

DOI: 10.5281/zenodo.20088748

PROBLEMATICS OF FARMERS' GENERATIONAL SHIFT AND THE SUSTAINABILITY OF FOOD SECURITY IN INDONESIA

Arie Tri Hedhianto¹, Nur Aini², Agus Riyanto³, Irene Kartika Eka Wijayanti⁴, Totok Agung Dwi Haryanto⁵ Purwanto Purwanto⁶ and Altri Mulyani⁷

¹Agricultural Science Program, Faculty of Agriculture, Jenderal Soedirman University, Indonesia. Email: arie.hedhianto@mhs.unsoed.ac.id, Orcid ID: <https://orcid.org/0009-0001-0692-4250>

²Agricultural Science Program, Faculty of Agriculture, Jenderal Soedirman University, Indonesia. Email: nur.aini@unsoed.ac.id. Orcid ID: <https://orcid.org/0009-0000-1694-0548>

³Agricultural Science Program, Faculty of Agriculture, Jenderal Soedirman University, Indonesia Email: agus.riyanto0208@unsoed.ac.id, Orcid ID: <https://orcid.org/0000-0001-8242-6272>

⁴Agricultural Science Program, Faculty of Agriculture, Jenderal Soedirman University, Indonesia. Email: irene.wijayanti@unsoed.ac.id, Orcid ID: <https://orcid.org/0000-0002-8576-2826>

⁵Agricultural Science Program, Faculty of Agriculture, Jenderal Soedirman University, Indonesia. Email: totok.haryanto@unsoed.ac.id, Orcid ID: <https://orcid.org/0000-0002-2319-0594>

⁶Agricultural Science Program, Faculty of Agriculture, Jenderal Soedirman University, Indonesia. Email: purwanto@unsoed.ac.id, Orcid ID: <https://orcid.org/0000-0003-4711-8084>

⁷Agricultural Science Program, Faculty of Agriculture, Jenderal Soedirman University, Indonesia. Email: altri.mulyani@unsoed.ac.id, Orcid ID: <https://orcid.org/0000-0001-9136-9812>

Received: 06/04/2026

Accepted: 29/04/2026

Corresponding Author: Arie Tri Hedhianto
(arie.hedhianto@mhs.unsoed.ac.id)

ABSTRACT

The aging of farmers is a structural issue that poses a risk to the sustainability of food security in Indonesia. The proposed study will examine the correlation between farmer aging and food security using a Systematic Literature Review (SLR) that will be formed based on the bibliometric data of 100 of the latest scientific articles published between 2020 and 2024 on Google Scholar and CrossRef using the Publish or Perish application. The results show that even though the academic interest towards this problem is growing, the academic input is still insufficient in terms of the quality of the citation, the network of authors, and the interdisciplinary approach. The application of VOSviewer shows that the most used topics, including farmer regeneration, agricultural sustainability, and food system transformation, are still disjointed. The research area has a conceptual gap that is identified as the absence of integration of the notion of farmer aging and food security in the framework of analytical research. The major causes of aging amongst farmers are low interest of the young generation in the agricultural sector, inaccessibility to land and capital, poor institutional backing, as well as urbanization. These effects are systematic in terms of productivity, adoption of technology, and local knowledge. It suggests that to make inclusive and sustainable food security policies, there should be the establishment of an interdisciplinary research agenda and a conceptual model of regeneration in farmers through the local socio-economic scenarios.

KEYWORDS: Agricultural Sustainability, Farmer Aging, Food Security, Regeneration of Farmers, Young Generation.

1. INTRODUCTION

Sustainable development and food systems in the country are major elements of food security. Over the last ten years, it has become a more complicated problem after being affected by the forces of climate change, geopolitical tensions, and the interruptions of global food supply chains. Food security is a critical challenge in Indonesia, regardless of the fact that agrarian resources are tremendous.

In Indonesia, food security is directly connected with the availability of rice because over 95% of the population still eats rice as it is the standard food item (Directorate of Public Welfare Statistics, 2025). In this regard, the government always aims to boost the national production of rice. The production of rice in Indonesia has been increasing since the year 1980 (Figure 1). There was, however, a period between 2017 and 2024 which saw a decline in production and a level. National production had hit 53.14 million tons of rice (Data source: Indonesian Central Statistics Agency 2025)

The new decrease in national rice production can largely be ascribed to two factors, namely, less harvested area and no growth in productivity. The area harvested was steadily growing since 1980 up to 2017, and starting to reduce between 2017 and 2020.

In the meantime, there was an increase in rice productivity up to 2012, and thereafter, no improvement. All these trends combined have contributed to a drop in the production of rice in the country since 2017 (Ishak et al., 2022).

This decrease will be a threat to national food sovereignty. Simultaneously, the governmental policies towards food sovereignty are met with structural barriers, one of which is the ageing phenomenon of the farmers, one of the major threats to food security (López-García & Carrascosa-García, 2023; Muis et al., 2025; Rivera et al., 2024).

Java and Sulawesi, as areas of high agricultural population, can be used as real examples of the processes of farmer regeneration and aging in Indonesia. According to data provided by Indonesian Central Statistics Agency (2025), East Java has the highest millennial farmers in the country, with 425,861 people or approximately 16.36% of all millennial farmers in the country, followed by Central Java (303,823) and West Java (242,390). In the meantime, South Sulawesi has the highest number of millennial farmers at 175,732, which is the highest in Eastern Indonesia.

Nevertheless, even with these numbers, the overall trends show that the number of young farmers is gradually decreasing every year. This condition exposes severe difficulties in the

regeneration of farmers, both regionally and nationally (Nurarifin & Kurniawan, 2025; Putri et al., 2025; Uddin & Antriandarti, 2025).

In theory, the aging of farmers would have an impact on productivity and adoption of technology, which subsequently would affect the sustainability of the agricultural sector. Nonetheless, these two concerns were disaggregated in the majority of the past research, either by aspects of demographic or sociological aging of farmers or by the aspects of food supply and policy, without directly covering the aspect of labor arrangements (Zou et al., 2018).

This implies there is a conceptual gap, and there is no thematic synthesis of these two issues as a whole and in a systemic manner.

The aging of farmers and food security are the two phenomena that are associated in the dynamics of agricultural development in Indonesia. The timeliness of investigating the relationship between the age structure of farmers and the sustainability of food systems in a country is encouraged by climate crises, demographic pressures, and reliance on imports (Antriandarti et al., 2023; Juliannisa et al., 2025; Ngadi et al., 2023).

Food and Agriculture Organization of the United Nations defines food security as having four key dimensions, which include availability, access, utilization, and stability. In Indonesia, the concept of food security is also strengthened in Law No. 18 of 2012, which focuses on the sustainable accomplishment of food in the individual level.

However, the attainment of food security in Indonesia is still limited by many challenges. According to the Global Food Security Index (GFSI) 2022, Indonesia was ranked 63rd of 113 countries. Though the undernutrition levels dropped to 8.5% in 2023 (World Food Programme, 2023), 68 regencies/municipalities are still considered food insecure, and the food is distributed unevenly.

Rice dependency is very high, and the production in the country is not enough to sustain the demand. This left the government with no other choice but to import 4.52 million tons of rice in 2024 (Indonesian Central Statistics Agency 2025). In some areas, production surpluses cannot be used to mitigate losses in others because of the lack of a system supporting logistics.

Food security as a concept under the sustainability framework encompasses all these aspects: productivity, social, economic, and environmental. The transformation of the food system should be followed by climate adaptation, the diversification of local food, and social inclusiveness. One of the most significant factors is the

sustainability of the agricultural labor force, especially with regard to the aging of farmers (Alonso-Adame et al., 2024; Lees et al., 2024; Preinfalk et al., 2024).

The aging process in the world is known as farmer aging, especially in agrarian countries. The percentage of farmers aged above 60 years has grown in Indonesia in 2020 to 21.2% as compared to the 16.7% in 2005 (Indonesian Central Statistics Agency, 2022). The agricultural labor force also decreased from 41.3 million in 2005 to 38.22 million in 2020. The same tendencies are found in Japan (average age of farmers 67 years) and Thailand (63.5 years) (FAO, 2023; Pongchompu et al., 2012).

Demographic Transition Theory (Frantsuz, 2025) states that a change in the age makeup of the workforce may affect the efficiency of production. At the same time, the importance of the adoption of technology is highlighted by the agricultural modernization theory of Schultz (Roumasset, 2015). Sadly, aged farmers are usually not that receptive to innovations and have very little access to training (Manzoor et al., 2025).

The reasons that have caused the farmer regeneration crisis include the lower appeal of agriculture to the younger generation, limited access to land and capital, as well as limited economic incentives. The tenure systems of land use are also inherited, which limits access to agricultural assets for a generation. The regeneration crisis (Borda et al., 2023) is worsened by negative attitudes towards farming as a profession and the lack of role models, as well.

Other nations have had more liberal regeneration policies, such as agricultural vocational education (Thailand and Vietnam), subsidies on young farmers (Japan), and incentives via the Common Agricultural Policy (Europe). Training and farm credit are among regeneration programs, which are not systematic and extensive enough in Indonesia.

The physical effects of farmer aging affect food sustainability and productivity. The efficiency of work among older farmers and the adoption of technology are influenced by physical limitations. The elderly farmers (Tong et al., 2024) in China have been confronted by physical and informational limitations, which have prevented them from investing in production inputs, subsequently causing a reduction in total factor productivity and the emergence of additional farmland.

In the concept of sustainable food security of Food and Agriculture Organization of the United Nations (FAO), the input of younger generations is critical in enhancing adaptive, technology-based, and

ecological farming. Food security strategies have to facilitate the modernization of production systems and the conservation of local knowledge at the same time.

Therefore, the aging of farmers is not only a demographic problem, but it has a systemic effect on the future of national food security. Past research in Indonesia is still scarce in scholarly incorporation of demographic aspects with food security in totality. The absence of interdisciplinary solutions and integrative policies emphasizes the dire need to conduct a comprehensive and in-depth literature review.

The literature available is either contextual or fragmentary, or covers a case study of a particular region. To date, there exists no literature review that would systematize the two issues of farmer aging and food security into one analysis. This disconnect can also be seen in the preliminary bibliometric results, where keywords such as aging farmers and food security remain in distinct clusters of literature with no significant interrelationships in the global publications. This explains why it is important to engage in a systematic literature review.

In order to fill in this gap, the current research suggests the following four guiding research questions:

- (1) What is the current trend of research on the issue of farmer aging and food security around the world?
- (2) What are the key factors that determine food security and the aging of farmers?

2. RESEARCH METHOD

The paper utilized a Systematic Literature Review (SLR) with the help of a bibliometric analysis to assess the connection between the phenomenon of aging farmers and the sustainability of food security. The SLR approach has been selected as one of the most effective methods applied to mapping the research trends, constructing thematic syntheses, and methodically detecting the gaps in the literature by evidence-based methods (Carrera-Rivera, 2022).

2.1. Research Design.

The searching and the selection of articles were based on the PRISMA protocol (Preferred Reporting Items to Systematic Reviews and Meta-Analyses), which comprised four primary steps: identification, screening, eligibility assessment, and inclusion. Figure 4 presents the PRISMA flow diagram (Moher et al., 2015).

Publish or Perish version 8.0 was used to conduct the literature search using the following keywords: "Aging Farmers", "Sustainable Food Security", and "Indonesia". The sources of data were Google Scholar and CrossRef, with the period of the articles not older

than 2020-2024. Out of 315 original publications, a filtering procedure was carried out and produced 100 scientific articles, the most relevant ones in terms of data completeness, contextual appropriateness, and citation quality.

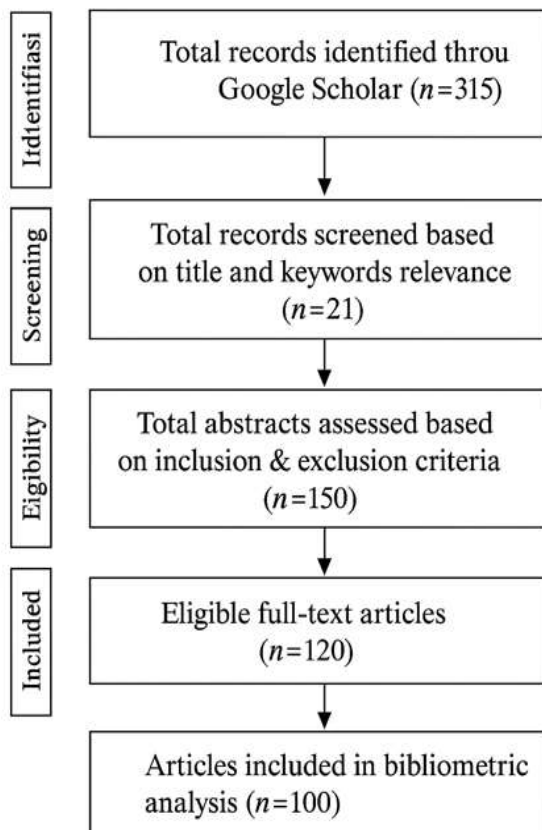


Figure 4: Prisma-Based Slr Review Flow.

2.2. Data Collection Technique

The bibliometric collection of data involved using metadata of articles, such as title, author(s), year of publication, institutional affiliation, journal name, citation counts, H-index, and G-index, and keywords. The data were then exported as an .xlsx file to be further visualized and tabulated. Exclusion criteria were non-academic articles, articles that did not have full-text, or articles that were not relevant to the Indonesian context.

The aim of this analysis was to find out overarching themes, the extent of collaboration, and research gaps that can be used to develop policy directions and

research agenda strategies (Donthu et al., 2021).

2.3. Data Analysis Technique

The analysis of data was done quantitatively and graphically as follows:

- (1) Publication and citation trend analysis per year using Publish or Perish.
- (2) Bibliometric indexes (H-index, G-index, AWCR, and so on) to assess the impact of the publications.
- (3) Visualization of keyword networks (co-occurrence) and author collaboration using VOSviewer, as presented in Figure 5.

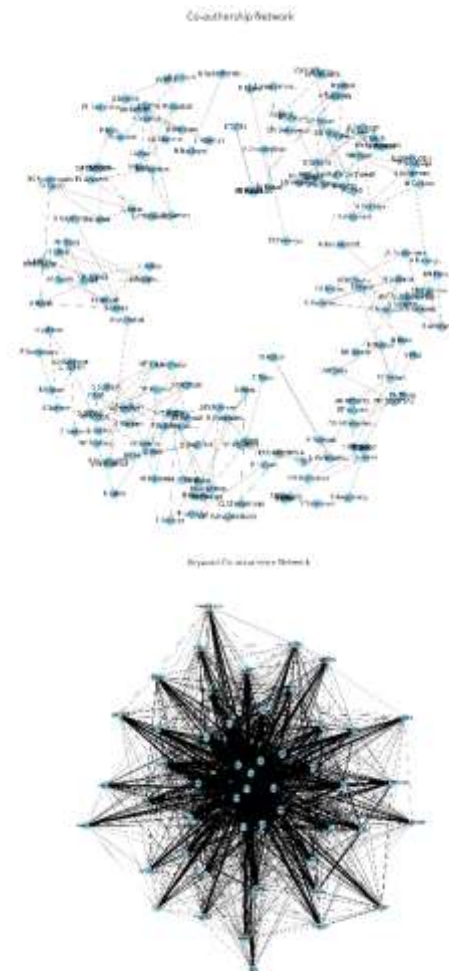


Figure 5: Vosviewer Visualization Of 100 Articles.

RESULTS AND DISCUSSION

3.1. Research Trends On Food Security And Aging Farmer Phenomenon

Food security constitutes a strategic issue in sustainable development, particularly in addressing global pressures such as climate change, geopolitical conflicts, and supply chain disruptions triggered by the pandemic. The interest of scholars in the issue has also risen in the last five-year period (2020-2024), which is evidenced by the growing number of scientific.

Bibliometric analysis has shown that the population of publications increased every year and reached its highest point in 2023. COVID-19 became the tipping point, generating a range of research on the instability of the food systems and ways of making them sustainable, contains metadata information of the investigated publications.

Regarding the scholarly impact, the total number of citations was 260, and the mean number of citations per article was 0.26. The H-index of 5 and G-

index of 6 mean that there are only a few publications that have significantly contributed to the academic community.

Food security has been studied in a wide range of different perspectives thematically: local food diversification, climate adaptation, distribution and logistics system, technological integration, and the role of younger generations (Sahar et al., 2025; Harsanto et al., 2025; Ujjwal et al., 2024). The development of this evolution implies a change in the story being a small and focused perspective on productivity to a broader and interdisciplinary one.

Although the interest in the issue has been increasing very fast, there are not enough strong and consistent academic inputs. This sets the prospects of future research that is more in-depth, integrative, and policy-relevant to formulate the food security agenda in Indonesia.

The process of aging of the farming population is a strategic problem in agricultural development, as it not only impacts demographic structures but also affects labor regeneration, productivity, and food system sustainability (Wang & Zhong 2026; Zhang et

al., 2023).

The young workers migrating to non-agricultural industries, as well as limited agricultural incentives, such as urbanization, have increased, causing the rise in the number of elderly farmers. In this respect, scholarly works will be necessary to inform the development of strategic policies in agriculture and food security (Griffith et al., 2021; Liu et al., 2023; Wu et al., 2026).

In the bibliometric analysis with Publish or Perish (PoP) with the keywords aging farmers, elderly farmers, farmer regeneration, and Indonesia (2020-2024), the difference in the number of publications in both national and international journals can be observed. This increase aligns with the increased focus on food security in the aftermath of the pandemic and the publication of the data provided by the Central Statistics Agency 2022, which showed that more than 20% of farmers in Indonesia were older than 60 years.

The yearly publication trends, which sharply increase starting in 2020 and reaching its peak in 2023, after which it slightly decreases in 2024. This indicates the steady awareness of the issue of aging of the farmers as a national study of interest.

VOSviewer visualization indicates that author collaborations are not very powerful in terms of creating strong academic networks, but stay within small groups. However, the analysis of the keywords showed that the prominent themes were farmer regeneration, sustainability, and agrarian demographics.

The majority of publications follow a sociological

and demographic line of thought, detailing the views of the youth, obstacles to regeneration, and the productivity effects of elderly farmers. Other countries, like the youth farmer programs in Japan and Europe, have some articles where policy experiences are compared. However, the direct connection of aging farmers to food security is not widely investigated, which is why it can be the subject of further research.

Hence, the problem of aging farmers should be further developed through more profound, interdisciplinary, and evidence-based research. This phenomenon is a structural problem that is directly connected to the national food security and can be resolved through multi-sectoral intervention and working together (Li et al., 2024; Mao., 2025; Tong et al., 2024).

3.1.1. Network Visualization

This VOSviewer network visualization (Figure 6) illustrates the connections between terms frequently appearing in research on the phenomenon of farmer aging and food security sustainability in Indonesia. Each color represents a specific thematic cluster that groups closely related terms. The visualization reveals six main clusters, each representing a distinct research direction and focus.

The purple cluster focuses on the terms “farmer,” “analysis,” “role,” “knowledge,” “evidence,” and “impact.” This cluster emphasizes the position of farmers as key actors, analyzed through empirical evidence.

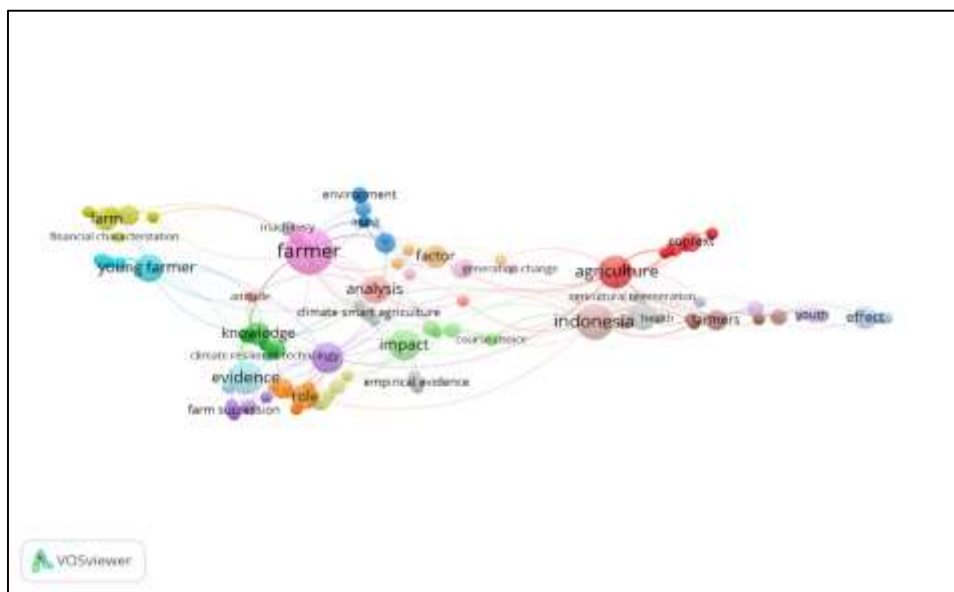


Figure 6: Network Visualization for A Research Project on The Aging of Farmers and the Sustainability of Food Security in Indonesia.

Research in this cluster tends to examine how farmers' roles, their knowledge, and the impact of agricultural activities contribute to food security, as well as how the issue of an aging farming population can be scientifically measured (Azadi et al., 2023; Nassar et al., 2025; Sasmita et al., 2025).

The green cluster highlights the terms "young farmer," "farm," "financial characterization," and "career choice." The main focus was on the regeneration of young farmers and the factors influencing their engagement, ranging from career choices to financial conditions in managing farming operations. This underscores the importance of structural support to attract the younger generation to the agricultural sector (Góngora Pérez et al., 2020; Haryati et al., 2024; May et al., 2019).

The blue cluster is associated with the terms "environment," "machinery," "climate-smart agriculture," and "factors." This theme illustrates the connection between environmental issues and agricultural practices, particularly through the implementation of climate-smart agriculture.

The role of machinery and technology is also highlighted as a key factor in addressing the decline in the labor force due to the aging of farmers (Ariom et al., 2022; Figurek et al., 2024; Mizik, 2021; Pagliacci et al., 2020; Wakweya, 2023; Zheng et al., 2024).

The red cluster centers on the terms "agriculture," "Indonesia," "context," and "agricultural regeneration." This cluster clearly demonstrates the importance of the Indonesian context in understanding the aging of farmers. The research included highlights the role of national conditions, policies, and agricultural regeneration in Indonesia in maintaining food security (Maulida et al., 2022; Rustandi & Farid, 2023; Tolinggi et al., 2023).

The brown cluster highlights the terms "generational change," "agricultural regeneration," "farmers," and "health." The primary focus areas are the transition of farming generations and the health conditions that affect the sustainability of their work. Issues in this cluster emphasize that agricultural regeneration is not only about generational change but also concerns the health of an aging farming

population (Csizmady et al., 2021; Rizki & Andini, 2025).

The blue cluster highlights the terms "youth" and "impact." Although small, this cluster underscores the importance of the role of young people and their impact on the agricultural sector. Research in this cluster typically focuses on young people's contributions to innovation, social dynamics, and food security

Thus, this visualization demonstrates that the issues of farmer aging and food security in Indonesia are examined from various perspectives, including the role and analysis of farmers, the regeneration of the younger generation, technological and environmental adaptation, the local Indonesian context, farmer health during generational transition, and the contributions of young people. All these areas are interconnected and provide a picture that food sustainability is not just about production, but also about social, economic, and technological regeneration in agriculture.

3.1.2. Visualization Overlay

The VOSviewer visualization overlay (Figure 7) above illustrates the evolution of key terms in research on the theme "The Phenomenon of Farmer Aging and the Sustainability of Food Security in Indonesia" over time. The colors on the map indicate the period of the terms' appearance in publications, with gradations from blue (older, around 2015–2019), green (around 2020–2021), to yellow (newer, 2022–2024). Thus, this map not only illustrates the interconnections between concepts but also displays research trends over time.

From 2015 to 2019 (blue), the dominant terms were "young farmer," "farm," and "financial characterization." Research during this period focused primarily on the issue of young farmer succession and the financial factors affecting the sustainability of the agricultural sector (Katchova & Ahearn, 2016; Katchova & Dinterman, 2018; Ruiz Salvago et al., 2019).

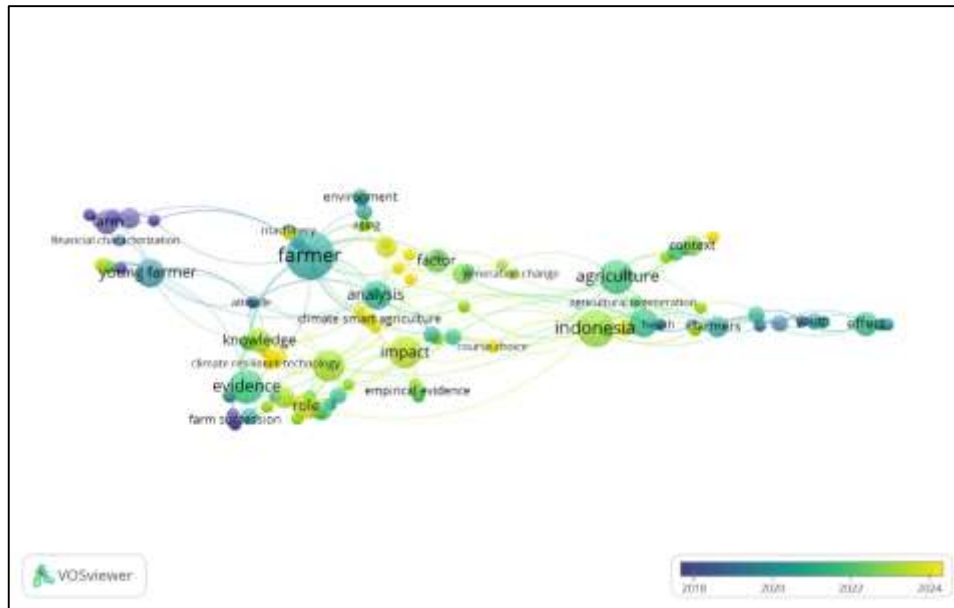


Figure 7: Visualization Overlay For a Research Study on The Aging of Farmers and the Sustainability of Food Security in Indonesia.

In 2020–2021 (green), terms such as farmer, analysis, knowledge, evidence, impact, role, factor, and climate-smart agriculture took center stage.

This reflects a shift in research toward analyzing the role of farmers, socio-economic impacts, and approaches based on empirical evidence and climate-smart technologies to address the challenges posed by an aging farming population (Autio et al., 2021; Azadi et al., 2021; Kangogo et al., 2021; Mujeyi et al., 2021; Zakaria et al., 2020).

During the 2022–2025 period (yellow), prominent terms include agriculture, Indonesia, generational change, agricultural regeneration, context, and farmers. Recent research has placed greater emphasis on the specific Indonesian context, agricultural regeneration, and the ongoing generational shift. The issues of youth and impact have also gained prominence during this period, signaling the growing importance of young people’s involvement in supporting food security (Otsuka, 2021; Sekaranom et al., 2021; Sukayat et al., 2023).

Overall, this visualization overlay shows that research trends have shifted from issues related to the renewal of the younger generation of farmers and financial factors (2018–2019), toward empirical analysis and adaptive agricultural technologies (2020–2021), and finally toward a focus on the national context, agricultural renewal, and current food policies (2022–2025). This means that research on farmer aging and food security is becoming increasingly comprehensive, with attention

expanding from individual issues toward food systems and national policies.

3.1.3. Density Visualization

Figure 8 shows the results of a VOSviewer density visualization analysis for a study titled “The Phenomenon of Farmer Aging and the Sustainability of Food Security in Indonesia.”

This visualization depicts the density of term occurrence in the literature, indicated by color variations: red denotes terms with very high frequency of occurrence and connectivity, yellow indicates moderate intensity, while green to blue denote terms with low frequency or limited connectivity. Thus, this map highlights the primary focus areas of the research as well as topics that are relatively rarely discussed.

The visualization results show that the terms with the highest density (red zones) are farmer, evidence, role, knowledge, analysis, and impact. This indicates that discussions regarding the aging of farmers primarily focus on the role of farmers, evidence-based analysis, socioeconomic impacts, and knowledge related to the sustainability of agricultural systems (Qonita et al., 2025; Yu et al., 2023).

In areas with moderate density (yellow zone), the prominent terms are “factors,” “climate-smart

agriculture,” “generational change,” “agriculture,” and “Indonesia.”

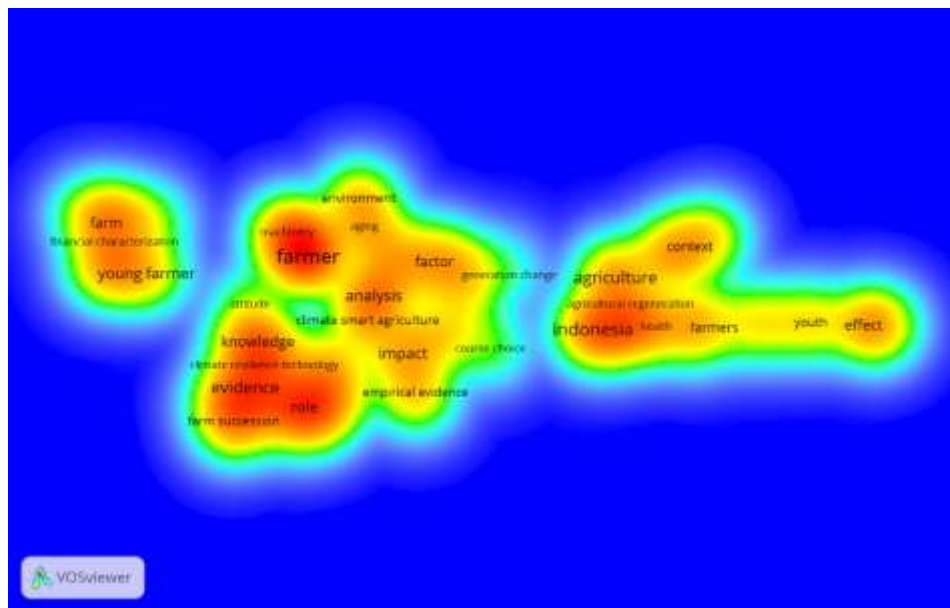


Figure 8: Density Visualization for a Research Study on the Aging of Farmers and the Sustainability of Food Security in Indonesia.

This indicates growing attention to factors influencing agricultural sustainability, generational change, climate-smart agricultural innovations, and the specific context of Indonesia (Agussabti et al., 2022; Gemtou et al., 2024; Harisudin et al., 2023; Khumalo et al., 2025; Murniati & Mutolib, 2020).

Meanwhile, terms with lower frequency (green to blue zones) such as “young farmer,” “farm succession,” “youth,” “effect,” and “context” indicate that, although important, these issues are still discussed less frequently than the core terms.

However, their presence remains significant because they are closely linked to efforts to regenerate the farming community and the role of the younger generation in food security. (Daniele, 2024; Kovách et al., 2022).

Overall, this density visualization shows that research has primarily focused on farmers as the main actors and evidence-based analysis as the research approach, while topics such as the regeneration of young farmers, local-context policies, and the impact of generational change still need to be further explored in future research.

3.2. Factors Affecting Food Security

Food security is the capacity of a country to supply its citizens with adequate, healthy, safe, and affordable food. The problem includes the aspects of availability, access, utilization, and stability under the influence of the external factors of climate change, disasters, and economic shocks (Azra et al., 2021;

Okpala et al., 2024; Trasca et al., 2025).

Six broad groups of factors affecting food security were outlined with the help of an SLR of publications published in 2020-2024: ecological, socio-demographic, economic, technological, institutional, and political (Akbari et al., 2022; Galanakis et al., 2025; Placzek, 2021; Nchanji & Lutomia, 2021).

(1) Ecological and Environmental Factors. The first difficulties are climate change, land degradation, and water scarcity. The risk of crop failure also rises because of the weather variability and because of land conversion and overuse of chemicals; the quality of soil is aggravated.

(2) Social and Demographic Factors. There is not sufficient workforce regeneration and farmer aging to facilitate sustainable production. Access to land, education, and capital is limited, and this increases inequality due to vulnerable populations like women farmers and indigenous people.

(3) Economic and Accessibility Factors. Purchasing power also influences food security. Food vulnerability increases due to fluctuations in prices, inflation, and reliance on imports, as witnessed in the COVID-19 pandemic.

(4) Technological and Agricultural Innovation Factors. Precision agriculture and digital farming have not yet been adopted widely. The access disparity and low digital literacy among smallholder farmers are key obstacles to agricultural transformation.

(5) Institutional and Infrastructure Factors. Lack

of coordination among institutions, overlapping regulations, and ineffective post-harvest infrastructure lower the distribution efficiency and income of the farmers.

(6) Political Stability and Policy Factors. Adaptive, participatory and evidence-based policies are important in food security. Nevertheless, the prevalence of top-down solutions and poor-quality data-driven policy assessment remain to be the organizational obstacles towards the construction of cohesive and non-discriminatory food systems.

3.2.1. Factors Influencing The Phenomenon Of Farmer Aging

Aging of the farmers is one of the structural issues in the agricultural system of Indonesian Central Statistics Agency and the Ministry of Agriculture show that most farmers are aged above 45 years, and the trend is also increasing.

The situation represents a crisis in the next generation of farmers, which, if not addressed in a timely manner, could threaten national food security, including in Indonesia. The factors could be divided into several important dimensions, which influence the phenomenon of the farmer aging in Indonesia (Akbar et al., 2025; Nurlaily et al., 2025; Sitompul, 2026; Toumbourou et al., 2023; Yusriadi et al., 2026) in the following way:

(1) Low Attractiveness of the Agricultural Sector for Younger Generations. The negative attitudes towards the occupation of farmers, including unpredictable income, large volumes of work, the inability to use and access technology and capital, and low social status, ensure that youths are not willing to join the occupation of farmers.

The descendants of farmers usually choose a career in services, manufacturing, or the digital field, which is viewed as more economically promising. This regeneration gap is further increased by the intergenerational gap in perception, the absence of successful farmer role models, and the lack of agricultural education that is focused on entrepreneurship.

The intergenerational perception gap, lack of successful farmer role models, and insufficient entrepreneurship-oriented agricultural education further exacerbate this regeneration gap.

(2) Limited Access to Land and Capital. Youths have challenges in venturing into farming business because they do not have access to land and capital. The practice of land fragmentation due to inheritance and the preeminence of older generations over the possession of productive assets does not allow young people to possess productive assets. Furthermore,

young farmers who lack collateral or business history are not usually supported by financial systems..

(3) Weak Regeneration Programs and Institutional Support. Other programs, like the Millennial Farmers, have not had a big influence because of unequal application and integration.

The institutional concerns are inclined towards the existing farmers, as opposed to the potential young farmers. This is caused by weak connections between training, market access, technology, and financing that prevent the regeneration of agricultural labor.

(4) Urbanization and Rural-to-Urban Migration. The process of urbanization causes young rural workers to move to urban areas since they have no chance to get economic opportunities in the villages.

The informal urban employment is viewed as a more appealing option than the agricultural sector, creating a lack of generational successors in the agricultural industry. This is worsened by the rural-urban development inequalities.

(5) Price Instability and Market Uncertainty. The volatility of commodity prices, the domination of the middlemen, and the reliance on the global markets make the profession of farming risky and economically unsustainable. Agriculture is not an appealing profession to young people in the absence of price guarantees and protection in the market.

(6) Insufficient Technological Integration and Digital Literacy. The youth potential that can be used in adopting digital technology is not fully exploited. Lack of access to training, machinery, and online farm initiatives makes the industry look modern and unattractive

The aging of the farmland is structurally dangerous to the sustainability of the national food system. With more and more elderly labor taking control of agriculture, the ability to adapt to environmental change, technological advancement, and market forces is highly limited.

Such disproportion of the population compromises the stability of the supply chain and undermines the fundamental aspects of food security of availability, access, and sustainability (Dharmalingam et al., 2021; Gómez & Lee, 2023; Saxena & Mohan, 2021; Wang et al., 2024).

The agricultural productivity is the most obvious effect. The old farmers are handicapped in controlling farmlands effectively, and this has led to less cultivated land, less effective production cycles, and late harvest times.

Large areas of farmland are lying idle as no younger generations report to occupy the farms. Reduced productivity destabilizes the possibility of

food surplus, which will eventually pose a threat to the national food supply.

Low digital literacy and adoption of technology are also barriers to the modernization of agriculture. Some elderly farmers tend to stick to their traditional ways of doing things and are unwilling to embrace new technologies like the use of precision agriculture, intelligent irrigation, and the use of big data in the farming industry. This unwillingness postpones the introduction of efficiency and the sustainability of the food system.

In addition to technical factors, the aging of farmers has the effect of breaking the flow of local knowledge, which is a contextual and localized knowledge of the ecosystem.

The risks of the disappearance of traditional farming experience and culture, which in many cases cannot be documented, contribute to self-reliance under the pressure of various socio-cultural factors (Caviedes *et al.*, 2024; Chomboko *et al.*, 2025; Melash *et al.*, 2023; Reyes *et al.*, 2020).

The effect of this phenomenon is also the cause of social inequalities in rural areas. Since the young generations are moving to urban areas, villages are becoming deprived of the socio-economic setups to support the local communities.

Such a gap can cause agrarian wars, decrease economic activity, and cause social disintegration, which, in the end, undermines the community-based food security (Guo *et al.*, 2025; Saputra *et al.*, 2022; Zhou *et al.*, 2025).

In addition, the national food system is more exposed to crises. In case of emergencies like natural calamities, climate crises, or disruptions in the distribution system, the predominance of farmers of old age affects responsiveness. Lack of an effective labor force will slow down recovery, making the food system less adaptive and resilient to external forces.

Therefore, the aging of farmers influences various aspects of food security, production, distribution, accessibility, and the sustainability of the ecological system.

The population can start working on protecting sustainable food security by intervening with the demographic composition of farmers, with regeneration policies, progressive agricultural education, and empowering young people in rural areas, so that agriculture is a promising and attractive career choice (Ahmadi *et al.*, 2023; Handoko *et al.*,

2026; Rochmawan *et al.*, 2025; Prastyanti *et al.*, 2024; Setiadi *et al.*, 2024; Sulaiman *et al.*, 2024).

4. CONCLUSION

This paper has also shown that the food security and aging of farmers are two issues that have a correlation in the agricultural development in Indonesia. Bibliometric analysis of 100 scientific publications in 2020-2024 shows that although academic interest in the issues has grown quantitatively, the quality of research work is not sufficiently deep and integrated.

The ecological, social, economic, technological, institutional, and policy factors influence food security in Indonesia. Among the key issues, the growing age of the population of farmers, which may limit productivity, technological usage, and the sustainability of the entire food system, deserves to be mentioned.

Poor interest of the youth in farming, inaccessibility to land and capital, ineffective regeneration programs, urbanization, market uncertainties, and inadequate adoption of technology in agriculture are some of the factors that make farmers age. These aspects enhance the influence of old farmers and undermine the national food security.

The effects of aging on the farmer are multidimensional, including decreased productivity and innovation resistance, a loss of local knowledge, and increased exposure to crisis. This situation is further exacerbated by social inequality and young people moving to the non-agricultural sectors.

The gap in research that is identified is that the majority of studies continue to discuss the antecedents of farmer aging in a sectoral fashion, but not within a system. In addition to that, there is no conceptual framework to take care of farmer regeneration, both conceptually and in practice.

Hence, future research in this dissertation will be directed towards the development of a conceptual framework of regenerating farmers with reference to the local socio-economic situations. This model is expected to contribute theoretically to the literature on agricultural regeneration and practically to public policy formulation in strengthening inclusive and sustainable food security in Indonesia.

REFERENCES

- Agussabti, A., Rahmaddiansyah, R., Hamid, A. H., Zakaria, Z., Munawar, A. A., & Abu Bakar, B. (2022). Farmers' perspectives on the adoption of smart farming technology to support food farming in Aceh Province, Indonesia. *Open Agriculture*, 7(1), 857–870. <https://doi.org/10.1515/opag-2022-0145>

- Ahmadi, D., Sulaiman, A.I., Runtiko, A.G., Noegroho, A., Ar Raqi, R.I., Maryani, A., Yuniati, Y., & Yulianita, N. (2023). Marketing Communications for Tourism Development in Ecoethno Leadcamp Site. *Studies in Media and Communication*, 11(4) 67-77., <https://doi.org/10.11114/smc.v11i4.5909>
- Akbar, A., Abdullah, S., & Muhammad, R. (2023). Youth phenomenon leaves agricultural sector in max weber social action perspective . *Enrichment : Journal of Management*, 13(5), 3250-3258. <https://doi.org/10.35335/enrichment.v13i5.1773>
- Akbari, M., Foroudi, P., Shahmoradi, M., Padash, H., Parizi, Z. S., Khosravani, A., Ataei, P., & Cuomo, M. T. (2022). The Evolution of Food Security: Where Are We Now, Where Should We Go Next? *Sustainability*, 14(6), 14(6), 3634. <https://doi.org/10.3390/su14063634>
- Alonso-Adame, A., Van Meensel, J., Marchand, F. Van Passe, S., & Farahbakhsh, S. (2024). Sustainability transitions in agri-food systems through the lens of agent-based modeling: a systematic review. *Sustain Sci* 19, 2101–2118. <https://doi.org/10.1007/s11625-024-01551-0>
- Antriyandarti, E., Barokah, U., Rahayu, W., Laia, D. H., & Asami, A. (2023). Factors Associated with Food Security of Dryland Farm Households in the Karst Mountains of Gunungkidul Indonesia. *Sustainability*, 15(11), 1-19. <https://doi.org/10.3390/su15118782>
- Ariom, T. O., Dimon, E., Nambeye, E., Diouf, N. S., Adelusi, O. O., & Boudalia, S. (2022). Climate-Smart Agriculture in African Countries: A Review of Strategies and Impacts on Smallholder Farmers. *Sustainability (Switzerland)*, 14(18), 1-32. <https://doi.org/10.3390/su141811370>
- Autio, A., Johansson, T., Motaroki, L., Minoia, P., & Pellikka, P. (2021). Constraints for adopting climate-smart agricultural practices among smallholder farmers in Southeast Kenya. *Agricultural Systems*, 194(103284), 1–13. <https://doi.org/10.1016/j.agsy.2021.103284>
- Azadi, H., Ghazali, S., Ghorbani, M., Tan, R., & Witlox, F. (2023). Contribution of small-scale farmers to global food security: a meta-analysis. *Journal of the Science of Food and Agriculture*, 103(6), 2715–2726. <https://doi.org/10.1002/jsfa.12207>
- Azadi, H., Movahhed, S., Burkart, S., Mahmoudi, H., Passel, S. Van, Kurban, A., & Lopez-carr, D. (2021). Rethinking resilient agriculture : From Climate-Smart Agriculture to Vulnerable-Smart Agriculture. *Journal of Cleaner Production*, 319, 1–10. <https://doi.org/10.1016/j.jclepro.2021.128602>
- Azra, M. N., Noor, M. I. M., Ikhwanuddin, M., & Ahmed, N. (2021). Global trends on Covid-19 and food security research: A scientometric study. In *Advances in Food Security and Sustainability* (1st ed., Vol. 6). Elsevier Inc. <https://doi.org/10.1016/bs.af2s.2021.07.005>
- Bangun, L. P. (2024). Strategic transformations for realizing food security in Indonesia. *Critical Issue of Sustainable Future*, 1(2), 123-129. <https://doi.org/10.61511/crsusf.v1i2.1961>
- Carrera-Rivera, A., Ochoa, W., Larrinaga, F., & Lasa, G. (2022). How-to Conduct a Systematic Literature review: a Quick Guide for Computer Science Research. *MethodsX*, 9(1), 1-12. <https://doi.org/10.1016/j.mex.2022.101895>
- Caviedes, J., José Tomás Ibarra, Calvet-Mir, L., Álvarez-Fernández, S., & André Braga Junqueira. (2024). Indigenous and local knowledge on social-ecological changes is positively associated with livelihood resilience in a Globally Important Agricultural Heritage System. *Agricultural Systems*, 216, 1-10. <https://doi.org/10.1016/j.agsy.2024.103885>
- Chomboko, D., Theodory, T., Brüntrup, M., Shilling, V., Kativu, S. N., & Hornidge, A. K. (2025). Indigenous knowledge for sustainable food security in Turiani division, Tanzania. *Cogent Social Sciences*, 11(1), 1-12. <https://doi.org/10.1080/23311886.2025.2493319>
- Csizmady, A., Csurgó, B., Kerényi, S., Balázs, A., Kocsis, V., & Palaczki, B. (2021). Young farmers' perceptions of sustainability in a wine region in hungary. *Land*, 10(815), 1-16. <https://doi.org/10.3390/land10080814>
- Daniele, B. C. (2024). The farm succession effect on farmers' management choices. *Land Use Policy*, 137(107014), 1–15. <https://doi.org/10.1016/j.landusepol.2023.107014>
- Dharmalingam, B., Giri Nandagopal, M. S., Thulasiraman, V., Kothakota, A., & Rajkumar. (2021). Short food supply chains to resolve food scarcity during COVID-19 pandemic – An Indian model. *Advances in Food Security and Sustainability*, 35–63. <https://doi.org/10.1016/bs.af2s.2021.08.001>
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Figurek, A., Morphi, K., & Thrassou, A. (2024). A Sustainable Risk Management Model and Instruments for

- Young Farmers in EU Agriculture. *Sustainability (Switzerland)*, 16(1), 1-24. <https://doi.org/10.3390/su16010283>
- Frantsuz, Y.A (2025). In Search for the Best-Fitting Theoretical Model for Explaining Demographic Dynamics. *Population and Economics* 9(1):108-128. <https://doi.org/10.3897/popecon.9.e128817>
- Galanakis, C.M., Daskalakis, M.L., Galanakis., Gallo A, Marino, E.A.E., Chalkidou, A., & Agrafioti, E. (2025). A systematic framework for understanding food security drivers and their interactions. *Discov Food* 5(178), 1-35. <https://doi.org/10.1007/s44187-025-00480-w>
- Gemtou, M., Kakkavou, K., Anastasiou, E., Fountas, S., Pedersen, S. M., Isakhanyan, G., Erekaló, K. T., & Pazos-Vidal, S. (2024). Farmers' Transition to Climate-Smart Agriculture: A Systematic Review of the Decision-Making Factors Affecting Adoption. *Sustainability (Switzerland)*, 16(2828), 1-34. <https://doi.org/10.3390/su16072828>
- Gómez, M. I., & Lee, D. (2023). Transforming food supply chains for sustainability. *Journal of Supply Chain Management*, 59(4), 79-92. <https://doi.org/10.1111/jscm.12310>
- Góngora Pérez, R. D., Milán Sendra, M. J., & López-i-Gelats, F. (2020). Strategies and drivers determining the incorporation of young farmers into the livestock sector. *Journal of Rural Studies*, 78, 131-148. <https://doi.org/10.1016/j.jrurstud.2020.06.028>
- Guo Y, Tian Y. Impact of Rural Ageing on Non-Grain Agricultural Production in China: An Analysis Based on Food Security Strategy. *Foods*. 2025 Mar 30;14(7): 1-18. <https://doi.org/10.3390/foods14071214>
- Handoko, W., Sulaiman, A. I., Prastyanti, S., Sari, L. K., Wijayanti, I. K. E., Windiasih, R., & Rofik, A. (2026). Empowerment of former female migrant workers in rural food security. *Multidisciplinary Science Journal*, 8(9), 2026576. <https://doi.org/10.31893/multiscience.2026576>
- Harisudin, M., Kusnandar, Riptanti, E. W., Setyowati, N., & Khomah, I. (2023). Determinants of the Internet of Things adoption by millennial farmers. *AIMS Agriculture and Food*, 8(2), 329-342. <https://doi.org/10.3934/AGRFOOD.2023018>
- Harsanto, B., Kasumaningrum, Y., Arviansyah, M. R., Siregar, A. YM., Purnomo, D., Iskandar, Y., Utama, I. D., & Sari, D. I. (2025). Leveraging disruptive technologies for food security: A systematic review on agricultural supply chain resilience to climate change. *Current Research in Food Science*, 10,1-12. <https://doi.org/10.1016/j.crfs.2025.101079>
- Haryati, N., Lasitya, D. S., Nurirrozak, M. Z., Herdianti, D. F., Fibrianiingtyas, A., & Hidayat, A. R. T. (2024). Demographics and course choices: impact on youth farming intention in Indonesia. *International Journal of Adolescence and Youth*, 29(1), 1-13. <https://doi.org/10.1080/02673843.2024.2358088>
- Juliannisa, I. A., Rahma, H., Mulatsih, S., & Fauzi, A. (2025). Regional Vulnerability to Food Insecurity: The Case of Indonesia. *Sustainability*, 17(11), 1-20. <https://doi.org/10.3390/su17114800>
- Kangogo, D., Dentoni, D., & Bijman, J. (2021). Adoption of climate-smart agriculture among smallholder farmers: Does farmer entrepreneurship matter? *Land Use Policy*, 109(105666), 1-13. <https://doi.org/10.1016/j.landusepol.2021.105666>
- Katchova, A. L., & Ahearn, M. C. (2016). Dynamics of farmland ownership and leasing: Implications for young and beginning farmers. *Applied Economic Perspectives and Policy*, 38(2), 334-350. <https://doi.org/10.1093/aep/ppv024>
- Katchova, A. L., & Dinterman, R. (2018). Evaluating financial stress and performance of beginning farmers during the agricultural downturn. *Agricultural Finance Review*, 78(4), 457-469. <https://doi.org/10.1108/AFR-08-2017-0074>
- Khumalo, N. Z., Sibanda, M., & Mdoda, L. (2025). The effect of heterogeneous adoption of climate-smart agriculture practices on household food and nutrition security of small-scale urban crop farmers in eThekweni Municipality. In *PLOS Climate* (Vol. 4, Issue 1). <https://doi.org/10.1371/journal.pclm.0000551>
- Kováč, I., Megyesi, B. G., Bai, A., & Balogh, P. (2022). Sustainability and Agricultural Regeneration in Hungarian Agriculture. *Sustainability (Switzerland)*, 14(2), 1-14. <https://doi.org/10.3390/su14020969>
- Lees, N. J., Sivakumar, S., & Lucock, X. (2024). Agrifood Sustainability Transitions in Firms and Industry: A Bibliographic Analysis of Research Themes. *Sustainability*, 16(16), 1-27. 7079. <https://doi.org/10.3390/su16167079>
- Li, T., Lu, H., Luo, Q., Li, G., & Gao, M. (2024). The Impact of Rural Population Aging on Agricultural Cropping Structure: Evidence from China's Provinces. *Agriculture*, 14(4), 586-586. <https://doi.org/10.3390/agriculture14040586>

- Liu, J., Fang, Y., Wang, G., Liu, B., & Wang, R. (2023). The aging of farmers and its challenges for labor-intensive agriculture in China: A perspective on farmland transfer plans for farmers' retirement. *Journal of Rural Studies*, 100, 103013. <https://doi.org/10.1016/j.jrurstud.2023.103013>
- López-García, D., & María Carrascosa-García. (2023). Sustainable food policies without sustainable farming? Challenges for agroecology-oriented farmers in relation to urban (sustainable) food policies. *Journal of Rural Studies*, 105, 103160–103160. <https://doi.org/10.1016/j.jrurstud.2023.103160>
- Manzoor F, Wei L, Siraj M, Lu X, Qiyang G. (2025). Digital agriculture technology adoption in low and middle-income countries a review of contemporary literature. *Frontiers in Sustainable Food Systems*. 29(9), 1-11. <https://doi.org/10.3389/fsufs.2025.1621851>
- Mao, H., Liu, M., Tang, H., & Fu, Y. (2025). Aging of agricultural labor and the adoption of improved crop varieties: A study based on rural China. *Journal of Rural Studies*, 119, 103769. <https://doi.org/10.1016/j.jrurstud.2025.103769>
- Maulida, Y. F., Wati, R. I., & Subejo. (2022). The Succession Patterns of Agricultural Lands in the Special Region of Yogyakarta Province, Indonesia. *Journal of Population and Social Studies*, 30, 625–639. <https://doi.org/10.25133/JPSSv302022.035>
- May, D., Arancibia, S., Behrendt, K., & Adams, J. (2019). Preventing young farmers from leaving the farm: Investigating the effectiveness of the young farmer payment using a behavioural approach. *Land Use Policy*, 82, 317–327. <https://doi.org/10.1016/j.landusepol.2018.12.019>
- Melash, A. A., Bogale, A. A., Migbaru, A. T., Chakilu, G. G., Percze, A., Ábrahám, É. B., & Mengistu, D. K. (2023). Indigenous agricultural knowledge: A neglected human based resource for sustainable crop protection and production. *Heliyon*, 9(1),1-9. <https://doi.org/10.1016/j.heliyon.2023.e12978>
- Mizik, T. (2021). Climate-smart agriculture on small-scale farms: A systematic literature review. *Agronomy*, 11(1096), 1–16. <https://doi.org/10.3390/agronomy11061096>
- Moher, D., Shamseer, L., Clarke, M., Ghersi, M., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L.A. & PRISMA-P Group. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, 4(1), 1-9. <https://doi.org/10.1186/2046-4053-4-1>
- Muis, A., Nurnaningsih, Suirlan, R., Haprin Dj Achmad, N., Firdayanti, & Baharuddin. (2025). Analysis of Food Sovereignty in Indonesia: Macroeconomic Data. *Research on World Agricultural Economy*, 6(2), 712–722. <https://doi.org/10.36956/rwae.v6i2.1675>
- Mujeyi, A., Mudhara, M., & Mutenje, M. (2021). The impact of climate smart agriculture on household welfare in smallholder integrated crop–livestock farming systems: evidence from Zimbabwe. *Agriculture and Food Security*, 10(1), 1–15. <https://doi.org/10.1186/s40066-020-00277-3>
- Murniati, K., & Mutolib, A. (2020). The impact of climate change on the household food security of upland rice farmers in sidomulyo, lampung province, indonesia. *Biodiversitas*, 21(8), 3487–3493. <https://doi.org/10.13057/biodiv/d210809>
- Nassar, S., Hossain, M., Naárné, É.Z.T. & Vasa, L. (2025). The mediating effect of farmer's knowledge on the relationship between agricultural services, skills acquisition and food security. *Environment, Development and Sustainability*, 1-21. <https://doi.org/10.1007/s10668-025-07005-6>
- Nchanji, E. B., & Lutomia, C. K. (2021). Sustainability of the agri-food supply chain amidst the pandemic: Diversification, local input production, and consumer behavior. In *Advances in Food Security and Sustainability* (1st ed., Vol. 6). Elsevier Inc. <https://doi.org/10.1016/bs.af2s.2021.07.003>
- Ngadi, N., Zaelany, A. A., Latifa, A., Harfina, D., Asiati, D., Setiawan, B., Ibnu, F., Triyono, T., & Rajagukguk, Z. (2023). Challenge of Agriculture Development in Indonesia: Rural Youth Mobility and Aging Workers in Agriculture Sector. *Sustainability (Switzerland)*, 15(2), 1–15. <https://doi.org/10.3390/su15020922>
- Nurarifin N., & Kurniawan, B.D. (2025). Youth, Agriculture, and Food Security: Understanding the Farmer Regeneration Challenge in Sumatra. *The Journal of Indonesia Sustainable Development Planning*, 6(1), 98-115. <https://doi.org/10.46456/jisdep.v6i1.650>
- Nurlaily, P.D., Widodo, S., Zuhriyah, A., and Siwalette, J.D. (2025). The interest of the younger generation in grouper farming in lembung village, galis district, pamekasan regency. *SEPA (Jurnal Sosial Ekonomi Pertanian dan Agribisnis)*, 22(2), 166 - 178. doi: <https://dx.doi.org/10.20961/sepa.v22i2.95454>
- Okpala, E. F., Korir, L., & Manning, L. (2024). Food Acquirability: An Unexplored Component of Food Security? *Foods*, 13(13), 1-18.. <https://doi.org/10.3390/foods13132052>
- Otsuka, K. (2021). Strategy for Transforming Indonesian Agriculture. *Bulletin of Indonesian Economic Studies*,

- 57(3), 321–341. <https://doi.org/10.1080/00074918.2021.2002387>
- Pagliacci, F., Defrancesco, E., Mozzato, D., Bortolini, L., Pezzuolo, A., Pirotti, F., Pisani, E., & Gatto, P. (2020). Drivers of farmers' adoption and continuation of climate-smart agricultural practices. A study from northeastern Italy. *Science of the Total Environment*, 710(136345), 1–13. <https://doi.org/10.1016/j.scitotenv.2019.136345>
- Placzek, O. (2021). Socio-economic and demographic aspects of food security and nutrition", OECD Food, Agriculture and Fisheries Papers, No. 150. Paris: OECD Publishing, <http://dx.doi.org/10.1787/49d7059f-en>
- Prastyanti, S., Wulandari, R., & Iman Sulaiman, A. (2024). Estrategia de comunicación participativa para el desarrollo de un programa de agricultura urbana en Yogyakarta, Indonesia. *Palabra Clave*, 27(4), 1-34. <https://doi.org/10.5294/pacla.2024.27.4.11>
- Preinfalk, E., Bednar-Friedl, B., Mayer, J., Lauk C., & Mayer A. (2024). Sustainability transitions in the agri-food system: Evaluating mitigation potentials, economy-wide effects, co-benefits and trade-offs for the case of Austria. *Ecological Economics*.1(226), 1-15. <https://doi.org/10.1016/j.ecolecon.2024.108357>
- Putri, A. Y. D., Winarno, S. T., & Setiawan, R. F. (2025). The Impact of Skills Training and Access to Financial Services on the Development of Young Farmers' Entrepreneurial Capacity in Pucanglaban District. *Jurnal Social Economic of Agriculture*, 14(1), 87-99. <https://doi.org/10.26418/j.sea.v10i2.94968>
- Qonita, R. R. A., Masyhuri, Jamhari, & Perwitasari, H. (2025). Social Environmental Support in Encouraging Entrepreneurial Behavior of Millennial Farmers in the Special Region of Yogyakarta, Indonesia: An Effort to Realize Sustainable Agriculture. *Caraka Tani: Journal of Sustainable Agriculture*, 40(1), 64–83. <https://doi.org/10.20961/carakatani.v40i1.92724>
- Reyes, S. R. C., Miyazaki, A., Yiu, E., & Saito, O. (2020). Enhancing Sustainability in Traditional Agriculture: Indicators for Monitoring the Conservation of Globally Important Agricultural Heritage Systems (GIAHS) in Japan. *Sustainability*, 12(14), 1-28. <https://doi.org/10.3390/su12145656>
- Rivera, I., Díaz de León D., & Pérez-Salazar, M.R. (2024) Drivers of the food system based on food sovereignty domains: an integrative systematic literature review. *Frontiers in Sustainable Food Systems*. 8, 1-31.1. <https://doi.org/10.3389/fsufs.2024.1450321>
- Rizki, M., & Andini, D. S. (2025). Becoming a young farmer: young people's pathways into farming: Canada, China, India, and Indonesia. *The Journal of Peasant Studies*, 52(1), 206–209. <https://doi.org/10.1080/03066150.2024.2392695>
- Rochmawan, H., Sulaiman, A.I., Putri, D.D., Rosyadi, S., Dharmawan, B., Haryanto, T.A. D., (2025). Community Empowerment Based On Local Wisdom In Agritourism Development: A Bibliometric Analysis Of Research From 2015 To 2025. *Scientific Culture*. 11(3), 341-368. <https://sci-cult.com/volume-view/page/3/?id=7>
- Roumasset, J. A. (2015). Reflections on the Foundations of Development Policy Analysis. *Sustainable Economic Development*, 11–45. <https://doi.org/10.1016/b978-0-12-800347-3.00002-9>
- Ruiz Salvago, M., Phiboon, K., Faysse, N., & Nguyen, T. P. L. (2019). Young people's willingness to farm under present and improved conditions in Thailand. *Outlook on Agriculture*, 48(4), 282–291. <https://doi.org/10.1177/0030727019880189>
- Rustandi, Y., & Farid, A. (2023). Involvement of Millennial Farmers in the Implementation of Integrated Agriculture in Trenggalek District, East Java, Indonesia. *Anuario Do Instituto de Geociencias*, 47, 1–14. https://doi.org/10.11137/1982-3908_2024_47_60967
- Sahar, R., Munawaroh, M. & Iqbal, J. (2025). Climate change adaptation in agriculture food supply chains: a bibliometric and content analysis. *Discov Sustain* 6, 1396, 1-34. <https://doi.org/10.1007/s43621-025-02105-9>
- Saputra, A., Istiqomah, I., & Binardjo, G. (2022). What Attracts Rural Youth To Farming? Evidence From Central Java. *Agrisocionomics: Jurnal Sosial Ekonomi Pertanian*, 6(1),23-32. <https://doi.org/10.14710/agrisocionomics.v6i1.10105>
- Sasmita, H. O., Saleh, A., Priatna, W. B., & Muljono, P. (2025). Digital motivation, knowledge, and skills: Pathways to adaptive millennial farmers. *Open Agriculture*, 10(1), 1–12. <https://doi.org/10.1515/opag-2025-0426>
- Saxena, A., & Mohan, S. B. (2021). The impact of food security disruption due to the Covid-19 pandemic on tribal people in India. *Advances in Food Security and Sustainability*, 65–81. <https://doi.org/10.1016/bs.af2s.2021.07.006>

- Sekaranom, A. B., Nurjani, E., & Nucifera, F. (2021). Agricultural climate change adaptation in Kebumen, central Java, Indonesia. *Sustainability (Switzerland)*, 13(13), 1–16. <https://doi.org/10.3390/su13137069>
- Setiadi, E., Sulaiman, A. I., C., Windiasih, R., Ahmadi, D., Suyanto, E., & Wijayanti, I. K. E., (2024). Important Factors in the Development of Young Entrepreneurial Groups in Forest Honeybee Cultivation and Products. *Journal of Ecohumanism*, 3(3), 1196–1207. <https://doi.org/10.62754/joe.v3i3.3420>
- Sitompul, T. (2026). What Drives Youth to Farm? Exploring Social, Economic, and Personal Factors. *JALOW | Journal of Agribusiness and Local Wisdom*, 9(1), 49–55. <https://doi.org/10.22437/jalow.v9i1.48916>
- Sukayat, Y., Setiawan, I., Suharfaputra, U., & Kurnia, G. (2023). Determining Factors for Farmers to Engage in Sustainable Agricultural Practices: A Case from Indonesia. *Sustainability (Switzerland)*, 15(13), 1–14. <https://doi.org/10.3390/su151310548>
- Sulaiman, A. I., Rosyadi, S., Handoko, W., Masrukin, M., Putri, D. D., Wijayanti, I. K. E., & Faozanudin, M. (2024). The Importance of Participatory Communication in Development Planning Deliberations for Agritourism Village Enhancement. *Journal of Intercultural Communication*, 24(1), 144–160. <https://doi.org/10.36923/jicc.v24i1.246>
- Tolinggi, W. K., Salman, D., Rahmadanih, & Iswoyo, H. (2023). Farmer regeneration and knowledge co-creation in the sustainability of coconut agribusiness in Gorontalo, Indonesia. *Open Agriculture*, 8(1), 1–18. <https://doi.org/10.1515/opag-2022-0162>
- Tong, T., Ye, F., Zhang, Q., Liao, W., Ding, Y., Liu, Y., & Li, G. (2024). The impact of labor force aging on agricultural total factor productivity of farmers in China: implications for food sustainability. *Frontiers in Sustainable Food Systems*, 8, 1–13. <https://doi.org/10.3389/fsufs.2024.1434604>
- Toumbourou, T., Dressler, W., Anna J.P. Sanders, Liu, E., Brown, T., & Utomo, A. (2023). Who are the future farmers? Media representations of youth in agriculture, food security and “modern” farming in Indonesia. *Asia Pacific Viewpoint*, 64(2), 188–208. <https://doi.org/10.1111/apv.12374>
- Trasca, T.I., Balan, I. M., Fintineru, G., Tiu, J. V., Nicoleta Mateoc-Sirb, & Ciprian Ioan Rujescu. (2025). Sustainable Food Security in Romania and Neighboring Countries – Trends, Challenges, and Solutions. *Foods*, 14(8), 1–35. <https://doi.org/10.3390/foods14081309>
- Uddin, M. B., & Antriyandarti, E. (2025). Strategies to overcome the declining trend of young farmers: A comprehensive review of agricultural development issues. *Journal of Agrosociology and Sustainability*, 3(1), 1–18. <https://doi.org/10.61511/jassu.v3i1.2025.1820>
- Ujjwal, KC., Campbell-Ross, H., Godde, C., Friedman, R., Lim-Camacho, L., & Crimp, S. (2024). A systematic review of the evolution of food system resilience assessment. *Global Food Security*, 40, 1–10. <https://doi.org/10.1016/j.gfs.2024.100744>
- Wakweya, R. B. (2023). Challenges and prospects of adopting climate-smart agricultural practices and technologies: Implications for food security. *Journal of Agriculture and Food Research*, 14, 1–8. <https://doi.org/10.1016/j.jafr.2023.100698>
- Wang Y., & Zhong Y. (2026). The impact of agricultural labor aging on wheat production efficiency. *Frontiers in Sustainable Food Systems*, 10, 1–14. <https://doi.org/10.3389/fsufs.2026.1676834>
- Wang, G., Wang, Y., Li, S., Yi, Y., Li, C., & Shin, C. (2024). Sustainability in Global Agri-Food Supply Chains: Insights from a Comprehensive Literature Review and the ABCDE Framework. *Foods*, 13(18), 1–32. <https://doi.org/10.3390/foods13182914>
- Wu, S., Ang, L. Z., Nugroho, T. W., Radin Firdaus, R. B., & Syafri, E. (2026). Agricultural development in Southeast Asia: a bibliometric and comparative analysis of palm oil, rubber, and rice (2014–2024). *Cogent Food & Agriculture*, 12(1), 1–17. <https://doi.org/10.1080/23311932.2025.2611178>
- Yu, Y., Zhang, J., Zhang, K., Xu, D., Qi, Y., & Deng, X. (2023). The impacts of farmer ageing on farmland ecological restoration technology adoption: Empirical evidence from rural China. *Journal of Cleaner Production*, 430, 139648. <https://doi.org/10.1016/j.jclepro.2023.139648>
- Yusriadi, Y., Cahaya, A., & Hamzah, F. (2026). Motivations and challenges in adopting food security strategies: Insights from rural Indonesia. *Social Sciences & Humanities Open*, 13, 1–11. <https://doi.org/10.1016/j.ssaho.2026.102497>
- Zakaria, A., Azumah, S. B., Appiah-Twumasi, M., & Dagunga, G. (2020). Adoption of climate-smart agricultural practices among farm households in Ghana: The role of farmer participation in training programmes. *Technology in Society*, 63(101338), 1–8. <https://doi.org/10.1016/j.techsoc.2020.101338>
- Zhang, H., Li, J., & Quan, T. (2023). Strengthening or Weakening: The Impact of an Aging Rural Workforce on Agricultural Economic Resilience in China. *Agriculture (Switzerland)*, 13(1436), 1–16.

<https://doi.org/10.3390/agriculture13071436>

Zheng, H., Ma, W., & He, Q. (2024). Climate-smart agricultural practices for enhanced farm productivity, income, resilience, and greenhouse gas mitigation: a comprehensive review. *Mitigation and Adaptation Strategies for Global Change*, 29(28), 1–38. <https://doi.org/10.1007/s11027-024-10124-6>

Zhou, Q., Zhang, S., Deng, W., Wang, Y., & Zhang, H. (2025). Demographic shifts and agricultural production efficiency in the context of urban-rural transformation: Complex networks and geographic differences. *Global Food Security*, 45, 100867–100867. <https://doi.org/10.1016/j.gfs.2025.100867>