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Research Article

Integrating Sustainable Food Security Policies and the Circular Economy through the Optimisation of Soya Bean

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Abstract

Food security is vital to people's lives as a basic human need. Consequently, the role of the government both central and local is essential in ensuring food security. Policies relating to food security are geared towards achieving food self-sufficiency and food sovereignty. Appropriate policy strategies are required to achieve sustainable food security through improved management of local resources. One strategy that can be implemented is the circular economy model. Sustainable food security through a circular economy system can be realised through the production and consumption of natural resources, for example soya beans. This is an interesting area for research, particularly in Majalengka, which is a leading soybean-producing region and is renowned for its distinctive local processed products. The study employed a descriptive qualitative approach. The results of the study indicate that the integration of sustainable food security policies and the circular economy in the soya bean sector in Majalengka requires synergy between a comprehensive policy framework, the coordinated involvement of subsystems, clear and measurable policy objectives, and effective policy instruments.

Keywords: Food Security; Sustainability; Circular Economy; Soybean Commodity; Policy.

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INTRODUCTION

Food security is a complex issue involving various sectors, including the social, economic, political and environmental sectors (Aziza, 2019) (Viona et al., 2025). The concept of food security encompasses four principles: the availability of food, ease of access to food, the appropriate use of food, and the stability of both the quantity and quality of food (Maulana et al., 2024). Food security is vital to people's lives as a basic human need. Consequently, the role of government both central and local is essential in ensuring food security. This is enshrined in Law No. 18 of 2012 on Food.

These food security policies are geared towards achieving food self-sufficiency and food sovereignty (Tono et al., 2023). A concept of food security focused on food self-sufficiency can be realised through the enhanced utilisation of local resources or potential. The management of local resources prioritises social aspects, economic growth, and environmental sustainability (Kurniawan et al., 2024) (Wijaya, 2024). These three aspects are considered for sustainability, thereby establishing a form of food security based on a sustainability model.

According to the 2022 Global Food Security Index, Indonesia ranks 113th in the world and 23rd in the Asia-Pacific region (Global Food Security Index (GFSI), 2022). The data also shows that Indonesia's food security scores are 81.4 for affordability; 50.9 for availability; 56.2 for quality and safety; whilst the score for sustainability and adaptation is 46.3. These figures indicate that the levels of affordability, availability, and food quality and safety in Indonesia are reasonably good. However, sustainability and adaptation remain suboptimal, with scores below 50. This means the government needs to address the issue of sustainable food security by adapting to new developments.

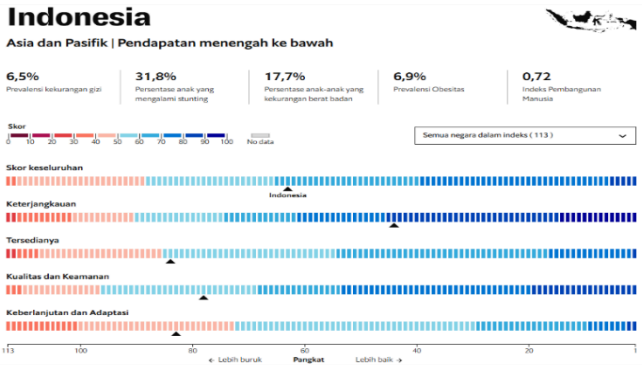


Figure 1. Indonesia Food Security Index 2022

Sustainable food security and adaptation are key priorities for Indonesia, particularly in building food resilience (Hotimah & Zain, 2024). Appropriate policy strategies are required to achieve sustainable food security through improved management of local resources. One strategy that can be implemented is the circular economy model. Indonesia has been actively engaged in sustainable development through the circular economy model (Utami et al., 2024). The implementation of the circular economy involves optimising resource utilisation, maximising resource use, environmentally friendly waste management, minimising emissions, and reducing energy consumption (Fahri et al., 2025) (Sahran et al., 2024). The context of the circular economy for natural resources involves minimising the exploitation of natural resources, minimising waste, and innovating with sustainability concepts in production and consumption processes (Utami et al., 2024). Various regions have implemented a zero-waste-based circular economy to improve food security, such as the City of Surabaya, Yogyakarta, Sleman Regency, Dharmasraya Regency,

and other areas (Irmawanto et al., 2025) (Sudrajat et al., 2025) (Ratri et al., 2025) (Purnomo et al., 2025).

Sustainable food security through a circular economy can be achieved through the production and consumption of natural resources (Yudha et al., 2025). This involves production that optimises utility and creative consumption, whilst minimising waste (Syahbanu & Pawestri, 2024). However, this must not come at the expense of health and nutritional value. One form of sustainable food security combined with the circular economy concept is maize. Maize is developed into foodstuffs, animal feed, industrial materials, energy sources, and economic growth towards food self-sufficiency. The concept of sustainable maize food security is achieved through strengthening farmers' institutions and adopting technology (Yusuf et al., 2025). Maize as a commodity that strengthens local food security has been innovated into gummy products (a type of sweet) (Sarusu et al., 2026). The by-products of maize processing do not end up as waste, but are utilised as a growing medium for mushrooms (Destiarini et al., 2025).

Furthermore, in Indonesia, the concept of food security is closely linked to cassava. Efforts to diversify cassava and enhance food security continue to be developed, with cassava serving as a food ingredient within the framework of the creative economy (Juwandi et al., 2021). Moreover, it is not only the tuber that is edible. The cassava leaves can be consumed as a vegetable and innovated into healthy foods such as cassava leaf nuggets (Astuti et al., 2025). Meanwhile, cassava waste can be processed into new products, such as the innovation of turning cassava peel into rice substitute as part of efforts towards food self-sufficiency (Yuniarti et al., 2026).

In addition to the two commodities mentioned above, Indonesia also produces soya beans, which are a key commodity in terms of both quality and quantity. Soya beans can serve as a sustainable food source (Roswita et al., 2021) (Chu et al., 2024). Soybeans can be processed into a variety of products (Unaizahroya, 2025). Even soybean waste can be processed into compost for use in sustainable agriculture (Hartawan et al., 2018). One of the major soybean-producing regions is Majalengka Regency. Data from the Majalengka Regency Central Statistics Agency for 2022 indicates that Majalengka Regency produced 16.01 tonnes of soya beans (Badan Pusat Statistik Kabupaten Majalengka, 2022). Majalengka Regency recognises the potential of soya beans, which are abundant and of high quality (Marina et al., 2023). Processed products from the soybean plant are widely produced and have become a hallmark of the region. Products such as soy sauce, tofu, tempeh, soya milk, and even soybean pulp and young leaves are processed into local specialities.

This constitutes a form of sustainable food security accompanied by a circular economy system. However, as the public has yet to fully grasp this concept, there is a need for reinforcement, development, guidance and government support. The government can provide support through policies, capital assistance, empowerment, and media outreach. Therefore, this study requires in-depth research on the integration of sustainable food security policies and the circular economy through the optimisation of soya bean commodities. The aim is to optimise policy implementation with community participation.

METHODS

This type of research falls under the category of field research, which is research conducted in the field based on factual observations. This research is specifically oriented towards direct research activities at the site or in the natural environment related to the research

phenomenon or subject. This research is useful for providing in-depth material on the latest background conditions and interactions within the social environment of the community (Sugiyono, 2020). This research utilises primary data obtained directly from the field through participant observation and in-depth interviews, as well as secondary data obtained from various documents related to the research topic. The collection of primary data was assisted by key informants, identified using purposive sampling techniques in line with the research objectives.

Type of Research

The type of research employed is a qualitative study with a descriptive approach. Descriptive qualitative research focuses on investigating the scientific conditions of the subject matter, with the researcher serving as the primary instrument, utilising inductive data collection techniques, and aiming for generalization (Sugiyono, 2020). Descriptive research contains systematic descriptions and depictions of facts related to the phenomena under discussion (Nazir, 2014). Descriptive qualitative research is appropriate for the research topic, which is to investigate and analyse phenomena related to the integration of sustainable food security and circular economy policies in the management of soya bean commodities.

Research Focus

The definition of the research focus is intended to narrow the scope of the study so that the research does not become bogged down by the sheer volume of data in the field, and to avoid data that is irrelevant to the research problem and objectives. Based on the research questions and the objectives to be achieved, the focus of this study is as follows: The study begins with an explanation of food security implementation; according to the Food and Agriculture Organisation (FAO), this encompasses four principles of food security, including food availability, accessibility of food, appropriate use of food, and stability in the quantity and quality of food (Maulana et al., 2024). Meanwhile, the concept of the circular economy, according to Ellen MacArthur (2013), identifies the components of the circular economy, including eco-friendly design, reuse, recycling, and closed-loop systems (Quraisy, 2025). This will then be analysed in accordance with the dimensions of the integration process variables identified by Jeroen J. L. Candel and R. Biesbroek (2016), which include the policy framework, subsystem involvement, policy objectives, and policy instruments (Supriyanto & Jannah, 2022).

Data Sources

The data sources for this study are divided into two categories. According to Sugiyono (2020) ata sources are classified into primary and secondary data, as detailed below:

Primary Data

Primary data is data that directly provides information to the researcher. It is data derived from primary sources. The data sources for this study consist of surveys and interviews. Primary data consists of respondents' answers to the research questionnaire and interviewees' responses during research interviews. The list of interview questions was posed to relevant parties and expert informants regarding the integration of sustainable food security policies and the circular economy in the management of soya beans.

Secondary Data

Secondary data is data collected indirectly through research data collection techniques. Data collection involves parties other than the researcher. The data sources applied in this research

relate to the results of previous studies with similar themes, methods, and other aspects, thereby serving as literature to strengthen existing theories. Secondary data is also supported by data from reports, archives, books, scientific articles, and legislation. Specifically, reports and archives refer to records of activities related to the integration of sustainable food security policies and the circular economy in soybean management.

Data Collection Techniques

Research procedures are linked to data collection techniques carried out objectively by the researcher. The research methods ensure that the data or information obtained can objectively describe or address the research findings.

Interview

A data collection technique in which the researcher interacts directly with the informant to obtain information relevant to the research topic. These interviews are conducted in line with the research focus. An interview is a dialogue conducted by the interviewer to obtain information from the interviewee.

Observation

Observation is the act of observing facts at the research site, with the focus of observation on the research subject. Objective observation is used to collect data with minimal manipulation or fabrication. The researcher must adopt a neutral and objective stance in the research, without being influenced by factors outside the research focus and methodology.

Documentation

Documentation is the act of collecting data in the form of documents, policies, and other records relevant to the research theme and scope. Documentation reinforces data from questionnaires, interviews, and observations.

Informant Selection Techniques

Informant selection was carried out using purposive sampling, whereby the sample was selected and determined based on specific criteria (Sugiyono, 2020). According to Pujileksono (2015) individuals selected as samples or informants are chosen on the basis that the researcher considers them to possess and be able to provide information relevant to the research needs (Pujileksono, 2015). Purposive sampling serves as a method to fulfil the research objectives and aims. The specific criteria for selecting research informants are as follows:

a. The key informant is the Head of the Majalengka Regency Food Security, Agriculture and Fisheries Agency.
b. The main informants are expert informants comprising one employee of the Majalengka Regency Food Security, Agriculture and Fisheries Agency, one representative of soya bean farmers, and one representative of business operators involved in soya bean management.
c. Supporting informants are three members of the public who experience and consume soya beans.

Research Instruments

Research instruments serve as guidelines for interviews and observations, with the researcher acting as the primary instrument (Arikunto, 2010). The research instruments used include:

a. Self-Research

In accordance with the research method employed—namely, the qualitative research method—the primary instrument in this study is the researcher themselves, who is directly involved with the research subject by participating in the research process. With the researcher acting as the instrument, there are several prerequisites that must be observed, including:

1) The researcher maintains a distance from the research subject
2) Remains objective
3) Is research-goal-oriented
4) Remains faithful to the research data
5) Conducts the research in accordance with the relevant discipline and paradigm.

b. Interview Guidelines

In qualitative research, the researcher plays a crucial role as a measuring tool in collecting and analyzing data, guided by interview rules and direct observation. Observation and interviews can provide insight into social interactions, capturing the feelings and values embedded in respondents' actions. Structured research utilizes a research instrument outline, which is then used as a guide for interviews and observations.

c. Supporting Instruments

Supporting instruments used in research are very helpful tools, including:

1) Writing instruments
2) Sound recording devices
3) Cameras
4) Computers or laptops
5) Other supporting tools.

Validity of Findings

The validity of qualitative research data is tested for internal validity (credibility), external validity (transferability), reliability (dependability), and objectivity (confirmability) (Sugiyono, 2020).

a. Internal Validity (Credibility)

Credibility testing for qualitative research data involves observation, increased diligence, triangulation, peer discussion, negative case analysis, and auditing. Longer observation patterns enhance the value of careful and continuous observations. Researchers include accurate and systematic descriptive opinions. Auditing is applied to strengthen research credibility by examining the data collected by researchers on research subjects. The goal is to determine the extent to which the data obtained aligns with what the subjects provided.

b. External Validity Test (Transferability)

External validity testing is a specific type of testing in quantitative research. External validity indicates the degree of accuracy or applicability of research results related to the sample taken. This external validity testing method is carried out by creating a detailed, clear, systematic, and reliable report. This allows readers to decide whether the research results can be applied elsewhere or whether the research techniques can be applied to future research on the same topic.

c. Reliability Test (Dependability)

Reliability testing is conducted by auditing the entire research process. The audit is conducted by the thesis supervisor. The goal is to ensure the research data and information are reliable.

d. Objectivity Test (Confirmability)
Research objectivity testing is conducted by examining the research results in relation to the process. The researcher's thesis supervisor will conduct this objective testing to determine whether the research process actually occurred. This testing ensures that the research process is carried out in a realistic manner.

Data analysis

Testing data analysis steps with systematic rules according to transcripts of notes, field data, and other materials. The goal is to present research findings in a more structured manner. Analysis relates to performance, operations, handling, and synthesis within a pattern. Elaboration is crucial and determines the results of the report. Sugiyono (2020) argues that the qualitative research data analysis process is determined from the beginning or pre-field research, during field research, and after field research. (Sugiyono, 2020).

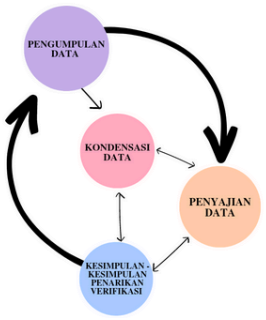


Figure 2. Data Analysis Flow
Source: Miles, M.B, Huberman & Saldana, 2014; Sidiq & Choiri, 2019

a. Data Condensation
Data reduction involves summarizing, sorting out key points, focusing on crucial points, and establishing themes and patterns. After data reduction, clear, detailed, and simple explanations can be prepared to facilitate further data collection.

b. Data Display
Data presentation facilitates research, enhancing understanding of events and future performance plans. Data presentation can utilize narrative text and include graphs, matrices, networks, and charts.

c. Conclusion Drawing or Verification
Data collected from pre-research will be connected and can be used as conclusions. Conclusion data must be verified during the research process. The sequential steps of data reduction, presentation, conclusion drawing, and verification are key to success in the analysis process.

RESULTS AND DISCUSSION

Majalengka Regency has significant potential for soybean development as part of a food security system and regional economic strengthening. Structurally, soybeans are classified as a superior food crop commodity, as evidenced by their relatively high comparative advantage compared to other regions. This indicates that soybeans not only play a role in meeting local consumption needs but also have the potential to be developed as a competitive agribusiness commodity. The contribution of the agricultural sector, particularly food crops, is a key pillar of the regional economy, thus soybean development holds a strategic position within the regional development framework.

The agro-ecosystem, geographic conditions, and land availability in Majalengka Regency strongly support soybean cultivation. The common cropping pattern is a rice-soybean rotation system. Soybeans are planted in paddy fields after the rice harvest, especially during the dry season. This use of paddy fields provides efficient use of land resources without the need to clear new areas. Furthermore, relatively favorable climatic conditions, including rainfall and temperature, support optimal soybean growth when combined with appropriate cultivation practices.

The potential for soybean production in this region is also supported by the use of superior varieties with high productivity and good seed quality. Varieties such as Anjasmoro, Dega-1, Dena-1, and Biosoy-1 have been widely developed by farmers due to their high adaptability to local conditions. The availability of superior seeds and support for cultivation technology are crucial factors in increasing production yields and efficiency in soybean farming.

On the demand side, soybeans play a strategic role as the primary raw material for food products such as tofu and tempeh, which are consumed daily by Indonesians. This high level of consumption is disproportionate to domestic production, opening up significant opportunities for regions like Majalengka to increase production and reduce dependence on imports. The concept of soybean development not only impacts farmers' incomes but also contributes to strengthening national food security.

Majalengka Regency was once known as a soybean production center, demonstrating the rich experience and local knowledge in cultivating this commodity. Currently, various revitalization efforts are being undertaken through the active participation of communities, farmer groups, and institutions such as cooperatives. This social capital is a crucial supporting factor in promoting sustainable soybean development at the local level.

Majalengka Regency's soybean potential is significant and strategic, both in terms of natural resources, technology, markets, and institutions. Optimizing this potential requires synergy between the government, farmers, and other stakeholders to ensure sustainable soybean development and significant contributions to food security and community well-being.

Food Security Principles

Soybeans are a strategic food commodity that plays a crucial role in supporting national food security, particularly as a source of vegetable protein for the community. In Majalengka Regency, soybeans are a leading food crop cultivated as part of both paddy and dryland farming systems. The management of this commodity can be analyzed using the four pillars of food security: availability, accessibility, utilization, and stability, to understand the extent to which soybeans can sustainably meet the community's food needs.

Availability Aspect

Soybean production in Majalengka Regency generally demonstrates sufficient availability to support local food needs, but production characteristics remain volatile over time. This fluctuation is closely related to the cultivation system, which generally places soybeans as an intercrop or rotation crop after rice, particularly during the dry season (the second planting season). This pattern results in soybean planting areas being unstable and highly dependent on the dynamics of farmer cropping patterns, water availability, and agro-climatic conditions such as rainfall, temperature, and land suitability. Furthermore, risk factors such as drought, pest and disease attacks, and limitations in cultivation technology also impact soybean productivity. This situation indicates that although soybeans have potential as a strategic commodity, their production system is still not fully stable and sustainable.

To increase soybean availability, the government has undertaken various efforts, including the provision of superior seeds adapted to local conditions, a program to expand planting areas, and the utilization of previously unproductive marginal land. These interventions are expected to gradually increase harvested area and productivity. However, implementation in the field still faces several structural obstacles, such as limited land specifically for soybeans due to competition with other, more economically profitable commodities, and the suboptimal implementation of modern agricultural technology at the farmer level. Furthermore, low economic incentives and price fluctuations also affect farmers' interest in developing intensive soybean cultivation. Therefore, a more comprehensive and integrated policy approach is needed, encompassing technical, economic, and institutional aspects, to ensure the continuity of soybean supply while strengthening this commodity's role in the regional food security system.

Accessibility Aspect

The ease of accessing soybeans in Majalengka Regency is still significantly influenced by economic factors and a suboptimal distribution system. From a production perspective, low farmer interest in cultivating soybeans is a major obstacle. This is due to the relatively lower profit margin compared to other commodities, such as rice or horticultural crops, making soybeans a less prominent priority in farmers' cropping patterns. Consequently, the supply of locally produced soybeans has not been able to optimally meet the community's consumption needs. This imbalance between production and demand ultimately drives dependence on supplies from outside the region, even at the national level, which are vulnerable to price and availability fluctuations.

Distribution is also a crucial factor in determining soybean accessibility. The relatively long and inefficient distribution chain leads to price disparities between producers and consumers. Limited distribution infrastructure, the lack of strong marketing institutions, and a suboptimal food logistics system exacerbate this situation. Consequently, soybean price stability is difficult to control, especially during times of supply disruptions or increased demand. This situation directly impacts public purchasing power and the sustainability of soybean processing industries, such as tofu and tempeh. Therefore, efforts are needed to improve the integrated distribution system, strengthen farmer and business actor institutions, and provide a fair pricing policy, in order to increase public access to soybeans in a more equitable, affordable and sustainable manner.

Utilization Aspect

Soybeans are widely used in the community, particularly as a raw material for food products such as tempeh and tofu. Their high nutritional content makes them an important alternative for meeting protein needs. However, soybean utilization in Majalengka is still dominated by traditional processed products and has not yet fully developed towards product diversification based on innovation or low-waste processing concepts. Optimizing soybean utilization through the development of derivative products and the utilization of processed waste has the potential to increase the added value of this commodity.

Soybeans are widely used in the community, particularly as a raw material for food products such as tempeh and tofu. Their high nutritional content makes them an important alternative for meeting vegetable protein needs. In Majalengka Regency, soybean utilization is not limited to these primary products but has also developed into various traditional regional dishes. One such dish is pecok katel, a soybean-based dish prepared with local spices and reflecting the local food wisdom. Furthermore, soybeans are also used in the production of Majalengka's signature soy sauce, which has its own distinctive flavor and is part of the region's culinary identity.

Soybean utilization also includes the use of byproducts or processed waste, such as soybean pulp (okara), which has the potential to be reprocessed into value-added products, such as animal feed raw materials, processed food additives, or innovative fiber-based food products. However, this waste utilization practice is still suboptimal and tends not to be integrated into sustainable production systems. However, a zero-waste approach can increase resource efficiency while reducing environmental impact.

Stability Aspect

The sustainability of soybean production and quality in Majalengka Regency still faces various complex and multidimensional challenges, particularly those related to the dynamics of climate change, fluctuations in harvested area, and limited application of cultivation technology at the farmer level. Climate variability, such as changes in rainfall patterns, rising air temperatures, and uncertainty in planting seasons, directly impact soybean growth and productivity. These conditions can lead to decreased yields, increased risks of pest and disease attacks, and inaccurate planting and harvest timing. Furthermore, the relatively unstable soybean harvest area due to cropping patterns that rely on rotation with other commodities also exacerbates production uncertainty over time. Limited access to modern cultivation technologies, such as the use of adaptive superior varieties, efficient irrigation systems, and agricultural mechanization, further exacerbates this situation.

The stability aspect of production is also influenced by suboptimal food reserve systems and post-harvest soybean management. The lack of adequate storage facilities, such as warehouses with controlled temperature and humidity, makes soybean quality susceptible to decline due to physical damage and pest attacks during storage. Furthermore, an incompletely integrated distribution system also impacts the continuity of supply in the market, resulting in unstable soybean availability. The absence of a robust regional food reserve system also makes the region vulnerable to price fluctuations and supply disruptions, both from within and outside the region. Therefore, strategic efforts are needed, including strengthening adaptation to climate change, improving cultivation and post-harvest technology, and developing an integrated food reserve system to ensure stable soybean production, availability, and quality on an ongoing basis.

Circular Economy Concept

The application of the circular economy concept to soybean management in Majalengka Regency is a strategic approach to realizing a sustainable, efficient, and environmentally friendly agricultural system. A circular economy emphasizes waste reduction through the design of sustainable production systems, resource reuse, recycling, and the implementation of closed-loop systems throughout the agricultural value chain. In the context of soybeans, this approach can be integrated from the cultivation stage to product processing and waste utilization.

Eco-friendly design aspect

Eco-friendly design in soybean management in Majalengka Regency emphasizes the design of agricultural production systems that are sustainable, efficient, and aligned with environmental carrying capacity. This approach focuses not only on increasing productivity but also on minimizing negative impacts on the ecosystem by optimizing the use of local resources and reducing dependence on external chemical-based inputs.

In cultivation practices, the application of environmentally friendly design can be achieved through the use of more sustainable agricultural inputs, such as organic fertilizers, biofertilizers, and botanical pesticides derived from natural ingredients. The use of these inputs can maintain the balance of the soil ecosystem, increase microbial activity, and reduce the risk of soil and water pollution. Furthermore, soil and water conservation techniques, such as minimum tillage, proper drainage, and the use of organic mulch, are crucial for maintaining the quality of soybean farmland amidst the pressures of climate change.

The rice-soybean rotation pattern commonly practiced by farmers in Majalengka is also part of a sustainable agroecosystem design. Soybean plants have the ability to fix nitrogen through a symbiosis with Rhizobium bacteria, naturally increasing the nitrogen content in the soil. This provides direct benefits to subsequent crops, particularly rice, reducing the need for synthetic nitrogen fertilizers. Thus, crop rotation serves not only as an agronomic strategy but also as a form of ecological efficiency in agricultural production systems.

Eco-friendly design also includes the utilization of organic waste from the soybean plants themselves. Leftover leaves, stems, and other unused plant parts can be processed into compost or organic fertilizer through natural decomposition processes or the use of simple technologies such as shredding. This utilization not only reduces agricultural waste, but also returns nutrients to the soil, thus creating a more closed and sustainable nutrient cycle.

Principles of Reuse

Soybean management from a circular economy perspective can be seen concretely through the reuse of production byproducts, both at the cultivation and processing stages. Agricultural waste such as straw and soybean crop residues can be reused as compost to improve soil fertility or as animal feed, thus avoiding waste and remaining in the production cycle. During the processing stage, soybean dregs (okara) produced from the tofu and tempeh production process also have significant potential for reuse as alternative food ingredients, processed product mixes, and animal feed. They can even be developed as raw materials for food-based creative industries.

Other parts of soybeans often considered waste can also be reused innovatively. Soybean bran, for example, can be processed into culinary dishes based on soybean meal, which has

economic and nutritional value, expanding the community's consumption. Furthermore, young soybean leaves also have value as a local food ingredient, such as in the signature dish pecok katel, a culinary icon of Majalengka Regency. This utilization of soybean leaves demonstrates that almost all parts of the soybean plant can be utilized optimally.

The principle of reuse in soybean management in Majalengka not only contributes to waste reduction but also encourages product diversification, increased economic value, and the preservation of local wisdom. This approach also strengthens the implementation of a sustainable agricultural system that aligns with the concept of a circular economy, where no resource is wasted without reuse.

Recycling Aspect

The concept of recycling plays a crucial role in supporting a circular economy system for soybean management in Majalengka Regency. Organic waste generated from soybean cultivation and processing, such as stalks, roots, and leaves, can be recycled into compost or liquid organic fertilizer, which can then be reused in agricultural production. The use of simple technology, such as a chopper, allows soybean plant residues to be chopped into smaller pieces, accelerating the decomposition process and improving the quality of the resulting organic fertilizer. This not only reduces agricultural waste but also naturally improves soil fertility.

Liquid waste from soybean processing industries, such as tofu and tempeh production, can be treated using biofilter technology or simple wastewater treatment plants to reduce environmental pollution before being reused, for example, as liquid fertilizer or limited irrigation water. Furthermore, soybean plant residues not used as fertilizer, such as old leaves and dried plant parts, can be recycled as animal feed, thus retaining their value within an integrated agricultural system.

The application of recycling principles to soybean management in Majalengka has created a more efficient production cycle, reduced dependence on external inputs, and strengthened environmental sustainability. This approach also encourages integration between the agricultural and livestock sectors into a mutually supportive system.

Closed System Aspect

The implementation of a closed system in soybean management in Majalengka Regency aims to establish a production cycle that minimizes waste, is efficient, and sustainable, where every output from one process is reused as an input in other processes. This approach emphasizes integration between sectors, particularly agriculture, livestock, and the processing industry, thus creating an interconnected production ecosystem that produces no waste.

This system begins with soybean cultivation on agricultural land. Unused plant residues, such as stems, roots, and leaves, are processed through shredding and composting into organic fertilizer that is returned to the land to improve soil fertility. The soybean harvest is then processed by home and small-scale industries into products such as tofu, tempeh, and Majalengka's signature soy sauce. This process produces solid waste in the form of soybean pulp (okara) and liquid waste.

Solid waste, such as soybean pulp, is used as animal feed or reprocessed into alternative food products. Meanwhile, liquid waste from the production process can be processed through simple installations such as biofilters or fermentation to become liquid organic fertilizer. This interconnectedness extends to the livestock sector, where livestock consuming soybean waste produce

manure that is then processed into manure or biogas. This manure is then reused on soybean farms, thus closing the entire production cycle.

This closed-loop system can also be strengthened by optimally utilizing other parts of the soybean plant, such as the husk, which is processed into culinary products based on soybean meal, and the young leaves, which are used as ingredients in local specialties like pecok katel. Thus, almost all parts of the soybean plant have utility value within a single, integrated system.

The implementation of this closed-loop system offers various benefits, including increasing resource efficiency, reducing dependence on external inputs such as chemical fertilizers, lowering production costs, and mitigating environmental pollution. Furthermore, this system contributes to creating added economic value through product diversification and the development of waste-based businesses. Therefore, support from appropriate technology, strong farmer institutions, and policies that encourage sector integration are needed to ensure the optimal and sustainable operation of the closed-loop soybean management system in Majalengka.

Integration of Sustainable Food Security and Circular Economy Policies in Soybean Commodities

The integration of sustainable food security and circular economy policies for soybeans in Majalengka Regency can be analyzed through a policy systems approach encompassing four main dimensions: policy framework, subsystem involvement, policy objectives, and policy instruments. This approach is crucial to ensure that soybean management focuses not only on increased production but also on resource efficiency, waste reduction, and environmental and local economic sustainability.

Policy Framework Aspects

The integration of food security and the circular economy can be understood as an effort to align the four pillars of food security (availability, accessibility, utilization, and stability) with the principles of the circular economy (reduce, reuse, recycle, and a closed-loop system). In the Majalengka context, soybean development policies need to be directed not only at increasing planting area and productivity, but also at designing environmentally friendly production systems, reusing agricultural and processing waste, and creating a closed production cycle. This framework positions soybeans as a strategic commodity that is managed in an integrated manner from upstream to downstream with a sustainable approach.

Subsystem Involvement Aspect

The implementation of this policy involves various interconnected actors and sectors. The upstream subsystem includes farmers, seed suppliers, and extension institutions, which play a role in soybean production based on environmentally friendly practices. The downstream subsystem involves processing industry players such as tofu, tempeh, and soy sauce producers, as well as small and medium enterprises developing soybean derivative products. Furthermore, there are supporting subsystems such as local governments, research institutions, financial institutions, and markets that function as facilitators, regulators, and catalysts for innovation. Integration between these subsystems is key to creating an effective circular economic system, as waste from one subsystem can be utilized by another.

Policy Objective Perspective

This integration aims to achieve sustainable food security by increasing the availability and access to soybeans, while simultaneously encouraging efficient resource use and waste reduction. Specifically, these objectives include increasing productivity and stability of soybean production, strengthening added value through product diversification, reducing dependence on imports, and improving the welfare of farmers and businesses. Furthermore, this policy aims to maintain environmental sustainability by reducing the use of synthetic chemicals, optimal waste management, and implementing a closed-loop production system.

Policy Instrument Aspects

Implementing this integration requires a combination of regulatory, economic, and educational instruments. Regulatory instruments can take the form of regional regulations that encourage the development of sustainable agriculture and circular economy-based waste management. Economic instruments include providing incentives for farmers and businesses implementing environmentally friendly practices, subsidizing organic inputs, and financial support for waste management innovations and soybean product diversification. Meanwhile, educational instruments include extension, training, and technical assistance to increase the capacity of farmers and businesses to apply circular economy principles. Furthermore, institutional strengthening and partnerships between actors are also essential components of policy instruments to ensure sustainable implementation on the ground.

The integration of sustainable food security and circular economy policies for soybeans in Majalengka Regency requires a systemic and collaborative approach. The successful implementation of this policy is crucially determined by synergy between actors, policy consistency, and the ability to adapt technological innovations and sustainable practices. Thus, soybeans serve not only as a food commodity but also as part of a sustainable and competitive local economic system.

CONCLUSION

Majalengka Regency has strong and strategic potential for soybean commodity development as part of a sustainable food security system and regional economic strengthening. Theoretically, this is supported by the region's comparative advantage, agro-ecosystem suitability, and the relatively developed social capital and farmer institutions. However, based on an analysis of the four pillars of food security, several fundamental challenges remain, particularly in terms of fluctuating availability, unequal accessibility due to economic and distribution constraints, limited utilization of traditional products, and vulnerability to climate change and limited post-harvest systems. These conditions indicate that soybean management in Majalengka has not yet fully achieved a resilient and sustainable food system, necessitating more integrated and adaptive policy interventions. From a circular economy perspective, soybean management in Majalengka offers significant opportunities for development through the application of environmentally friendly design principles, reuse, recycling, and closed systems. This integration conceptually improves resource efficiency, reduces waste, and creates economic added value through product diversification and the utilization of agricultural waste. Practically, the implementation of this system can strengthen the linkages between the agricultural, livestock, and processing sectors within a single sustainable production cycle. However, the successful implementation of a circular

economy depends heavily on technological readiness, human resource capacity, and consistent institutional and policy support. The integration of sustainable food security and circular economy policies for soybeans in Majalengka requires synergy between a comprehensive policy framework, coordinated subsystem involvement, clear and measurable policy objectives, and effective policy instruments. Local governments play a key role in formulating regulations, providing incentives, and facilitating collaboration between stakeholders. Meanwhile, farmers, businesses, and communities need to be encouraged to adopt sustainable innovations and practices through educational and empowerment approaches. Soybean development is not only oriented towards increasing production but also towards transforming the food system towards a sustainable, inclusive, and circular economy-based model.

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