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Agroecology and Bioeconomy Strategies for Overcoming Challenges in Shallot Green Agriculture Practice Adoption

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ABSTRACT

This research investigates the dynamics of farmer perceptions regarding adopting agroecology and bioeconomy systems in shallot farming, mainly focusing on the associated benefits, challenges, and influencing factors. The study identifies a critical research gap in understanding the nuanced motivations and concerns that shape farmers' decisions to transition to agroecology and bioeconomy systems, offering a comprehensive exploration of the economic, environmental, and regulatory dimensions. The problem formulation addresses the multifaceted considerations involved in this transition, highlighting farmers' apprehensions about initial investment, technical knowledge requirements, and potential risks associated with adopting biotechnologies. The novelty of this research lies in its nuanced examination of the bioeconomy's potential economic benefits, environmental sustainability, and regulatory incentives, providing a holistic understanding of the complex interplay between motivations and barriers. The research purposes encompass a dual focus on uncovering the motivations propelling farmers towards bioeconomy adoption, such as economic profitability and environmental sustainability, and the inhibiting factors, including perceived risks and knowledge gaps. Surveys, interviews, and observations are used to explore farmer perspectives using a mixed-methods approach. The research results reveal diverse perspectives, with a majority acknowledging the long-term benefits of agroecology and bioeconomy systems, yet variations in experiences and challenges faced during adoption. The findings shed light on the economic, environmental, and knowledge-based considerations influencing farmer decisions, providing valuable insights for policymakers, practitioners, and researchers aiming to facilitate the widespread adoption of sustainable agricultural practices.

KEYWORDS:

agricultural decision-making; biotechnology adoption; environmental conservation; farming practices; sustainable agriculture

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INTRODUCTION

In Indonesia, a discernible surge in demand for green agricultural practices has emerged in recent years, propelled by environmental consciousness, the imperative for sustainable food production, and a collective aspiration to mitigate the adverse effects of conventional farming methods. This burgeoning demand underscores a societal commitment to minimize reliance on synthetic inputs, conserve precious natural resources, and foster ecological equilibrium. However, adopting these green agricultural practices for shallot cultivation encounters challenges, necessitating a nuanced understanding of impediments to aligning sustainable practices with Indonesia's evolving agrarian landscape (Sukayat et al., 2023).

Adopting agroecology and bioeconomic strategies in shallot green agriculture practices faces multifaceted challenges. A pervasive lack of awareness regarding the manifold benefits associated with these approaches inhibits their widespread embrace (Slayi et al., 2023). Additionally, farmers encounter hurdles in accessing requisite resources and support crucial for implementing agroecological practices. Prevailing resistance rooted in traditional agricultural methodologies and an entrenched reluctance to embrace change exacerbates the issue (Mudekhere et al., 2023). Economic impediments, typified by substantial initial investment costs and unpredictable returns, hinder the transition (Naidoo, 2020). Furthermore, a dearth of knowledge and training on agroecological principles persists among farmers, impeding the integration of sustainable practices (Achmad et al., 2022). The existing inadequacy in infrastructure for the processing, distribution, and marketing of agroecological products adds a layer of complexity to the overall challenge, underscoring the need for comprehensive interventions to foster sustainable agricultural practices in shallot cultivation (Mariyono et al., 2020).

Agroecology and bioeconomy jointly aspire to revolutionize agricultural systems by integrating ecological principles and sustainable economic strategies (Agus et al., 2021). In the context of shallot green agriculture, adopting these approaches can effectively address challenges by fostering ecological balance, optimizing resource utilization, and promoting social equity (Marchetti et al., 2020). With its focus on plant, animal, human, and environmental interactions, agroecology can help build resilient farming systems (Altieri & Nicholls, 2020). Concurrently, bioeconomy strategies leverage renewable biological resources for food, materials, and energy production, creating a more sustainable agricultural sector (Fava et al., 2021). The synergistic application of these frameworks holds promise in advancing environmentally conscious and economically viable practices, thereby enhancing the viability of shallot green agriculture (Das et al., 2022).

The impediment posed by resistance to change among farmers in adopting innovative agricultural practices is a multifaceted challenge. This resistance to agrarian reform is rooted in cultural norms, risk aversion, and a deep fear of disrupting farming systems (Lucas, 2021). Preserving traditional methods, often deeply embedded in cultural practices, engenders a reluctance to depart from established norms (Anderson & Maughan, 2021). Simultaneously, farmers' aversion to risks, influenced by economic considerations and uncertainties, further solidifies their resistance to embracing new methodologies (Li & Li, 2022). The fear of potential disruptions underscores the need for targeted interventions that address these psychological and contextual factors, facilitating a more seamless transition to progressive and sustainable farming practices (Baur, 2020).

A comprehensive approach encompassing biotechnological, economic, social, and environmental dimensions is imperative in navigating the challenges associated with adopting sustainable practices in shallot green agriculture (Barañano et al., 2021). Strategic investment in research and development tailored to shallot cultivation is essential to address biotechnological hurdles, focusing on genetically modified varieties resistant to prevalent pests and diseases (Khar et al., 2020). Simultaneously, fostering awareness and understanding among farmers through targeted training programs is crucial for mitigating resistance to biotechnological solutions (Egea et al., 2021). On the economic front, creating market incentives, ensuring access to financial support, and exploring value-added opportunities contribute to the economic viability of sustainable shallot production (Tinaprilla et al., 2022). Social factors necessitate awareness campaigns, farmer networks, and community engagement to promote the social benefits of shallot green agriculture (Martini et al., 2023). Environmentally, promoting sustainable practices, agroecological approaches, and conservation initiatives emerge as pivotal strategies to minimize environmental impacts and ensure the long-term ecological resilience of shallot cultivation (Bellone et al., 2023). This holistic approach addresses the multifaceted challenges, fostering a more sustainable and resilient shallot green agriculture paradigm.

The fusion of agroecology and bioeconomy principles emerges as a potent strategy for overcoming shallot green agriculture adoption challenges, concurrently fostering environmental stewardship and economic prosperity (Leff, 2021). Central to this approach is promoting agroecological practices, encompassing crop rotation, intercropping, agroforestry, and biological pest control (Patel et al., 2020). These practices bolster soil health, biodiversity, and ecosystem services while mitigating reliance on synthetic inputs (Yadav et al., 2023). Facilitating knowledge exchange through farmer networks and platforms enhances the dissemination of agroecological practices (Richardson et al., 2022). Additionally, bioeconomy strategies targeting sustainable inputs, market incentives, and policy support further fortify the foundation for sustainable shallot production, aligning agricultural practices with ecological resilience and economic viability.

The research addresses the formulation of a problem within the shallot green agriculture adoption domain, seeking to develop strategies rooted in agroecology and bioeconomy principles. The primary purpose of the writing is twofold: to craft an agroecology strategy and a bioeconomy strategy to encourage the adoption of environmentally friendly shallot farming systems. The research novelty lies in its timeliness, addressing the burgeoning interest in shallot green agriculture due to its perceived environmental and health benefits. A distinctive aspect is the amalgamation of two promising approaches, agroecology and bioeconomy, offering complementary pathways toward sustainable agriculture. The research's strength is its focus on adoption barriers, recognizing their pivotal role in the success of agricultural innovations. However, areas for improvement include the lack of specificity in addressing particular challenges, potential redundancy in the term "green agriculture," and the need for contextual details, such as the specific region or shallot variety under consideration. To improve the research contribution, adopt a more explicit and focused title that clearly states the difficulties and potential solutions. Research limitations may arise from the scope of the study, necessitating clear delineation of the research boundaries to ensure the validity and generalizability of findings.

METHODOLOGY

The fundamental research methods employed in this study encompass case studies and explanations. The determination method is rooted in elucidating intricate phenomena through detailed examinations of individual cases and comprehensive explanations to derive overarching insights (Sarkar & Shukla, 2023). The synergy of these methods offers distinct advantages, enabling a nuanced exploration of complex phenomena and facilitating a complete understanding that extends beyond isolated instances, thereby enhancing the robustness and depth of the research findings (Daniel et al., 2022).

The research employs a purposive method for selecting the study locations, specifically focusing on three critical red shallot production centers in Central Java: Brebes, Demak, and Boyolali. Deliberate and intentional selection criteria underpin the determination of these locations. This purposive approach allows for a targeted investigation (Campbell et al., 2020) into regions integral to red shallot production, ensuring the research's relevance and applicability. The advantages of this method lie in its strategic selection, enabling a focused exploration of areas critical to the study's objectives (Cash et al., 2022). Thorough literature reviews and preparatory surveys have been included to reduce errors and improve research precision and dependability (Aslam et al., 2021).

Table 1. Sample research data

No	Regency and District	Village	Respondents
1	Brebes, Wanasari	Jagalempeni	30
2	Brebes, Larangan	Larangan	20
3	Demak, Mijen	Pasir	30
4	Demak, Karanganyar	Magersari	20
5	Boyolali, Cepogo	Jerukan	30
6	Boyolali, Cepogo	Gedangan	20

Source: Observation data (2023)

As indicated in **Table 1**, the total number of respondents is 150. This comprehensive selection aims to provide a holistic overview of perceptions pertinent to formulating agroecology and bioeconomy strategies for red shallot cultivation. The substantial respondent pool ensures a robust and nuanced understanding of diverse perspectives (Salmiah et al., 2024), contributing to the efficacy and relevance of the strategy devised for cultivating red shallots.

The research employs a simple random sampling method to determine respondents, with the selection criteria based on production levels in two sub-districts within each district. This method involves randomly selecting respondents from different villages, with a deliberate allocation of 30 respondents in the first village and 20 respondents in the second village, aiming for a representative sample. The significance of using this method lies in its ability to ensure unbiased representation and generalizability of findings across diverse production levels (Zhao, 2021). By incorporating production as the basis for respondent selection, the research not only enhances its external validity but also attains the benefits of randomness (Yang et al., 2023), minimizing potential biases and yielding a sample that accurately reflects the larger population under investigation (Wiśniowski et al., 2020).

Data collection methods encompass surveys, interviews, and observation, with interviews conducted through questionnaires. The survey involves systematic inquiries, while interviews delve deeper into insights, ensuring a comprehensive data set (Johnson et al., 2020). Observation captures real-time situational nuances (Pryce et al., 2021). The structured questionnaire format employed in interviews enhances precision and standardization. This methodological triad facilitates a thorough examination, yielding rich, multifaceted data essential for the research's robustness and reliability.

RESULT AND DISCUSSION

Agroecology, centered on comprehending the intricate interactions among plants, animals, humans, and the environment, aims to cultivate resilient farming systems (Barrios et al., 2020). In parallel, bioeconomy strategies pivot on utilizing renewable biological resources for food, materials, and energy production, fostering a more sustainable agricultural sector (Faucon et al., 2023). The synergy of agroecology and bioeconomy principles presents a holistic approach to shallot green agriculture adoption. This amalgamation not only aids farmers in surmounting obstacles but also champions environmental stewardship and economic prosperity (Mrabet, 2023).

By integrating these frameworks, a harmonious balance is struck, fortifying the agricultural landscape and propelling the adoption of sustainable practices in shallot cultivation.

3. 1. Agroecological Strategy Approach

The philosophy of agroecology, which emphasizes understanding the complex relationship between plants, animals, people, and the environment, can be used as a basic framework for developing resilient farming systems (Cradock-Henry, 2021). According to Javadinejad et al. (2021), this approach prioritizes a holistic understanding of ecological relationships to enhance the sustainability and adaptability of agricultural practices. The agroecological strategy for shallot cultivation embodies a comprehensive system that emulates natural processes, emphasizing environmental sustainability. Key practices involve prioritizing soil health through composting, cover cropping and reduced tillage (Yang et al., 2020). Biodiversity is enhanced through intercropping, companion planting, and habitat preservation, fostering natural pest control (Cloyd, 2020). Water management employs efficient irrigation and drainage methods, while additional practices include crop rotation, seed selection, and waste minimization (Koropeckyj-Cox et al., 2021). The benefits encompass reduced environmental impact, increased resilience, improved crop quality, and potential economic gains (Zabala et al., 2023). However, challenges such as initial investments, the need for new knowledge and skills, and limited market recognition pose considerations for farmers (Karunathilake et al., 2023). This agroecological approach was a promising paradigm for cultivating shallots, aligning environmental conservation with agricultural productivity.

3. 1. 1. Agroecological Systems Effectiveness Perception

Table 2. Perception of various agroecological systems' efficacy and easiness in greening shallot farming

No	Statement	Agree	Disagree
1	Use of cover crops to improve soil health and prevent erosion.	59,33%	40,67%
2	Crop rotation to maintain soil fertility and reduce pest and disease pressure.	82,00%	18,00%
3	Integration of livestock for natural fertilizer production and weed control.	52,67%	47,33%
4	Implementation of agroforestry systems for biodiversity enhancement and microclimate regulation.	32,00%	68,00%
5	Adoption of organic farming practices to minimize the use of synthetic inputs.	72,00%	28,00%
6	Promoting water conservation through efficient irrigation methods such as drip irrigation or rainwater harvesting.	36,67%	63,33%
7	Ecological pest management techniques such as biological control, trap cropping, and crop diversification are utilized.	77,33%	22,67%

Source: Primary data (2023)

Positive perceptions and the ease of adoption of agroecological practices among shallot farmers are influenced by key factors identified through observation. Environmental awareness, particularly regarding soil health and biodiversity, makes farmers more receptive to agroecology as an alternative to resource-intensive practices. Previous experience with traditional ecological knowledge enhances adaptability to agroecological principles (Irawan, 2023). The scale of the farm matters, with smaller farms finding it easier to implement agroecological practices due to increased flexibility. Supportive community environments, including knowledge-sharing platforms, offer valuable resources. Financial incentives, such as subsidies, further enhance the appeal of agroecological practices among shallot farmers.

The challenges and negative perceptions associated with adopting agroecological practices among shallot farmers are multifaceted. A fundamental obstacle arises from knowledge and skill gaps, where a lack of awareness hinders widespread adoption. Limited access to crucial resources, including organic inputs and agroecology-adapted seeds, compounds the issue, especially in specific regions. The substantial initial investment costs in infrastructure and training present a significant barrier, particularly for financially constrained farmers. Resistance to adopting agroecology stems from concerns about labor intensity, market uncertainties, and societal pressure favoring conventional farming approaches.

The utilization of cover crops for enhancing soil health and preventing erosion within the agroecological framework garnered mixed perceptions among respondents. While 59.33% agreed on its effectiveness, 40.67% expressed disagreement. Observations and interactions with respondents revealed the intricate landscape of convenience, problems, and challenges associated with implementing this agroecological system. These encompassed the need for suitable cover crops aligned with specific agroecological conditions, managing concurrent growth with main crops, balancing implementation costs against potential benefits, and the imperative of educating and training farmers on optimal practices. These findings resonate with prior research by Rudiarto et al. (2020), aligning with the complexities inherent in integrating cover crops for soil improvement within diverse agricultural contexts.

Adopting crop rotation within the agroecological strategy to sustain soil fertility and mitigate pest and disease pressure garnered positive responses, with 82% of respondents agreeing and 18% expressing disagreement. Observational insights elucidate both the convenience and challenges inherent in implementing this system. Crop rotation, involving the sequential cultivation of different crops on the same land, aligns with broader agroecological practices, including intercropping and biological pest control, fostering sustainability. Embracing green practices, such as using organic fertilizers and minimizing chemical inputs, aligns with the holistic approach to shallot farming, considering soil requirements, climate suitability, and market demand. While integrating agroecological strategies into shallot farming offers benefits like improved soil health, challenges include initial transition costs, potential yield fluctuations, and labor demands for managing diverse cropping systems. This result resonates with research by Tiemann and Douxchamps (2023), emphasizing the multifaceted nature of implementing agroecological practices in enhancing sustainable agricultural systems.

The integration of livestock for natural fertilizer production and weed control within the agroecological strategy yielded a nuanced response, with 52.67% of respondents in agreement and 47.33% expressing disagreement on its perceived effectiveness and ease of adoption. Observational insights reveal the advantages and challenges of implementing this system in shallot farming. The integration of livestock, serving as a sustainable approach to reduce synthetic inputs and enhance biodiversity, faces challenges such as high initial investment costs, the need for expertise in agroecological principles, and potential resistance from conventional farming practices. While agroecology strategies in shallot farming offer long-term benefits like improved soil health and decreased external input dependency, challenges include an initial yield decrease, management complexity, and potential market uncertainties. These findings align with research by Farias et al. (2020), emphasizing the multifaceted considerations inherent in integrating livestock for agroecological purposes in shallot farming.

Implementing agroforestry systems for biodiversity enhancement and microclimate regulation encountered a notable divergence in respondent perceptions, with 32% agreeing and 68% expressing disagreement on its perceived effectiveness and ease of adoption in shallot farming. Observational insights reveal complexities surrounding the convenience and challenges of integrating agroforestry systems. Despite the potential benefits of enhanced biodiversity and microclimate regulation, challenges include low perceived convenience, marked by resistance among respondents. Interestingly, this dissenting view contradicts findings from research by Burgess et al. (2022), emphasizing the need for further exploration and context-specific understanding to reconcile varying perspectives on incorporating agroforestry systems in shallot farming within the agroecological framework.

The adoption of organic farming practices within the agroecological strategy, aimed at minimizing synthetic inputs, resonated positively among respondents, with 72% in agreement and 28% expressing disagreement on its perceived effectiveness and ease of adoption in shallot farming. Observational insights underscore both the convenience and challenges associated with incorporating these practices. Adopting agroecology strategies in shallot farming, featuring green practices like crop rotation, composting, and biological pest control, strives for sustainability and environmental conservation. While these practices offer potential benefits such as boosted soil fertility and improved crop resilience, challenges persist, including initial investment costs, knowledge transfer, and market access hurdles for organic produce. This result aligns with research by Mandal et al. (2021), highlighting the multifaceted considerations and potential benefits of embracing agroecology strategies, particularly in promoting sustainability and minimizing environmental impact within shallot production.

From the findings presented in Table 2, the agroecological strategy of promoting water conservation through methods like drip irrigation or rainwater harvesting faced significant challenges, with 63.33% of respondents expressing disagreement. Financial barriers, including upfront costs and ongoing maintenance, posed challenges for smallholder farmers with limited resources and restricted access to credit. Knowledge gaps, skepticism, and traditional practices hindered adoption, while infrastructure issues like inconsistent water supply and a lack of markets for used equipment added complexity. Policy-related challenges included subsidies favoring conventional methods. Land tenure insecurity and labor availability further compounded adoption difficulties. Notably, this research diverges from Abdallah et al. (2021), emphasizing unique contextual obstacles in implementing water conservation strategies for shallot farming.

Ecological pest management techniques, encompassing biological control, trap cropping, and crop diversification, garnered strong agreement from 77.33% of respondents. In comparison, 22.67% expressed disagreement regarding its perceived effectiveness and ease of adoption in shallot farming. Observational insights reveal both the conveniences and challenges associated with implementing these techniques. On the positive side, these techniques reduce reliance on chemical pesticides, promote environmental sustainability, offer long-term effectiveness, and contribute to crop protection through diversification. However, challenges include the complexity and knowledge requirements for implementation, site-specific considerations, integration with conventional practices, economic viability concerns, the potential for resistance and adaptation among pests, and the influence of scale and agricultural context. These findings align with research by Fahad et al. (2021), emphasizing the multifaceted considerations involved in adopting ecological pest management techniques within agroecological strategies, particularly in shallot farming.

3. 1. 2. Agroecological Systems Benefit Perception

Agroecological strategies benefit shallot producers, including mulching, intercropping, and post-harvest residue (Manzeke-Kangara et al., 2023). According to Milheiras et al. (2022), these behaviors boost livelihood-generating activities, natural access, and livestock ownership. Agroecology promotes biodiversity, ecological services, and responsible resource use, promoting environmental sustainability (Raj et al., 2021). It promotes crop diversification and challenges industrial farming by easing farm transitions (Rodriguez et al., 2021). Agroecological systems contribute to climate change resilience by sequestering carbon and offering mitigation and adaptation options (Snapp et al., 2023). Shallot farmers' well-being, environmental stewardship, farm diversification, and climatic resilience depend on how agroecological systems are seen.

The diverse perspectives among shallot farmers on the benefits of agroecological systems (AES) emerge from a complex interplay of factors. Individual farm dynamics, including size, available resources, and existing practices, influence the willingness to embrace AES, with larger farms potentially more open to experimentation. Local conditions such as soil quality and water availability further shape farmers' perceptions, as those with naturally fertile land may be less inclined to adopt AES. Knowledge and understanding, driven by information access and training, play a pivotal role; farmers with better insights into AES principles are more likely to view them positively. Economic considerations, influenced by market access and government policies, contribute to divergent perspectives, with the potential for long-term economic benefits sometimes outweighed by immediate incentives. Social and cultural influences, encompassing community norms and cultural attitudes towards risk, significantly impact the adoption of AES. Finally, the specifics of the implemented AES, including complexity, management requirements, and the visibility of immediate benefits, further shape farmers' attitudes and adoption decisions.

Table 3. Farmers' perception of the agroecological system's benefits in green shallot farming

No	Statement	Agree	Disagree
1	I perceive agroecology systems as a sustainable and environmentally friendly approach to farming.	84,67%	15,33%
2	I see agroecology as a way to improve soil health and fertility while reducing the reliance on synthetic inputs.	39,33%	60,67%
3	I believe that agroecology can contribute to biodiversity conservation and ecosystem resilience.	52,67%	47,33%
4	I perceive agroecology as a means to enhance food security and promote local food systems.	62,00%	38,00%
5	I view agroecology as a way to mitigate the impacts of climate change on agricultural production.	54,67%	45,33%

Source: Primary data (2023)

Farmers overwhelmingly perceive agroecology systems as a sustainable and environmentally friendly approach to green shallot farming, with 84.67% of respondents agreeing and only 15.33% disagreeing, according to **Table 3**. The positive farmer perception aligns with research findings by Kareem et al. (2022), reinforcing the acknowledged benefits of agroecological practices. These include increased biodiversity on the farm, enhanced soil health and fertility, reduced reliance on chemical inputs, improved resilience to climate change, and better utilization of natural resources. Such perceptions highlight the recognition among farmers of the multifaceted advantages associated with adopting agroecological systems in green shallot farming. This alignment with existing research underscores the importance of promoting sustainable and environmentally friendly farming practices in the agricultural landscape, fostering a holistic and resilient approach.

While 39.33% of shallot farmers acknowledge agroecology to enhance soil health and fertility while reducing reliance on synthetic inputs, 60.67% disagree, as per **Table 3**. This research diverges from th findings of De Corato et al. (2024), suggesting a nuanced perception among shallot farmers regarding the benefits of agroecological systems. The farmers who agree emphasize the positive impacts of agroecological practices, including enhanced soil structure, increased organic matter, and minimized synthetic input dependency. These perceptions align with agroecology principles, emphasizing ecological processes for sustainable agriculture. The notable divergence in opinions underscores the need for context-specific investigations, considering the variability in farmers' perspectives on the agroecological benefits of shallot farming. This nuanced understanding is crucial for tailoring strategies that effectively promote sustainable practices and address the concerns of shallot farmers, ultimately fostering more widespread adoption.

This research aligns with the findings by Amoak et al. (2022), indicating a consensus among shallot farmers on the potential benefits of agroecology for biodiversity conservation and ecosystem resilience. The data from **Table 3** demonstrates that 52.67% of respondents agree that agroecology contributes to these aspects. Shallot farmers acknowledge the positive impacts of agroecological practices such as crop diversification and habitat creation in supporting biodiversity. The perceived advantages extend to natural pest control, recognizing the role of beneficial organisms in reducing the need for chemical pesticides. Furthermore, farmers acknowledge that agroecology enhances ecosystem resilience through diverse farming practices, contributing to improved soil health, water management, and nutrient cycling. The alignment of perceptions emphasizes the significance of agroecological strategies in shallot farming for both ecological and agricultural benefits.

This research aligns with the findings by Ewert et al. (2023), underscoring the consensus among shallot farmers regarding the perceived benefits of agroecology in enhancing food security and promoting local food systems. The data from **Table 3** indicates that 62% of respondents agree that agroecology serves to achieve these objectives. Shallot farmers recognize the role of agroecological practices, particularly crop diversification and ecological pest management, in fostering diverse and resilient food production systems. Reducing external input dependency is advantageous, contributing to increased self-sufficiency in farming. Moreover, farmers acknowledge the emphasis of agroecology on local and regional food systems, viewing it as an opportunity to strengthen local markets, preserve traditional knowledge, and engage communities in participatory decision-making. The alignment of perceptions emphasizes the multifaceted benefits of agroecology, positioning it as a holistic approach to ensuring food security, sustainability, and community empowerment.

This research concurs with the findings by Rahman and Anik (2020), as shallot farmers overwhelmingly perceive agroecology as a potent strategy to mitigate the impacts of climate change on agricultural production. The data from Table 3 reveals that 54.67% of respondents agree. Shallot farmers recognize agroecology's role in climate change adaptation by promoting resilient farming practices such as crop diversification and ecological pest management. These practices enhance the adaptive capacity of farming systems, addressing challenges associated with extreme weather events, shifting growing seasons, and emerging pest and disease patterns. Additionally, agroecology contributes to climate change mitigation by facilitating carbon sequestration in the soil, thereby reducing greenhouse gas emissions. Sustainable resource management practices embedded in agroecology, including efficient water use and reduced reliance on synthetic inputs, align with climate change mitigation efforts. Furthermore, providing ecosystem services by agroecological systems supports the overall resilience of agricultural ecosystems to climate change impacts, reinforcing the comprehensive role of agroecology in climate change adaptation and mitigation.

3. 2. Bioeconomic Strategy Approach

The Bioeconomic Strategy Approach constitutes an economic strategy involving utilizing biological resources and biotechnology in producing goods and services (Wei et al., 2022). Bioeconomics is a field of study that encompasses the production and usage of food, feed, and non-food items (Callo-Concha et al., 2020). Its primary objective is to promote sustainable economic growth by generating job opportunities and promoting the exploitation of sustainable biological resources (Fava et al., 2021). Its primary aim is to promote a sustainable economy, generating employment while optimizing the sustainable use of natural resources (Miao et al., 2022).

3. 2. 1. Bioeconomy Systems Effectiveness Perception

Bioeconomy strategies present significant advantages for shallot commodities, offering environmental sustainability and economic prosperity (Saptana et al., 2021). Environmentally, these strategies reduce reliance on synthetic inputs, fostering a cleaner production system and protecting soil health (Tahat et al., 2020). Circular economy principles emphasizing water conservation lead to increased resource efficiency and reduced water consumption (Borghi et al., 2020). Diversifying farming practices under bioeconomy initiatives creates ecological habitats, enhances biodiversity, and promotes natural pest control (Yadav et al., 2023). Furthermore, implementing carbon sequestration practices mitigates the impact of agriculture on climate change (Sun et al., 2020). Economically, bioeconomy strategies provide premium pricing opportunities for sustainably produced shallots, diversification into biobased products for additional revenue streams, improved market access, and reduced production costs (D'Adamo et al., 2021). Additionally, empowering farmers through knowledge and skills enhancement and creating green jobs contribute to rural development (Ravazzoli et al., 2021). However, addressing challenges such as market infrastructure, consumer awareness, investment needs, and policy support is crucial for successfully implementing and adopting bioeconomy strategies in shallot farming (D'Adamo et al., 2021).

Table 4. Perception of various bioeconomy systems' efficacy and easiness in greening shallot farming

No	Statement	Agree	Disagree
1	Implementing agroecological practices such as crop rotation and intercropping to enhance soil health and biodiversity.	84,00%	16,00%
2	Adopting precision farming techniques for efficient use of resources, including water, fertilizers, and pesticides.	32,00%	68,00%
3	Incorporating renewable energy sources such as solar power for sustainable energy supply on the farm.	24,00%	76,00%
4	Utilizing organic farming methods to reduce reliance on synthetic chemicals and promote ecological balance.	90,00%	10,00%
5	Investing in developing innovative biobased products from shallots for diversified revenue streams.	44,00%	56,00%
6	Participating in carbon offset programs or implementing carbon sequestration practices to mitigate greenhouse gas emissions from farming activities.	36,00%	64,00%
7	Engaging in partnerships with local communities or organizations to promote environmental stewardship and conservation efforts related to shallot farming.	70,00%	30,00%
8	Developing sustainable packaging solutions using biodegradable materials or recyclable packaging options for shallot products.	48,00%	52,00%

Source: Primary data (2023)

The farmer perceptions gathered from **Table 4** underscore a widespread agreement on the efficacy and feasibility of implementing agroecological practices, specifically crop rotation and intercropping, to enhance soil health and biodiversity in shallot farming. The observations and interviews reveal that adopting these bioeconomy systems provides numerous economic conveniences, including improved soil health, reduced reliance on synthetic fertilizers, natural pest and disease management, and diversified income streams through multiple-crop cultivation. However, challenges emerge in the form of limited knowledge and awareness among farmers, difficulties in accessing essential resources, uncertainties in market demand and pricing, and the necessity for robust policy and regulatory support to encourage sustainable agricultural practices. These findings corroborate with Beillouin et al. (2021) research, reinforcing the importance of addressing these challenges for successful bioeconomy adoption in shallot farming.

The results from **Table 4** indicate a notable divergence in farmer perceptions regarding the efficacy and ease of adopting precision farming techniques for greening shallot farming. While 32% of respondents agreed, 68% disagreed with the viability of this bioeconomy system. Economic considerations, derived from observations and interviews, suggest that precision farming offers substantial conveniences, such as optimized resource utilization leading to cost reduction, improved crop yields, and reduced environmental impact. However, formidable challenges include technological barriers due to the need for advanced equipment, high initial investment costs, data management complexities, knowledge gaps, and the necessity for supportive policy frameworks. These findings underscore the intricate nature of adopting precision farming in shallot agriculture. Importantly, it's worth noting that this research diverges from Bolfe et al. (2020) findings, indicating a potential contrast in perspectives on precision farming's feasibility in green shallot farming.

The results from **Table 4** reveal a notable disparity in farmer perceptions regarding the efficacy and ease of incorporating renewable energy sources, such as solar power, into shallot farming practices. While only 24% of respondents agreed, 76% disagreed with the feasibility of this bioeconomy system. Economic considerations, derived from observations and interviews, indicate that incorporating renewable energy sources presents several conveniences. These include reduced energy costs, independence, and environmental sustainability through clean energy production. However, substantial challenges confront farmers looking to adopt such systems, including high initial investment costs, the need for technical expertise, intermittent energy supply concerns, regulatory barriers, and limited access to financing. This research presents a nuanced understanding of the complexities of integrating renewable energy sources into shallot farming practices. It's essential to note that these findings deviate from the perspectives presented in Kiloes et al. (2023) research, suggesting a potential divergence in viewpoints on the practicality of renewable energy adoption in the context of green shallot farming.

Table 4 highlights a strong consensus among farmers, with 90% in agreement, regarding the efficacy and ease of adopting organic farming methods for shallot cultivation to promote ecological balance and reduce reliance on synthetic chemicals. Economic considerations, drawn from observations and interviews, underscore several advantages of using organic farming methods. These include the promotion of healthier soil through practices like composting and crop rotation, leading to enhanced soil fertility and long-term productivity. Moreover, organic farming methods contribute to reduced input costs by minimizing reliance on synthetic fertilizers and pesticides, opting instead for natural alternatives like compost, cover crops, and biological pest control. Notably, the market dynamics favor organic products, commanding premium prices due to heightened consumer demand for healthier and environmentally friendly options, thereby offering economic benefits to farmers. However, challenges and obstacles in adopting organic farming methods for shallot commodities are also recognized. These challenges encompass the transitional period, where adjustments in farming practices may lead to lower yields and increased pressure from weeds or pests. Additionally, farmers face hurdles related to knowledge and training, certification and compliance processes, market access and competition, and the need for effective risk management strategies. This comprehensive analysis aligns with the findings of Hasnain et al. (2023), affirming the multifaceted nature of transitioning to organic farming and the associated economic and practical considerations in the context of shallot cultivation.

Table 4 shows that 44% of farmers supported investing in shallot biobased product research and development to diversify revenue streams, while 56% opposed it. Economic analysis of observations and interviews shows that such investments are beneficial. First, developing creative biobased items like shallot-based sauces, extracts, and cosmetics could generate additional money. These value-added products can attract niche markets prepared to pay premium pricing. Investing in R&D helps farmers differentiate their products and gain a commercial edge. Eco-conscious consumers want innovative biobased products with unique features or sustainability benefits. Finally, diversifying revenue streams with such technologies helps farmers sustain their income by minimizing their dependence on commodities markets. However, developing a bioeconomy for shallot commodities presents hurdles. The high research and development costs require farmers to budget for everything from research to product testing. Collaboration with researchers, scientists, or product development professionals may be needed for particular technical competence. Innovation in biobased goods depends on market demand and consumer acceptance, requiring market research. Compliance with safety, labeling, and marketing standards complicates matters. Once a unique product is produced, scaling up manufacturing requires infrastructure, equipment, and supply chain management investments. This research differs from Sierra et al. (2021) in the challenges and benefits of investing in shallot biobased product research and development.

Table 4 shows that 36% of farmers supported carbon offset programs or carbon sequestration to reduce greenhouse gas emissions, while 64% opposed them. Observations and interviews show that such programs offer various benefits for green shallot farming. Carbon offset schemes and carbon sequestration strategies reduce greenhouse gas emissions, reducing farmers' carbon footprint and supporting sustainable agriculture. These initiatives also provide market opportunities as consumer and industry interest in sustainable and environmentally friendly products rises. Bioeconomy and carbon offset farmers may gain new markets and higher prices. Farmers can also receive cash incentives, subsidies, and technical assistance from such initiatives to help them migrate to a bioeconomy system and adopt green agricultural methods. Despite these conveniences, adopting a bioeconomy system in green agriculture is difficult for shallot producers. One of the biggest obstacles is technical expertise. Farmers must learn new farming methods, carbon accounting methods, and complex rules and certification systems during the changeover, which takes time. Adoption requires enormous upfront costs and investments, which may hamper farmers with low funds. Farmers must also determine the demand for sustainably produced shallot goods and achieve premium market certification requirements. Finally, bioeconomy systems and carbon offset programs' varied or unclear policies make green farming techniques challenging to adopt. This study differs from Paul et al. (2023) in assessing the pros and cons of carbon offset schemes and carbon sequestration in shallot farming.

The analysis of **Table 4** reveals that 70% of surveyed farmers agree with engaging in partnerships with local communities or organizations for environmental stewardship in shallot farming, while 30% disagree. Farmers face initial hesitations, such as fear of the unknown and time constraints, addressed through open communication and workload distribution benefits. The approach emphasizes maximizing benefits, including tapping into local expertise, collaborative action for environmental challenges, and eco-friendly branding for market access. However, challenges like sharing control and unequal resource distribution require clear communication and long-term commitment. Practical steps for farmers involve networking, seeking guidance, starting small, and regular communication. This research aligns with Hill et al. (2020), emphasizing collaborative efforts and partnerships for environmental stewardship in agriculture.

The analysis of farmer perceptions on developing sustainable packaging solutions for shallot products indicates a balanced response, with 48% agreement and 52% disagreement. Concerns primarily revolve around cost implications, limited availability, technical challenges, uncertain consumer behavior, and inadequate waste management infrastructure. Mitigation strategies include subsidies, infrastructure investment, technological innovation, consumer education, and collaborative partnerships. Overcoming these challenges is vital for successfully adopting sustainable packaging in a bioeconomy. Effective dialogue and collaboration among farmers, policymakers, researchers, and the packaging industry are crucial for developing viable solutions and fostering a supportive environment. Unlike Martini et al. (2023), this study focuses on specific challenges and mitigation strategies related to sustainable packaging in shallot farming.

3. 2. 2. Bioeconomy Systems Benefit Perception

Bioeconomy systems present a promising avenue for cultivating sustainable and profitable shallot farming, with farmers' adoption decisions significantly influenced by their perceptions of benefits and challenges (Mallappa & Pathak, 2023). The motivations driving the adoption of bioeconomy systems encompass a spectrum of environmental, economic, and social factors (Stegmann et al., 2020). Farmers are drawn to the ecological benefits, such as enhanced soil health, improved water resource management, reduced pollution, and increased resilience against climate change (Doran et al., 2020). On the economic front, the allure lies in premium pricing for sustainable products, diversified income streams through intercropping or bioproduct development, reduced production costs, and improved market access (Durham & Mizik, 2021). Additionally, there are social benefits, including strengthened community collaboration, enhanced knowledge of sustainable farming practices, and the potential for rural development and poverty reduction (Castro-Arce & Vanclay, 2020). These multifaceted motivations underscore the complex interplay of factors influencing farmers' decisions in embracing or hesitating towards bioeconomy systems in shallot farming (Polimeni et al., 2022).

Table 5. Farmers' perception of the bioeconomy system's benefits in green shallot farming

No	Statement	Agree	Disagree
1	I perceive bioeconomy systems as sustainable and environmentally friendly alternatives to traditional farming practices.	78,67%	21,33%
2	I see bioeconomy systems as offering the potential for higher yields and increased profitability.	46,00%	54,00%
3	I believe that adopting bioeconomy systems can lead to reduced reliance on synthetic inputs such as fertilizers and pesticides.	81,33%	18,67%
4	I perceive bioeconomy systems as contributing to soil health and biodiversity conservation on their farms.	31,33%	68,67%
5	I may be concerned about the initial investment and technical knowledge required for transitioning to a bioeconomy system, but they also recognize the long-term benefits it can offer.	69,33%	30,67%

Source: Primary data (2023)

Adopting bioeconomy systems in shallot farming encounters several barriers that impede widespread acceptance among farmers. A fundamental challenge lies in the inadequate knowledge and awareness of bioeconomy principles and practical implementation methods, hindering informed decision-making. Access to essential resources, including organic inputs, seeds, and suitable machinery tailored for bioeconomy practices, is often limited, exacerbating farmers' difficulties. Financial concerns pose a significant obstacle, as the higher initial investment costs associated with bioeconomy practices may surpass the financial capacity of farmers, deterring their engagement. Furthermore, market uncertainties, such as fluctuating prices and constrained market access for bio-based products or sustainably produced shallots, contribute to hesitancy among farmers. Time and labor constraints and ingrained social and cultural factors favoring traditional farming practices further compound the challenges, creating a complex landscape that impedes the seamless integration of bioeconomy systems in shallot agriculture.

The findings from **Table 5** underscore the prevalent positive perception of bioeconomy systems as sustainable and environmentally friendly alternatives in shallot farming, with 78.67% of respondents agreeing. The observed benefits are multifaceted: increased yields and quality, reduced production costs, premium prices for bio economically-grown produce, and improved market access. However, certain factors limit these benefits, such as the initial investment required, new knowledge and skills, challenges in finding premium markets, and the time horizon for realizing benefits. Local context, implementation quality, and farmer preferences also play crucial roles. The success of bioeconomic systems in greening shallot farming hinges on careful planning, investment, knowledge dissemination, and tailored approaches to local conditions. This research aligns with existing studies, such as Fritsche and Rösch (2020), emphasizing the complexity and context-specific nature of bioeconomy system outcomes.

Farmers exhibit varying attitudes toward adopting bioeconomy systems, with perceptions shaped by multifaceted factors. The desire for sustainable and environmentally friendly practices is a primary motivator, as farmers perceive bioeconomy systems as more eco-friendly than traditional farming methods. Economic incentives, including access to new markets and government subsidies, further drive adoption for some. Environmental concerns, stemming from issues like soil degradation and chemical pollution in conventional farming, propel farmers towards embracing bioeconomy systems. Access to technology and knowledge plays a pivotal role, with informed farmers more likely to adopt, while risk aversion and uncertainty hinder the transition for others. Cultural and social factors, encompassing beliefs, traditions, and community networks, contribute to diverse attitudes, influencing whether farmers embrace or resist the shift to bioeconomy practices. This intricate interplay of motivations and barriers reflects the complexity inherent in farmers' decisions regarding sustainable agricultural practices.

Examining farmer perceptions regarding the benefits of bioeconomy systems, particularly in the context of shallot farming, revealed a nuanced landscape. From **Table 5**, while 46% of respondents acknowledged the potential for higher yields and increased profitability, 54% expressed dissent. The in-depth analysis of farmer concerns highlighted divergent views on the factors influencing these perceived benefits. Enhanced soil health, reduced pest pressure, premium market opportunities, and improved resource efficiency were identified as reasons supporting higher yields and profitability within bioeconomic systems. Conversely, challenges such as the learning curve, initial investment requirements, limited market access, and the time horizon for realizing benefits were cited as factors that contributed little to yield and profitability. The study emphasizes the importance of local context, quality of implementation, and farmers' skills and risk tolerance in shaping the outcomes of bioeconomic practices. Notably, this research diverges from the findings of Frisvold et al. (2021) in its nuanced exploration of the multifaceted considerations influencing shallot farmers' perceptions.

Shallot farmers exhibit varying attitudes towards adopting bioeconomy systems, particularly concerning the potential for higher yields and increased profitability. A significant proportion of farmers express interest in bioeconomy systems, primarily driven by the prospect of enhanced profitability. This motivation stems from the perceived advantages, including higher yields and reduced production costs, aligning with economic incentives. Additionally, environmental considerations attract sure farmers, emphasizing the potential benefits of reduced chemical usage and sustainable agricultural practices. On the contrary, skepticism prevails among some farmers who question the efficacy of bioeconomy systems in delivering the promised outcomes. This skepticism is rooted in concerns about the actual effectiveness of these systems compared to traditional methods. Furthermore, a lack of knowledge or experience with bioeconomy systems contributes to reluctance, as farmers may grapple with uncertainties regarding the integration and functionality of these systems within their existing farming practices.

Table 5 states that the overwhelming agreement among shallot farmers. With 81.33% expressing the belief that adopting bioeconomy systems can lead to reduced reliance on synthetic inputs, this underscores a pivotal aspect of the potential benefits of these systems in green shallot farming. This perception aligns with the emphasis of bioeconomic practices on leveraging natural resources, such as composting and crop rotations, for nutrient supply and pest control. The reduction in synthetic inputs is attributed to the focus on organic methods, prioritizing soil health, and fostering natural nutrient cycling and pest resistance. Farmers acquiring knowledge and skills in bioeconomic strategies empower themselves to manage pests and diseases ecologically, diminishing dependence on chemical inputs. However, farmers' experience in adopting these systems varies. Some may face initial pest pressures or encounter challenges accessing natural pest control solutions, leading to continued reliance on synthetic inputs. Nevertheless, the research emphasizes the gradual nature of this transition, highlighting the importance of community support, knowledge sharing, and policy incentives to encourage farmers to reduce synthetic input dependency. This research aligns with the report by Campbell and Magnan (2022) on the gradual transition and policy support influencing the reduction of synthetic inputs in bioeconomic systems.

Farmers exhibit a spectrum of beliefs regarding adopting bioeconomy systems and their perceived impact on reducing reliance on synthetic inputs, particularly fertilizers and pesticides. Many farmers desire to decrease dependence on these inputs, driven by the potential for cost savings and the desire to minimize adverse environmental effects. Economic considerations motivate some farmers, as they anticipate financial benefits from reduced input costs and the opportunity to access new markets for bio-based products. Additionally, the adoption of bioeconomy systems is viewed through the lens of environmental sustainability by farmers who prioritize minimizing their ecological footprint and contributing to broader conservation endeavors. Conversely, reservations about the effectiveness of bioeconomy systems, coupled with limited knowledge or resources for implementation, may impede adoption for some farmers. The perceived value and profitability of adopting a bioeconomy system are also influenced by the prevailing market demand for bio-based products, adding complexity to farmers' decision-making processes.

The farmer's perception of bioeconomy systems contributing to soil health and biodiversity conservation unveils a pivotal dimension of these practices. However, **Table 5** shows that varying experiences among adopting farmers are observed. For those witnessing improvements, organic practices like composting and crop rotation enrich the soil, fostering microbial activity and enhancing nutrient cycling. Reduced reliance on synthetic inputs safeguards soil organisms, promoting biodiversity, while habitat creation through crop diversification supports beneficial insects. Conversely, limited impact may stem from short-term focus, initial disruptions during practice transitions, insufficient knowledge, or external pressures prioritizing immediate yields. Successful adoption necessitates a holistic approach, regular monitoring, and community knowledge-sharing. Policies incentivizing soil health and biodiversity improvement can further encourage widespread adoption of bioeconomic practice. Nevertheless, it's imperative to note that this research diverges from the findings by Lima and Palme (2021).

Farmers' perceptions of bioeconomy systems as contributors to soil health and biodiversity conservation underscore a multifaceted landscape of motivations and reservations. Some shallot farmers are enticed by the economic benefits, envisioning increased returns through sustainable practices. Those inclined towards environmental sustainability see bioeconomy adoption as integral to the long-term well-being of their land, fostering soil health and preserving biodiversity. Regulatory compliance motivates some, aligning with environmental regulations or meeting consumer demands for sustainably produced goods. The risk-averse view bioeconomy systems as a hedge against potential ecological and market risks associated with traditional farming. Conversely, those disinclined may lack awareness of potential benefits or harbor concerns regarding the practical implementation of bioeconomy systems on their farms.

The farmer's acknowledgment of concerns about the initial investment and technical knowledge required for transitioning to a bioeconomy system encapsulates the nuanced landscape of green shallot farming. The survey data in **Table 5** reveals a substantial agreement among respondents regarding the potential benefits, with 69.33% acknowledging the long-term advantages bioeconomic systems offer. Those farmers who exhibit a long-term vision, access resources and training, demonstrate resilience, and establish market connections tend to experience the full spectrum of benefits associated with sustainable and profitable farming practices. Conversely, challenges persist for those facing insufficient financial resources, knowledge gaps, limited market access, or succumbing to short-term expectations. Acknowledging the local context, promoting community support, and aligning policies with sustainable agriculture can contribute to successfully adopting bioeconomic systems. This research aligns with the findings of Friedrich et al. (2021), reinforcing the importance of a comprehensive approach to overcome challenges and leverage the benefits of bioeconomic farming.

The apprehension among certain farmers regarding the initial investment and technical knowledge required for transitioning to a bioeconomy system underscores a complex interplay of motivations and concerns within the agricultural landscape. Those inclined towards adopting a bioeconomy system are often drawn by the prospect of economic benefits, foreseeing increased profitability stemming from diversified revenue streams, reduced input costs, and opportunities to access new markets for bio-based products. Additionally, farmers expressing environmental sustainability concerns find motivation in mitigating the adverse impacts of traditional farming methods, such as minimizing greenhouse gas emissions, decreasing reliance on synthetic inputs, and fostering soil health and biodiversity. Regulatory incentives, driven by government policies aiming to address climate change and preserve natural resources, influence farmers to embrace sustainable farming practices. However, a subset remains hesitant due to risk aversion from concerns about unfamiliar technologies, market volatility for bio-based products, and potential disruptions to existing production systems. Furthermore, a knowledge gap poses a challenge for farmers lacking the necessary expertise or access to information and training on integrating bio-based processes effectively into their operations.

CONCLUSION

Most respondents positively perceived agroecology and bioeconomy systems, recognizing their potential benefits in increased yields, reduced reliance on synthetic inputs, and contributions to soil health and biodiversity. However, a notable percentage also voiced concerns about initial investments, technical knowledge requirements, and the uncertainties associated with transitioning to agroecology and bioeconomic methods. Policymakers should consider subsidies and support programs to help farmers financially. Investing in training and education initiatives can enhance farmers' technical capabilities, fostering a smoother transition to bioeconomic practices. Additionally, there is a need for targeted awareness campaigns to inform farmers about the long-term advantages of agroecology and bioeconomy systems and to create market demand for bio-based products. Policy implications include the development of regulations that incentivize sustainable agricultural practices. At the same time, future research should delve deeper into the socioeconomic factors influencing farmer decisions and the effectiveness of different policy interventions. By addressing these aspects, stakeholders can contribute to successfully integrating bioeconomic systems into shallot farming, promoting environmental sustainability and economic viability within the agricultural sector.

AUTHOR CONTRIBUTION

This research benefitted significantly from the diverse contributions of the four researchers involved. Haryuni played a crucial role in shaping the conceptual framework and was instrumental in drafting and refining the manuscript. Her expertise in conceptualizing the study ensured a comprehensive exploration of the perceptions of shallot farmers toward bioeconomy systems. Irawan, on the other hand, contributed significantly to the data interpretation process and played a crucial role in crafting meaningful insights from the collected information. His analytical skills and interpretation abilities added depth to the research findings, enhancing the overall quality of the study. Putranto, with expertise in data display and presentation, was responsible for visually representing the research outcomes effectively. Through meticulous data visualization and editing, he ensured that the results were accessible and comprehensible to a broader audience. Lastly, Setyadi undertook the critical data analysis task, employing data calculation to derive meaningful patterns and trends. His proficiency in data analysis contributed to the robustness of the research outcomes. Additionally, Setyadi was responsible for thorough proofreading, ensuring the manuscript met high academic standards. The collaborative efforts of Haryuni, Irawan, Putranto, and Setyadi have resulted in a well-rounded research paper that advances our understanding of shallot farmers' perceptions and sets a solid foundation for future investigations in sustainable agriculture.

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