability of its findings across different agro-ecological and socio-economic context Additionally, while fsQCA is valuable for uncovering complex causal patterns, it does not support probabilistic inference and is inherently sensitive to contextual variability, thereby limiting its universal applicability. To address these constraints, future research should undertake comparative investigations across diverse geographic and institutional settings to validate and extend the findings. The integration of mixed-methods approaches combining fsQCA with in-depth qualitative techniques such as case studies or narrative interviews could yield richer insights into the mechanisms underpinning empowerment. Moreover, longitudinal designs are recommended to capture temporal shifts and evaluate the long-term sustainability of empowerment outcomes. Expanding the analytical scope to incorporate dimensions such as digital technology adoption, climate change adaptability, and psychological resilience would further enhance our understanding of empowerment processes in rural agricultural communities, thereby informing more effective, evidence-based interventions.

Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Ginting, A., Purba, E.; Design: Ginting, A., Purba, E., Data Collection or Processing: Ginting, A., Hanafi, N. D.; Statistical Analysis: Ginting, A., Hanafi, N. D.; Literature Search: Ginting, A., Purba, E., Chalil, D.; Writing, Review and Editing: Ginting, A., Chalil, D., Hanafi, N. D.

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