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Analysis of Horticultural Farmers' Perception and Preparedness Toward the Impacts of Climate Change in Vegetable Production Centers

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A B S T R A C T

Climate change is a global challenge that directly affects the horticultural sector, which is highly dependent on microclimatic conditions and water availability. This study analyzes horticultural farmers' perceptions and preparedness regarding the impacts of climate change in major vegetable production centers using a systematic literature review of scientific articles published between 2015 and 2025. Data were analyzed through literature screening, thematic coding, categorization, and triangulation to identify relationship patterns among key variables. The findings reveal that horticultural farmers' perceptions of climate change have improved, influenced by factors such as farming experience, education, access to climate information, and participation in farmer groups. However, preparedness remains low due to limited access to adaptive technologies, financial capital, extension services, and institutional support. The study concludes that enhancing preparedness cannot rely solely on strengthening perceptions but must also be supported by resource provision, training, financial access, and the empowerment of local institutions. Further recommendations emphasize the importance of mixed-methods field research to develop contextual and sustainable horticultural adaptation models.

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INTRODUCTION

Climate change is a global phenomenon that has become a serious challenge for the agricultural sector worldwide. In recent decades, rising average temperatures, shifting rainfall patterns, and the increasing frequency of extreme weather events have affected crop productivity and food security (Parker et al., 2019). These impacts are not only observed at the macro level but are also evident among smallholder farmers who rely on stable agroclimatic conditions for their livelihoods (Williams et al., 2019). Consequently, the horticultural sector—highly dependent on microclimatic conditions and water availability—has become one of the most vulnerable subsectors to these changes. Therefore, this study aims to examine how climate change influences the perceptions and preparedness of horticultural farmers (Dumitru et al., 2023). A deeper understanding of these aspects is expected to support the development of more targeted adaptation strategies.

The horticultural sector possesses unique characteristics: vegetable crops generally require specific temperature and rainfall ranges, exhibit rapid growth cycles, and depend on markets that are highly sensitive to product quality and production continuity. Thus, when climate change manifests through rising temperatures, declining rainfall, or sudden flooding, vegetable production can be disrupted, leading to significant farmer losses. Recent studies have shown that horticultural farmers are increasingly aware of these impacts, as reflected in declining yields and occasional crop failures. In the Indonesian context, research conducted in East Java revealed that horticultural farmers have developed a relatively high awareness of climate change and have begun implementing certain adaptive practices (Atasa et al., 2024). Therefore, it is essential to examine in depth how horticultural farmers' perceptions and preparedness are shaped and function in practice.

In Indonesia, vegetable production centers play a strategic role in maintaining food security and meeting both domestic and export market demands. However, these regions often face socio-ecological vulnerabilities, such as small-scale farming structures, limited access to technology, intensified climate impacts in highland or rainfall-prone areas, and weaknesses in agricultural extension and adaptation systems (Irham et al., 2022). These conditions have shifted the traditional paradigm that horticultural production is inherently stable; farmers must now adapt to increasingly unpredictable climatic dynamics. Hence, research focusing on vegetable production centers is particularly relevant, as it reflects the complex interactions among farmers' perceptions, environmental realities, and levels of preparedness toward climate change.

This study focuses on how horticultural farmers perceive the impacts of climate change and how prepared they are to face these impacts within vegetable production centers. It also seeks to identify the factors that influence perception and preparedness, as well as to explore the relationship between them. Through this understanding, the study aims to provide empirical insights and policy recommendations that can strengthen farmers' adaptive capacity to climate change. Such efforts are essential to ensure that the horticultural sector remains productive, resilient, and sustainable amid both global and local environmental transformations.

THEORETICAL REVIEW

Risk Awareness and Interpretation

Horticultural farmers' perceptions of climate change stem from their awareness and interpretation of climate-related signals such as rising temperatures, altered rainfall patterns, and extreme weather events that affect vegetable production. Studies conducted in Indonesia indicate that horticultural farmers already possess a high level of perception regarding climate change, as they recognize declines in productivity attributed to climatic variations (Atasa et al., 2024). Similarly, global literature suggests that farmers are generally aware of increasing temperatures and shifting planting seasons (Lennert et al., 2024).
Sociodemographic factors—including education, farming experience, membership in farmer groups, and access to climate information—have been shown to significantly influence these perceptions (Sri & Wen-Chi, 2022). Moreover, systematic review findings indicate that farmers tend to perceive temperature changes more readily than rainfall changes, largely due to their direct and empirical experiences with temperature fluctuations (Lennert et al., 2024). Therefore, developing a strong perception of climate change represents a crucial initial step in the adaptation process among horticultural farmers, forming the foundation for effective preparedness strategies.

Factors Determining Farmers' Perceptions

Farmers' perceptions of climate change are not formed automatically but rather emerge through the interaction of multiple determinants. Several studies have identified that landholding size, ownership status, and social networks—such as membership in farmer groups or cooperatives—are positively associated with farmers' perceptions of climate change (Sri & Wen-Chi, 2022). Moreover, access to climate-related information through extension services, mass media, or digital technologies plays a crucial role in shaping accurate and informed perceptions (Kumar et al., 2025).

Review studies further highlight that farmers who have personally experienced extreme climatic events—such as droughts or floods—tend to develop perceptions of climate change more rapidly than those who have not (Lennert et al., 2024). Empirical research conducted in vegetable-producing regions of Indonesia confirms that declining yields associated with adverse climate conditions often serve as a trigger for farmers' awareness and recognition of climate change (Atasa et al., 2024). Therefore, a comprehensive understanding of these contextual determinants is essential for designing effective and context-specific interventions aimed at strengthening farmers' perceptions and adaptive capacities.

Preparedness: Definition and Key Dimensions

Farmer preparedness for the impacts of climate change encompasses technical readiness, institutional capacity, access to information resources, and a proactive attitude toward adaptive action. Within the literature on disaster management and agricultural adaptation, preparedness is defined as the capacity to anticipate, respond to, and recover from climatic disturbances (Saran et al.,

2024). Empirical studies indicate that farmers equipped with irrigation technologies, stress-tolerant crop varieties, or access to weather information systems exhibit higher levels of preparedness (Grigorieva et al., 2023).

A review of horticultural systems further reveals that technical preparedness tends to dominate adaptation strategies, whereas institutional dimensions—such as coordination, policy support, and community-based organizations—remain relatively underdeveloped (Obossou et al., 2025). Therefore, preparedness should not merely be understood as awareness of risk, but as a combination of capability, access, and institutional support that enables concrete adaptive actions. It thus represents a crucial mediating variable linking horticultural farmers' perceptions with their adaptive behaviors in responding to climate change.

Determinants and Barriers

Numerous factors both promote and constrain farmers' preparedness for climate change. Evidence from various contexts indicates that access to financial capital, appropriate technologies, timely weather information, and institutional networks—such as farmer associations or cooperatives—significantly influence the level of preparedness (Zeleke et al., 2023). Conversely, barriers including limited access to credit, insufficient adaptation training, and inadequate policy support are frequently highlighted in the literature (Grigorieva et al., 2023).

In the context of horticultural systems, review studies have revealed that although farmers generally demonstrate awareness of climate change, institutional support remains relatively weak compared to the technical measures they have adopted (Grigorieva et al., 2023). Similarly, national-level research in Indonesia indicates that despite farmers' positive perceptions of climate change, their overall preparedness remains constrained by financial limitations and restricted access to technology (Atasa et al., 2024). Therefore, enhancing the determinants of preparedness through enabling policies, capacity-building initiatives, and institutional empowerment is essential to strengthen the adaptive capacity of horticultural farmers in the face of climate change.

Concepts and Practices of Horticultural Farmer Adaptation

Climate change adaptation in the horticultural sector refers to the strategies and actions undertaken by farmers to reduce vulnerability and enhance resilience to the impacts of climate change. Adaptation practices may be technical—such as the use of stress-tolerant crop varieties, efficient irrigation systems, and adjustments in planting schedules—or non-technical, including farmer training, inter-farmer collaboration, and the utilization of weather and climate information systems.

Empirical studies in Indonesia reveal that horticultural farmers have responded to climate change by modifying cropping patterns, selecting more resilient varieties, and improving irrigation practices (Atasa et al., 2024). Likewise, international studies demonstrate that adaptation is widely implemented in vegetable production systems, with a predominant focus on water management and stress-tolerant cultivars (Obossou et al., 2025).

Adaptation behavior is also strongly influenced by farmers' perceptions of risk and their level of preparedness; those with higher risk awareness and better preparedness are more likely to adopt adaptive strategies proactively (Kumar et al., 2025). Therefore, adaptation should not be viewed merely as a reactive measure but as an outcome of an integrated process shaped by farmers' perceptions, preparedness, and contextual challenges within the dynamic realities of climate change.

Synergy of Perception Preparedness Adaptation and Horticultural Contexta

To comprehensively understand horticultural farmers' adaptation to climate change, it is essential to examine the synergy between perception, preparedness, and adaptation within specific spatiotemporal and socio-ecological contexts. Conceptual frameworks suggest that the perception of climate-related risks stimulates preparedness, which in turn facilitates the implementation of effective adaptive actions (Zeleke et al., 2023). However, existing literature also emphasizes that in the absence of adequate resource availability and institutional support, this synergy tends to weaken, thereby constraining the overall adaptation process (Obossou et al., 2025).

In the context of vegetable production centers, the inherent characteristics of horticultural systems—such as high input intensity, sensitivity to microclimatic variations, and market responsiveness—make adaptation even more critical. Empirical studies in Indonesia demonstrate that while horticultural farmers in East Java have initiated adaptive practices, their efforts remain constrained by limited institutional and infrastructural support (Atasa et al., 2024). Therefore, research on horticultural adaptation must adopt a holistic perspective that considers the entire continuum from perception to adaptive behavior, while also integrating local spatial and socio-ecological dimensions to ensure that adaptation strategies are contextually relevant, targeted, and effective.

METHODOLOGY

This study employs a qualitative approach grounded in a systematic literature review (SLR) to analyze horticultural farmers' perceptions and preparedness regarding the impacts of climate change. This approach was chosen because it enables the synthesis of diverse empirical and theoretical studies related to the themes of perception, preparedness, climate change, farming, and horticulture. Through this method, the researchers aimed to identify key patterns, determine influential variables, and formulate evidence-based recommendations. The research process consisted of four main stages: literature identification, data collection, data analysis, and synthesis writing.

The inclusion criteria for the literature were as follows: (1) peer-reviewed scientific articles published between 2015 and 2025 to ensure the currency and relevance of the findings; (2) studies containing the keywords *perception*, *preparedness*, *climate change*, *farmers*, *horticulture*, or their conceptual equivalents; (3) research conducted within agricultural contexts, particularly those focusing on horticultural or vegetable production; and (4) studies analyzing either

perception, preparedness, or both. The literature was obtained from major academic databases, including Scopus, Web of Science, and Google Scholar.

The literature analysis was carried out through several systematic steps: (a) screening titles and abstracts for thematic relevance; (b) conducting full-text reviews of eligible studies; (c) coding content based on major themes—such as perception, determinants, preparedness, adaptation, and barriers; (d) organizing the findings into thematic matrices; and (e) triangulating data to ensure consistency, validity, and the minimization of interpretive bias. This analytical process enabled the identification of both generalizable trends and context-specific variables in the adaptation behavior of horticultural farmers.

To ensure the validity and reliability of the synthesis, two strategies were employed. First, intercoder reliability was maintained by involving two independent researchers in the coding and analysis stages. Second, cross-contextual literature from various countries was included to enhance the generalizability and robustness of the conclusions. Furthermore, each article was critically appraised for methodological rigor, including aspects such as sample size, analytical transparency, and robustness of statistical procedures. These measures ensured that the resulting synthesis was both systematic and empirically grounded.

Nevertheless, this study recognizes several methodological limitations inherent to systematic literature reviews. These include the limited availability of primary data specifically focused on Indonesia's vegetable production centers, potential publication bias favoring significant results, and contextual heterogeneity across studies that may constrain the generalizability of findings. To address these limitations, the study explicitly emphasizes that its conclusions should be interpreted within the diversity and localized contexts of horticultural farmers.

RESULTS

A synthesis of the literature reveals that farmers' perceptions of climate change have generally increased in recent years. Studies in Indonesia indicate that horticultural farmers in East Java demonstrate a high level of awareness regarding climate change, perceiving its impacts through declining productivity and shifting seasonal patterns (Atasa et al., 2024). Similarly, global reviews show that farmers whose livelihoods are directly dependent on agriculture tend to exhibit higher awareness of climate change (Fierros-González & López-Feldman, 2021). Thus, perception is not merely an abstract cognitive awareness but often emerges from farmers' real-world experiences and observable environmental changes.

Sociodemographic factors have been consistently found to influence farmers' perceptions of climate change. Higher levels of education, longer farming experience, and exposure to climate-related training or agricultural extension services are positively associated with more accurate perceptions. Cross-country analyses have shown that younger and more educated farmers tend to possess more realistic and evidence-based understandings of climate change than older farmers (Fierros-González & López-Feldman, 2021). These findings underscore that educational and extension interventions are essential for fostering adequate climate perceptions among farmers.

Environmental and geographic conditions also play a significant role in shaping perceptions. Farmers located in areas prone to low rainfall, frequent droughts, or extreme climate events tend to have higher awareness of climate change than those in regions with stable irrigation systems or favorable agro-climatic conditions (Fierros-González & López-Feldman, 2021). Hence, direct exposure to climate risks serves as a critical driver of farmers' perceptions. The specific context of vegetable production centers—often situated in highland or climatically vulnerable zones—further amplifies both vulnerability and perceived risk.

The literature also demonstrates that the level of horticultural farmers' preparedness varies significantly across regions and socio-economic conditions. Several studies report that farmers have begun implementing adaptive measures such as altering crop varieties, adjusting planting schedules, improving irrigation systems, and adopting better soil management practices (Atasa et al., 2024). However, preparedness often remains limited due to insufficient access to advanced technologies, financial capital, and institutional support systems. This suggests that while perception of climate change has improved, it does not automatically translate into adequate preparedness.

Common adaptation strategies identified in the literature include the use of stress-tolerant varieties, crop rotation, mulching, drip irrigation, and crop diversification. In East Java, for instance, horticultural farmers have adapted by modifying cropping patterns, selecting more resilient varieties, and enhancing their knowledge through training and peer collaboration (Atasa et al., 2024). Non-technical measures—such as farmer cooperation, extension participation, and improved access to weather and climate information—have also emerged as key components of preparedness.

The relationship between risk perception and preparedness is frequently highlighted as a significant mechanism. Farmers with stronger perceptions of climate risks and higher awareness of exposure and vulnerability are more likely to undertake adaptive or preparedness actions. As explained by Fierros-González and López-Feldman (2021), perception functions as a necessary precondition for adaptation. However, perception alone is insufficient; adaptive capacity and supportive structures are equally critical to translating awareness into action.

Key barriers to strengthening horticultural farmers' preparedness include limited access to finance, unavailability of stress-resistant technologies or varieties, inadequate information and extension services, and weak institutional frameworks. Studies across different countries have found that restricted access to credit, insurance, or weather early-warning systems severely hampers farmers' ability to prepare and adapt (Chemeda et al., 2023). Therefore, enhancing preparedness requires not only strengthening farmers' perceptions but also improving access to resources, institutional support, and enabling environments.

The role of government agencies, agricultural extension workers, farmer associations, and local communities is pivotal in building horticultural farmers' preparedness for climate change. The literature highlights that interventions

such as farmer training, climate education, and access to digital information and communication technologies (ICT) substantially improve farmers' adaptive capacity. Evidence from India shows that ICT-based information services significantly enhance farmers' ability to anticipate and respond to climatic variability (Chetri, 2021). Furthermore, collaborative networks among farmers and agricultural institutions accelerate the transfer and adoption of adaptive technologies (Ofoegbu & New, 2021).

Overall, the synthesis of the reviewed literature reveals a clear relational pattern among key variables: **sociodemographic and environmental factors → perception → preparedness → adaptation**. This study therefore concludes that enhancing horticultural farmers' preparedness for climate change requires more than improving awareness. It necessitates the strengthening of underlying determinants—such as education, farming experience, and access to information—alongside robust institutional support and the provision of adaptive resources. These interlinked relationships represent one of the major findings of this systematic literature analysis within the horticultural context.

Table 1. The Concept of Perception and Preparedness of Horticultural Farmers toward Climate Change

Conceptual Aspect	Perception	Preparedness
Conceptual Definition	Perception is the cognitive and affective process by which farmers observe, assess, and interpret changes in climatic elements (temperature, rainfall, wind, humidity) that impact horticultural cultivation activities. Perception forms the foundation for adaptive actions and preparedness.	Preparedness refers to the level of readiness of individual farmers or farmer groups to anticipate, respond to, and recover from the negative impacts of climate change on horticultural production systems through technical, social, and institutional strategies.
Main Theoretical Foundations	Environmental Perception Theory; Social Cognitive Theory; Environmental Risk Perception Theory.	Disaster Preparedness Theory; IPCC Framework of Adaptation Capacity; Agricultural Community Resilience Model.
Key Determinant Factors	(1) Knowledge of local climate; (2) Field experience regarding climate change; (3) Access to information	(1) Level of risk perception and awareness; (2) Access to technology and resources; (3) Economic

	and extension services; (4) Farmers' education and age; (5) Local cultural values and beliefs.	capital capacity; (4) Farmer institutions and community networks; (5) Government support and extension.
Empirical Indicators	• Awareness of changes in temperature and rainfall. • Recognition of declining crop productivity. • Belief that climate change threatens the sustainability of farming. • Knowledge of the causes and impacts of climate change.	• Availability of adaptation strategies (land, irrigation, climate-resistant varieties). • Access to weather information and technology. • Ability to implement preventive or adaptive measures. • Involvement in extension or training programs.
Derived Behavior	Positive perception → motivation to adapt. Low perception → denial or indifference to climate risks.	High preparedness → rapid decision-making during climate anomalies. Low preparedness → high vulnerability and production losses.
Relationship between the two	Perception serves as a key psychological factor that triggers (precursors) preparedness. A strong perception of climate change increases the likelihood of farmers taking adaptive measures.	Preparedness is a manifestation of perceptions that are internalized into real actions through land management, planting patterns, and technology.
Conceptual Goals	Understanding how farmers interpret climate change and the risks it poses.	Measuring how prepared farmers are to face and adapt to climate change in practical terms.

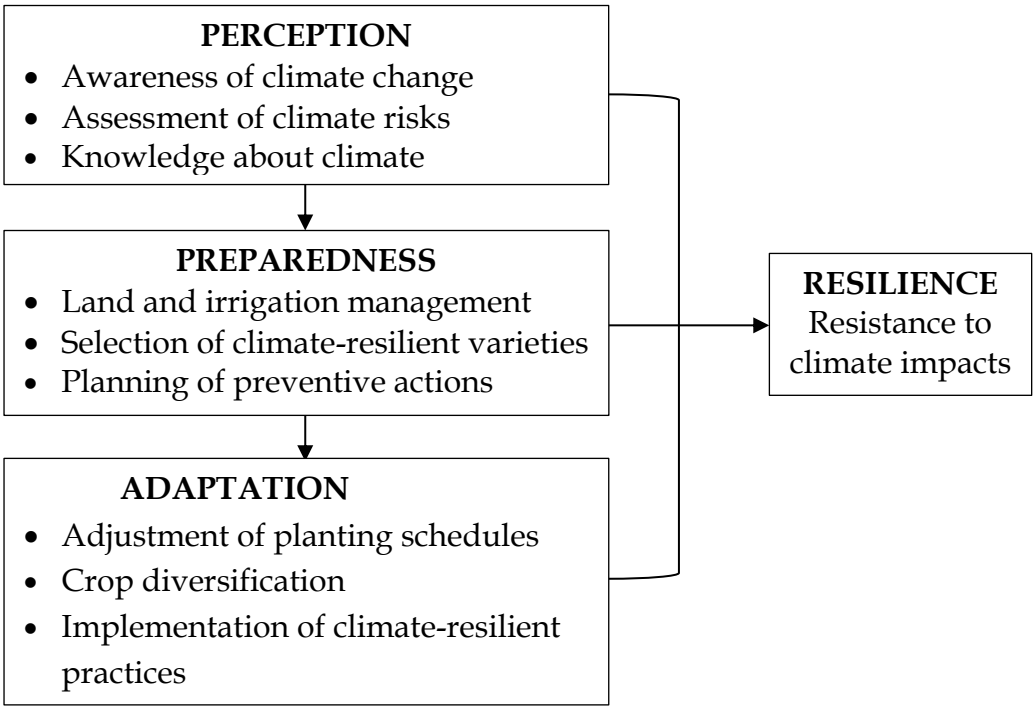

Figure 1. Conceptual Model of the Relationship between Perception, Preparedness, and Adaptation to Climate Change.

DISCUSSION

The findings of this study have important theoretical implications for environmental risk perception theory. The evidence that farmers' perceptions of climate change influence their preparedness actions supports the argument that perception serves as a key psychological mechanism in adaptive behavior. This aligns with environmental psychology theory, which posits that perceptions, beliefs, and attitudes shape individuals' behavioral responses to environmental risks. Accordingly, this study reinforces the theoretical premise that effective adaptation interventions must explicitly incorporate perceptual and cognitive dimensions, rather than focusing solely on technical or structural measures.

From a climate adaptation policy perspective within the horticultural sector, the results highlight two critical priorities: first, fostering accurate and evidence-based perceptions among farmers; and second, strengthening preparedness through adequate resource and institutional support. Adaptation programs that emphasize technological solutions without addressing farmers' cognitive and perceptual contexts are unlikely to succeed. Therefore, climate policies should be designed in an integrated manner that combines education, agricultural extension, technology dissemination, financial access, and institutional strengthening.

When comparing global findings with local conditions in Indonesia, it becomes evident that while key determinants of perception and preparedness—such as education, farming experience, and information access—are broadly similar, specific contextual differences exist. These include horticultural characteristics, landholding size, and the socio-cultural attributes of Indonesian farmers. Consequently, successful adaptation strategies from other countries cannot be directly replicated in Indonesia without appropriate contextualization and localization.

The role of agricultural education and extension services in strengthening farmers' preparedness is particularly significant. Empirical evidence consistently shows that farmers who receive climate-related training and have access to weather information and adaptive technologies demonstrate higher levels of preparedness. Therefore, one practical recommendation emerging from this study is the need to enhance the institutional capacity of horticultural extension services and expand farmers' access to timely and actionable climate information, especially in major vegetable production centers.

Furthermore, strengthening farmer organizations and community-based adaptation networks is vital and should not be overlooked. Collaborative linkages among farmers, associations, and partnerships with government agencies or research institutions can accelerate the transfer of adaptive technologies and foster collective resilience. Adaptation, therefore, should be viewed not merely as an individual behavioral response but as a collective socio-institutional process that relies on coordination, knowledge sharing, and joint resource management.

Finally, as a critical reflection, this study acknowledges the limitations inherent in existing systematic literature, particularly concerning the horticultural and vegetable production contexts in Indonesia. Hence, the findings should be interpreted with caution. Future research is encouraged to incorporate primary field surveys, longitudinal analyses, and cross-generational approaches to capture the dynamic nature of farmers' adaptive behavior. Additionally, integrating economic impact assessments specific to the vegetable subsector would further enrich the understanding of adaptation effectiveness and sustainability.

CONCLUSIONS AND RECOMMENDATIONS

Overall, this study concludes that horticultural farmers' perceptions of climate change have improved in recent years and exert a significant influence on their level of preparedness. However, preparedness remains suboptimal due to persistent barriers such as limited access to technology, financial capital, information, and institutional support. Therefore, enhancing farmers' perceptions must be accompanied by the strengthening of adaptive capacity and structural support systems to effectively realize comprehensive preparedness.

The policy implications of this study emphasize the need for a holistic and integrated approach to developing climate change adaptation within the horticultural sector. This approach should include: (1) strengthening education and agricultural extension to build accurate perceptions and awareness among farmers; (2) expanding access to adaptive technologies and financial resources; and (3) reinforcing farmer organizations and institutional frameworks to support collective adaptation. Furthermore, adaptation policies must be context-specific and tailored to the ecological and socio-economic realities of vegetable production centers to ensure effectiveness and sustainability.

In conclusion, this study lays the groundwork for future, more targeted research on horticultural farmers in Indonesia's vegetable production centers. Such research should utilize primary field data and longitudinal designs to better capture the dynamics of farmers' perceptions, preparedness, and adaptation over time. Ultimately, the findings of this study contribute to advancing sustainable

food security and climate resilience in the horticultural sector—an area of growing importance in the era of global climate change.

FURTHER STUDY

Future research is recommended to expand the empirical scope through a mixed-methods approach involving field surveys of horticultural farmers across different regions of Indonesia. Longitudinal and spatial analyses are essential to measure the dynamic relationships between farmers' perceptions, actual climatic variations, and the adaptation strategies implemented at the local level.

In addition, future studies should develop predictive models of preparedness based on socioeconomic determinants and explore how gender and generational factors shape adaptive behavior. ICT-based policy interventions and farmer training programs should also be experimentally tested to evaluate their effectiveness in enhancing adaptive capacity.

Furthermore, integrating economic analyses of adaptation with institutional performance assessments will be critical for generating contextual, inclusive, and sustainable policy recommendations for Indonesia's national horticultural sector. Such research will provide a more comprehensive understanding of the behavioral, structural, and economic dimensions of climate adaptation among horticultural farmers.

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