

SUSTAINABLE FOREST MANAGEMENT PRIORITIES IN A SPECIAL PURPOSE FOREST AREA, TEMANGGUNG

Variantika Metasari^{*1}, Rahmawaty², Feti Fatimatuazzahroh¹

¹Master of Environmental Studies Program, Graduate School, Universitas Terbuka, Indonesia

²Faculty of Forestry, Universitas Sumatera Utara, Medan, Indonesia

*Email: variantikameta1@gmail.com, rahmawaty@usu.ac.id,
feti.fatimatuazzahroh@ecampus.ut.ac.id

Received: 10/06/2026, Revised: 16/06/2026, Approved: 16/06/2026

ABSTRACT

The Special Purpose Forest Area of the Indonesian National Counterterrorism Agency (KHDTK BNPT) in Central Java, Indonesia, is a forest area developed for forest rehabilitation, community empowerment, and social rehabilitation, including deradicalization and social reintegration programs for former terrorism convicts through productive forestry activities. However, repeated forest fires, vegetation degradation, and community dependence on land utilization pose challenges to sustainable management. This study aimed to determine sustainable management priorities of KHDTK BNPT using the Analytical Hierarchy Process (AHP). Data were collected through field observations, interviews, literature reviews, and AHP questionnaires involving eight expert respondents. The criteria and management alternatives were developed based on ecological, social, economic, and institutional considerations integrated with the Nature-Based Solutions (NbS) approach. The results showed that institutional and forest management was the highest-priority criterion (0.413), followed by ecology and environment (0.265), Social and Community Dimension (0.163), and Economic Dimension (0.159). The global priority ranking indicated that institutional activity of Forest Farmer Groups (KTH), area security stability, land tenure status, and Vegetation Density were the highest-priority management alternatives. These findings demonstrate that sustainable management of KHDTK BNPT depends on strengthening local institutions, improving governance effectiveness, maintaining ecosystem rehabilitation efforts, and enhancing community participation to support the long-term implementation of Nature-based Solutions (NbS). Therefore, management programs should prioritize strengthening the capacity and involvement of Forest Farmer Groups (KTH), improving area security and land tenure clarity, and maintaining vegetation restoration activities as key actions to support the implementation of Nature-based Solutions (NbS) and sustainable forest management.

Keywords: Agroforestry; Analytical Hierarchy Process; KHDTK BNPT; Nature-Based Solutions; Sustainable Forest Management

INTRODUCTION

Sustainable forest management has become one of the major challenges in modern environmental development because forest areas function not only as ecological buffers, but also play important roles in supporting community welfare, climate change mitigation, and sustainable development (Fischer, 2018; Hallaj *et al.*, 2026; Oldekop *et al.*, 2025). In practice, forest management frequently faces various pressures, including land degradation, vegetation cover change, forest fires, and high community dependence on forest resources (Hu *et al.*, 2025; Souza-Alonso *et al.*, 2022; Langlentombi & Kumar, 2021). These conditions indicate that forest management cannot rely solely on ecological approaches, but also needs to integrate social, economic, and institutional aspects (Fischer, 2018; Ahammad *et al.*, 2023).

In Indonesia, Forest Areas for Special Purpose (KHDTK) serve as strategic instruments for supporting forestry-based research, education, training, and community empowerment programs. One unique example is KHDTK managed by the National Counterterrorism Agency (BNPT) in Temanggung Regency, Central Java, Indonesia. The area was developed not only for forest rehabilitation and forest management, but also to support deradicalization and social reintegration programs for former terrorism convicts through productive forestry activities (BNPT, 2023). Therefore, KHDTK BNPT represents a unique forest management landscape that combines ecological rehabilitation, community empowerment, and institutional objectives, making it an important case for evaluating sustainable forest management priorities. Given the dual objectives of ecological rehabilitation and community empowerment in KHDTK BNPT, understanding ecological conditions and the socio-economic characteristics of local communities is fundamental for identifying appropriate and sustainable forest management strategies.

Ecological conditions can indicate ecosystem disturbances and rehabilitation needs, while socio-economic conditions are closely related to community dependence on forest resources, land utilization patterns, and community participation in rehabilitation programs (Ahammad *et al.*, 2023; Tchékoté *et al.*, 2026). Therefore, consideration of ecological and socio-Economic Dimensions is important in supporting adaptive and sustainable forest management (Oldekop *et al.*, 2025; Fischer, 2018). One relevant approach for sustainable forest management is Nature-Based Solutions (NbS), which emphasizes ecosystem-based approaches capable of providing ecological benefits while simultaneously supporting community welfare (Lozano *et al.*, 2025; Zhao *et al.*, 2025). In the context of KHDTK BNPT, the NbS approach can serve as a conceptual framework for supporting vegetation rehabilitation, fire risk reduction, soil and water conservation, agroforestry development, and community empowerment as key components of sustainable forest management (Ma *et al.*, 2022; Hallaj *et al.*, 2026).

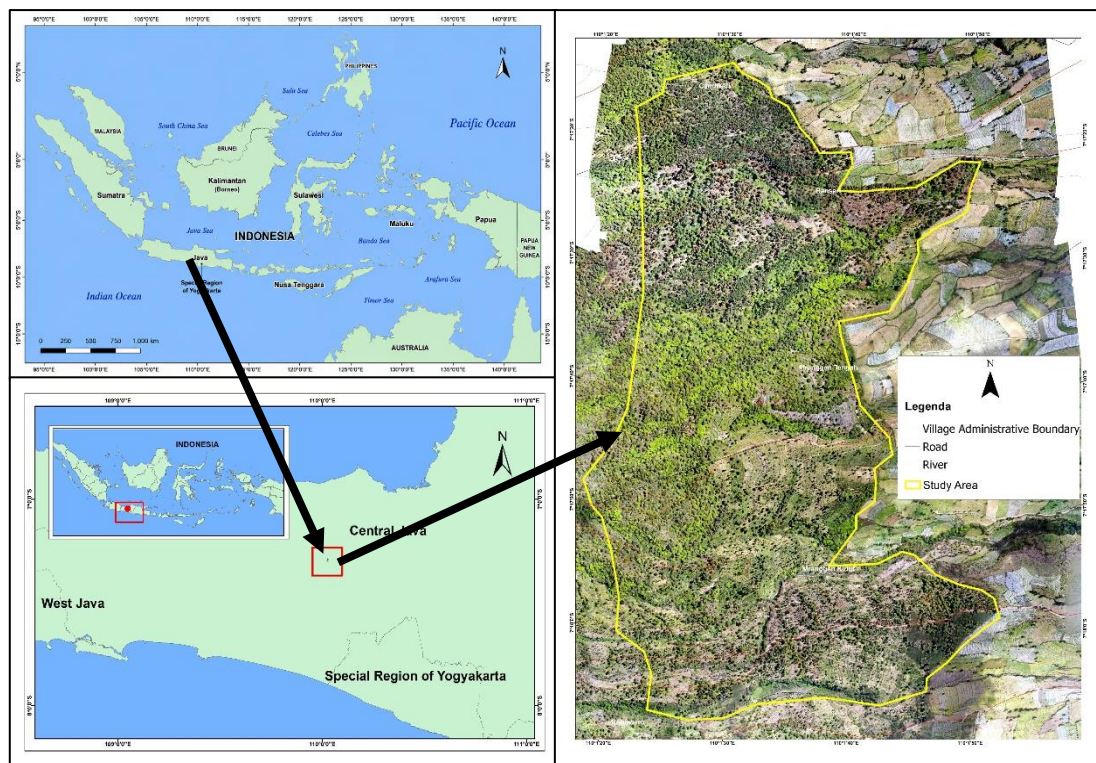
However, these management aspects require priority determination to ensure that management strategies can be implemented effectively and sustainably. Forest management often involves multiple criteria and stakeholder interests, requiring a systematic decision-making approach. One widely used method for multi-criteria decision-making is the Analytical Hierarchy Process (AHP), which enables complex problems to be structured hierarchically and management priorities to be determined objectively based on expert and stakeholder judgments (Pouya Sahar *et al.*, 2020; Rahmawaty *et al.*, 2022; Murali *et al.*, 2018).

Previous studies have examined sustainable forest management from ecological, socio-economic, institutional, and restoration perspectives (Fischer, 2018; Ahammad *et al.*, 2023; Oldekop *et al.*, 2025). Several studies have also highlighted the role of Nature-Based Solutions (NbS) in supporting ecosystem restoration, biodiversity conservation, climate adaptation, and community well-being (Ma *et al.*, 2022; Lozano *et al.*, 2025; Zhao *et al.*, 2025). In the context of tropical forest restoration, successful restoration outcomes are strongly influenced by governance arrangements, institutional capacity, stakeholder collaboration, and community participation (Indrajaya *et al.*, 2022; Robiyana & Sarihati, 2025). Community-based forest management has been widely recognized as an effective approach for improving forest sustainability while enhancing local livelihoods through active community involvement (Afriyie *et al.*, 2021; Indrajaya *et al.*, 2022). Furthermore, coffee agroforestry systems have been increasingly promoted as community-based restoration strategies due to their potential to support ecosystem rehabilitation, biodiversity conservation, carbon sequestration, and household income generation (Maulana *et al.*, 2025). In addition, the Analytical Hierarchy Process (AHP) has been widely applied to support environmental and natural resource management decision-making, including agroforestry species selection and community forest management planning (Rahmawaty *et al.*, 2022; Sitanggang *et al.*, 2021; Pouya Sahar *et al.*, 2020; Murali *et al.*, 2018). However, studies integrating the NbS framework with AHP to determine sustainable management priorities in Forest Areas for Special Purpose (KHDTK) remain limited, particularly in forest landscapes that simultaneously support forest rehabilitation, community empowerment, and social reintegration objectives. This research

gap highlights the need for a systematic assessment of management priorities that considers ecological, social, economic, and institutional dimensions within an NbS framework. Therefore, this study aims to determine and rank sustainable forest management priorities across ecological, social, economic, and institutional dimensions in KHDTK BNPT using the Analytical Hierarchy Process (AHP) within a Nature-based Solutions (NbS) framework.

METHOD

The study was conducted in the Forest Area for Special Purpose managed by the National Counterterrorism Agency (KHDTK BNPT) located in Temanggung Regency, Central Java Province, Indonesia. The area covers approximately 102.584 ha and is characterized by lower montane forest ecosystems with hilly topography and a humid tropical climate (BNPT, 2023). The location and boundary of the study area are presented in Figure 1.



Source: Authors' analysis, 2025

Figure 1. Location and boundary of the KHDTK BNPT study area in Temanggung Regency, Central Java Province, Indonesia

This study employed a quantitative descriptive approach using a multi-criteria decision-making method (Pouya Sahar *et al.*, 2020; Murali *et al.*, 2018). Research data were collected through literature studies, interviews, field observations, and Analytical Hierarchy Process (AHP) questionnaires involving expert respondents (expert judgment). Data collection was conducted during 2025–2026. Field observations were carried out to identify general site conditions, land utilization patterns, rehabilitation activities, and management-related issues within the KHDTK BNPT area. Interviews were conducted to obtain information regarding forest management conditions, management needs, and stakeholder perceptions toward KHDTK BNPT management.

Expert respondents were selected using purposive sampling based on their involvement, experience, and understanding of KHDTK BNPT management. A total of eight expert respondents participated in this study, consisting of representatives from the National Counterterrorism Agency (BNPT), the Ministry of Forestry, the Regional Forestry Branch Office (CDK), the Regional National Unity and Politics Agency (Kesbangpol), and four leaders

of Forest Farmer Groups (KTH) surrounding the study area. The selection of respondents followed the AHP approach, which emphasizes the competency and quality of expert judgment rather than sample size (Pouya Sahar *et al.*, 2020; Goushehgir *et al.*, 2021).

The selected respondents represented the main stakeholders directly involved in KHDTK BNPT management. These included BNPT as the managing institution, the Ministry of Forestry as the authority responsible for the forest area, the Regional Forestry Branch Office (CDK) as the agency responsible for extension and community engagement activities, the Regional National Unity and Politics Agency (Kesbangpol) due to its involvement in the social reintegration of former terrorism convicts, and Forest Farmer Group (KTH) leaders as the primary community actors participating in forest management activities. This composition was intended to ensure that the priority rankings reflected the perspectives of stakeholders directly involved in the planning and implementation of KHDTK BNPT management.

The development of management criteria and alternatives was conducted gradually through the integration of ecological information, socio-economic conditions, literature studies, field observations, and stakeholder information. This approach reflects the multidimensional nature of sustainable forest management, which requires consideration of ecological, social, economic, and institutional aspects (Fischer, 2018; Ahammad *et al.*, 2023). Initial information was obtained from the identification of vegetation conditions, land utilization, rehabilitation activities, and socio-economic conditions of communities surrounding KHDTK BNPT. These aspects were used as the basis for identifying management issues and management needs within the area.

The development of the AHP questionnaire was conducted in two stages. First, preliminary management criteria and alternatives were identified based on ecological and socio-economic conditions of KHDTK BNPT, supported by field observations, stakeholder interviews, and literature review. These preliminary criteria and alternatives were presented to expert respondents through an initial questionnaire to assess their relevance and to obtain additional suggestions. Respondents were given the opportunity to propose new criteria and alternatives based on their knowledge and experience regarding KHDTK BNPT management. The resulting inputs were subsequently consolidated, reviewed, and categorized according to the Nature-Based Solutions (NbS) framework to establish the final hierarchy used in the AHP analysis.

The final AHP hierarchy was structured to reflect the multidimensional principles of Nature-Based Solutions (NbS). Four main criteria were established, namely Ecology and Environment, Social and Community Dimension, Economic Dimension, and Institutional and Forest Management. The ecological dimension was represented by vegetation change, Vegetation Density, biodiversity, fire history, and water availability. The social dimension included community participation and perception, community acceptance, stakeholder involvement, and potential social conflict. The economic dimension comprised livelihood dependence, economic impact, potential non-timber forest products (NTFPs), and ecosystem services. The institutional dimension was represented by institutional/KTH activeness, extension service intensity, land tenure status, and Area Security and Stability. These alternatives were subsequently evaluated through pairwise comparisons to determine sustainable forest management priorities within KHDTK BNPT.

Before completing the pairwise comparison questionnaire, all respondents received a briefing regarding the objectives of the study, the AHP procedure, and the interpretation of Saaty's 1–9 scale. Written guidelines explaining the pairwise comparison process and the meaning of each scale value were also provided to ensure a consistent understanding among respondents. The relevance and clarity of the questionnaire were refined based on feedback obtained from expert respondents during the preliminary questionnaire stage prior to the final AHP analysis.

To systematically organize these aspects, this study adopted the Nature-Based Solutions (NbS) approach as a conceptual framework (Lozano *et al.*, 2025; Hallaj *et al.*, 2026). The

developed criteria and alternatives were subsequently used in pairwise comparison analysis within the Analytical Hierarchy Process (AHP) framework (Pouya Sahar *et al.*, 2020; Murali *et al.*, 2018). Based on the literature review, field observations, interviews, and expert validation, a total of four criteria and seventeen alternatives were identified for the AHP analysis (Table 1).

Table 1. Criteria and Alternatives Used in the AHP Analysis

Criteria	Alternatives
Ecology and Environment	Vegetation Change
	Vegetation Density
	Biodiversity
	Fire History
	Water Availability
Social and Community Dimension	Community Participation and Perception
	Community Acceptance
	Stakeholder Involvement
	Potential Social Conflict
Economic Dimension	Livelihood Dependence
	Economic Impact
	Potential Non-Timber Forest Products (NTFPs)
	Ecosystem Services
Institutional and Forest Management	Institutional/KTH Activeness
	Extension Service Intensity
	Land Tenure Status
	Area Security and Stability

Source: Authors' analysis, 2026

Management priorities were determined using the Analytical Hierarchy Process (AHP) method developed by Saaty (1980). The AHP method is widely applied in environmental management, sustainability assessment, and natural resource management studies because it enables complex decision-making problems to be structured into a hierarchical framework and evaluated systematically through pairwise comparisons (Pouya Sahar *et al.*, 2020; Murali *et al.*, 2018)

The criteria and alternatives presented in Table 1 were evaluated through pairwise comparisons using Saaty's fundamental importance scale ranging from 1 to 9, where a value of 1 indicates equal importance and a value of 9 indicates extreme importance of one element over another (Saaty, 1980). The scale used in this study is presented in Table 2. The comparison values obtained from expert respondents were processed to generate priority weights for each criterion and alternative. Higher weight values indicate higher management priority levels.

The hierarchy structure in this study consisted of three levels: (1) the main objective of sustainable management of KHDTK BNPT, (2) management criteria, and (3) management alternatives. The resulting priority weights were subsequently used to determine sustainable forest management priorities.

Table 2. Saaty's Fundamental Scale for Pairwise Comparison

Scale	Definition
1	Equal importance
2	Between equal and moderate importance
3	Moderate importance
4	Between moderate and strong importance
5	Strong importance
6	Between strong and very strong importance
7	Very strong importance

8	Between very strong and extreme importance
9	Extreme importance

Source: Saaty (1980)

The pairwise comparison judgments obtained from the eight expert respondents were entered individually into Expert Choice 11 and combined using the software's group decision-making function. The aggregated judgments were then analyzed to calculate priority weights and consistency values for the final assessment.

To ensure the consistency of expert judgments, a Consistency Ratio (CR) test was conducted on each pairwise comparison matrix. The CR value was calculated based on the Consistency Index (CI) and Random Index (RI) following Saaty (1980). Judgments were considered consistent when the CR value was less than 0.10. If the CR value exceeded this threshold, the corresponding pairwise comparisons were re-evaluated to improve consistency. Questionnaire data were tabulated using Microsoft Excel, while the AHP analysis was performed using Expert Choice 11 software to obtain priority weights, eigenvectors, and consistency ratios.

RESULTS AND DISCUSSION

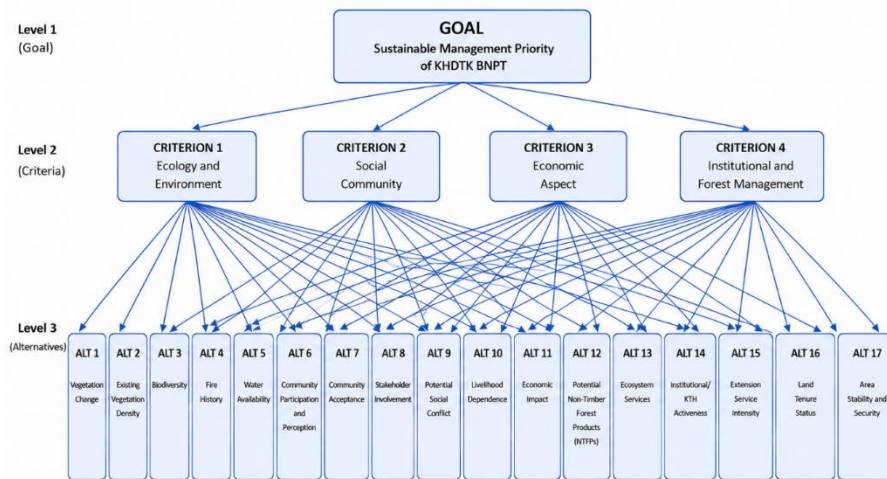
Development of AHP Hierarchy Structure

The development process resulted in an AHP hierarchy structure consisting of four main criteria and seventeen management alternatives for sustainable management of KHDTK BNPT (Figure 2). The four main criteria were ecology and environment, Social and Community Dimension, Economic Dimension, and institutional and forest management.

The management alternatives identified under the ecology and environment criterion included vegetation change, Vegetation Density, biodiversity, fire history, and water availability. Alternatives related to the Social and Community Dimension criterion consisted of community participation and perception, community acceptance, stakeholder involvement, and potential social conflict. Under the Economic Dimension criterion, the identified alternatives were livelihood dependence, economic impact, potential non-timber forest products (NTFPs), and ecosystem services. Meanwhile, alternatives associated with the institutional and forest management criterion included institutional/KTH activeness, extension service intensity, land tenure status, and Area Security and Stability.

The hierarchy structure was developed based on literature review, field observations, interviews, and expert validation. The selected criteria and alternatives reflect the ecological, social, economic, and institutional dimensions considered essential for sustainable forest management and are consistent with the principles of Nature-Based Solutions (NbS) and integrated forest management approaches (Ahammad *et al.*, 2023; Oldekop *et al.*, 2025; Hallaj *et al.*, 2026).

In accordance with the Nature-Based Solutions (NbS) framework and sustainable forest management principles, the identified ecological, social, economic, and institutional dimensions were integrated into an AHP hierarchy structure. This framework was developed to support the systematic assessment of management priorities within KHDTK BNPT. The resulting hierarchy structure is presented in Figure 2.



Source: Authors' analysis, 2026

Figure 2. AHP Hierarchy Structure for Determining Sustainable Management Priorities

Priority of Management Criteria

The weighting results showed that institutional and forest management was the highest-priority criterion with a weight of 0.413, followed by ecology and environment (0.265), Social and Community Dimension (0.163), and Economic Dimension (0.159). The Consistency Ratio (CR) value of 0.0053 indicates acceptable consistency, as it is well below the recommended threshold of 0.10 (Saaty, 1980). Furthermore, consistency testing was performed for all pairwise comparison matrices, and all CR values were below the acceptable threshold of 0.10, indicating reliable judgments. The priority weights and ranking of the main management criteria are presented in Table 3.

Table 3. Priority Weights of Main Management Criteria for KHDTK BNPT

Criteria	Weight	Priority Rank
Institutional and Forest Management	0.413	1
Ecology and Environment	0.265	2
Social and Community Dimension	0.163	3
Economic Dimension	0.159	4

Source: Authors' analysis, 2026

Note: Consistency Ratio (CR) = 0.0053

The high priority assigned to institutional and forest management indicates that the long-term sustainability of KHDTK BNPT depends not only on ecological conditions but also on the effectiveness of governance structures, stakeholder coordination, and institutional capacity. Successful forest management requires strong institutional arrangements capable of facilitating collaboration among government agencies, local communities, and other stakeholders involved in conservation and restoration activities (Afriyie *et al.*, 2021). This result reflects the current management context of KHDTK BNPT, where effective coordination among stakeholders is essential to support rehabilitation, monitoring, fire prevention, and community empowerment programs. Respondents therefore perceived institutional strengthening and forest management as fundamental prerequisites for achieving sustainable management objectives within the area.

Furthermore, KHDTK BNPT is currently managed under the coordination of BNPT and does not yet have a dedicated technical management unit responsible for day-to-day operations. This condition highlights the importance of strengthening institutional arrangements and enhancing stakeholder coordination to improve long-term management effectiveness and ensure the continuity of rehabilitation and community empowerment programs.

The ecology and environment criterion ranked second with a weight of 0.265, emphasizing the importance of maintaining vegetation cover, ecosystem functions, and environmental stability within the area. The relatively high weight assigned to this criterion is closely associated with the ecological challenges faced by KHDTK BNPT, particularly forest fire disturbances and the need for ecosystem recovery. Vegetation rehabilitation and post-fire ecosystem recovery are widely recognized as essential components of sustainable forest management, particularly in areas affected by recurrent fire disturbances (Souza-Alonso *et al.*, 2022; Lin *et al.*, 2024). The repeated occurrence of forest fires in KHDTK BNPT suggests that vegetation restoration and fire risk reduction should remain key priorities in future management interventions (Ahammad *et al.*, 2023).

The Social and Community Dimension criterion received a weight of 0.163, indicating that community participation and stakeholder engagement remain important considerations in forest management. Previous studies have shown that active involvement of local communities contributes to improved conservation outcomes, reduced conflicts, and greater support for forest initiatives. Given the role of local communities in agroforestry activities and rehabilitation programs, their participation is essential for ensuring long-term management success.

Although ranked fourth, the Economic Dimension remains an important component of sustainable forest management. Economic benefits derived from agroforestry practices, non-timber forest products, and ecosystem services can provide incentives for local communities to support conservation and restoration efforts (Ma *et al.*, 2022; Oldekop *et al.*, 2025). In KHDTK BNPT, coffee-based agroforestry has the potential to improve community livelihoods while supporting vegetation rehabilitation and long-term ecosystem sustainability.

Overall, the results suggest that institutional capacity and forest management function as enabling factors that influence the effectiveness of ecological restoration, community participation, and economic development within KHDTK BNPT. Therefore, strengthening governance and management systems should be considered a strategic priority for achieving long-term sustainability in the study area.

Global Priority Ranking of Management Alternatives

The global priority ranking was obtained by combining the weights of the main criteria and their corresponding management alternatives. The results provide an overall assessment of the relative importance of each management alternative in supporting the sustainable management of KHDTK BNPT. The global ranking of management alternatives is presented in Table 4.

Table 4. Global Priority Ranking of Management Alternatives for Sustainable Management of KHDTK BNPT

Criteria	Alternatives	Weight	Rank
Ecology and Environment	Vegetation Change	0.036	14
	Vegetation Density	0.086	4
	Biodiversity	0.026	16
	Fire History	0.054	8
	Water Availability	0.063	7
Social and Community Dimension	Community Participation and Perception	0.044	10
	Community Acceptance	0.042	11
	Stakeholder Involvement	0.039	12
	Potential Social Conflict	0.038	13
Economic Dimension	Livelihood Dependence	0.027	15
	Economic Impact	0.049	9

Institutional and Forest Management	Potential Non-Timber Forest Products (NTFPs)	0.066	6
	Ecosystem Services	0.017	17
	Institutional/KTH Activeness	0.141	1
	Extension Service Intensity	0.067	5
	Land Tenure Status	0.088	3
	Area Security and Stability	0.117	2

Source: Authors' analysis, 2026

The results indicate that institutional-related alternatives dominated the highest global priorities. Institutional activity of Forest Farmer Groups (KTH) ranked first with a global weight of 0.141, followed by area security stability (0.117) and land tenure status (0.088). These findings highlight the importance of strengthening local institutions, improving governance systems, and ensuring management stability to support long-term forest rehabilitation and sustainable management efforts.

Among ecological alternatives, Vegetation Density emerged as the highest-ranked alternative with a global weight of 0.086, indicating the importance of vegetation recovery in maintaining ecosystem functions and environmental resilience. Water availability and fire history were also identified as important priorities, reflecting the need to maintain hydrological functions and reduce wildfire risks within the KHDTK area.

Among the social alternatives, community participation and perception achieved the highest global ranking (rank 10; global weight = 0.044), indicating the importance of community involvement in supporting rehabilitation and forest management programs. Within the Economic Dimension, the potential of non-timber forest products (NTFPs), particularly coffee-based agroforestry, was identified as the highest-ranked economic alternative (rank 6; global weight = 0.066). Although this alternative was not among the highest global priorities, it remains strategically important within KHDTK BNPT because coffee cultivation represents one of the main livelihood activities of local Forest Farmer Groups (KTH) involved in managing the area. In addition, coffee-based agroforestry supports ecological restoration by maintaining tree cover while providing economic benefits to local communities. This finding suggests that agroforestry can contribute to both livelihood improvement and sustainable forest management objectives within KHDTK BNPT.

Overall, the global ranking demonstrates that sustainable management of KHDTK BNPT requires a balanced approach that integrates institutional strengthening, ecosystem rehabilitation, community participation, and sustainable economic development. These priorities are consistent with the principles of Nature-Based Solutions (NbS), which emphasize the integration of ecological restoration, community well-being, and long-term sustainability objectives (Lozano *et al.*, 2025; Hallaj *et al.*, 2026).

Implications for Sustainable KHDTK Management

The findings of this study indicate that sustainable management of KHDTK BNPT requires an integrated approach that simultaneously addresses ecological, social, economic, and institutional dimensions. The dominance of institutional and forest management criteria, as well as the high global ranking of institutional activity of Forest Farmer Groups (KTH), area security stability, and land tenure status, suggest that long-term sustainability depends not only on vegetation rehabilitation but also on effective governance systems, stakeholder coordination, and community institutional capacity. Similar findings have been reported in forest restoration studies, which emphasize the importance of institutional arrangements and collaborative governance in achieving sustainable management outcomes (Ahammad *et al.*, 2023; Oldekop *et al.*, 2025).

Strengthening local institutions, particularly Forest Farmer Groups (KTH), is considered a key strategy for supporting ecosystem rehabilitation and promoting the sustainable implementation of agroforestry practices. Strong community institutions can facilitate

stakeholder coordination, improve local participation, reduce management conflicts, and enhance the effectiveness of long-term management programs within the KHDTK area (Afriyie *et al.*, 2021; Hallaj *et al.*, 2026).

Furthermore, the development of coffee-based agroforestry systems and other high-value Non-Timber Forest Products (NTFPs) offers significant opportunities to improve local livelihoods while maintaining the ecological functions of forest ecosystems. Agroforestry-based restoration approaches have been widely recognized for their ability to generate economic benefits, support biodiversity conservation, and contribute to forest landscape restoration simultaneously (Koelemeijer *et al.*, 2021; Derisso *et al.*, 2025). Therefore, expanding sustainable agroforestry initiatives may provide an effective mechanism for balancing conservation objectives with community economic development.

From an ecological perspective, the high ranking of Vegetation Density, water availability, and fire history highlights the importance of maintaining ecosystem resilience through continuous rehabilitation efforts and wildfire risk reduction measures. Given the history of repeated fire disturbances in the area, future management strategies should focus on strengthening vegetation recovery, improving ecosystem functions, and reducing vulnerability to future fire events (Souza-Alonso *et al.*, 2022; Lin *et al.*, 2024).

Overall, the results suggest that the Nature-Based Solutions (NbS) approach provides an appropriate framework for adaptive KHDTK management through the integration of ecosystem rehabilitation, community empowerment, wildfire risk reduction, and governance strengthening. By simultaneously addressing ecological restoration and socio-economic development objectives, NbS can enhance the long-term resilience, sustainability, and multifunctionality of KHDTK BNPT while supporting both conservation and community well-being (Hallaj *et al.*, 2026; Lozano *et al.*, 2025). The global priority ranking further indicates that institutional factors, particularly Institutional/KTH Activeness, Area Security and Stability, and Land Tenure Status, are critical for supporting the implementation of NbS. As the managing institution, BNPT plays a central role in coordinating relevant stakeholders, including government agencies and forest farmer groups (KTH), to facilitate ecosystem restoration and sustainable livelihood programs. Through community-based activities such as forest rehabilitation and sustainable coffee cultivation, KTH contributes to both environmental conservation and local economic development, demonstrating how NbS can be operationalized to achieve ecological and socio-economic objectives within KHDTK BNPT.

CONCLUSION AND RECOMMENDATIONS

This study applied the Analytical Hierarchy Process (AHP) to determine sustainable management priorities for KHDTK BNPT in Temanggung Regency, Central Java. The results showed that institutional and forest management was the highest-priority criterion (0.413), followed by ecology and environment (0.265), Social and Community Dimension (0.163), and Economic Dimension (0.159). The global priority ranking of management alternatives indicated that institutional activity of Forest Farmer Groups (KTH), area security stability, land tenure status, and Vegetation Density were the highest-priority alternatives for sustainable management of KHDTK BNPT. These results demonstrate the dominant role of institutional and governance-related factors, supported by ecological restoration efforts, in achieving long-term sustainability.

The findings suggest that sustainable management of KHDTK BNPT should prioritize institutional strengthening, governance improvement, vegetation rehabilitation, wildfire risk reduction, and community participation. The results provide a scientific basis for developing adaptive management strategies that integrate ecological restoration, community empowerment, and sustainable livelihood development within the framework of Nature-Based Solutions (NbS). Practically, these findings highlight the importance of strengthening the capacity and activeness of Forest Farmer Groups (KTH) as key actors in forest management, enhancing coordination among BNPT, government agencies, and local stakeholders, and

promoting community-based ecosystem rehabilitation programs. Sustainable livelihood initiatives, such as environmentally friendly coffee cultivation, may further support local economic development while maintaining ecosystem functions and contributing to the long-term sustainability of KHDTK BNPT.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to the National Counterterrorism Agency of the Republic of Indonesia (BNPT), the Ministry of Forestry, the Regional Forestry Branch Office (CDK), the Regional National Unity and Politics Agency (Kesbangpol), and the Forest Farmer Groups (KTH) surrounding KHDTK BNPT for their support, valuable information, and participation throughout the research process.

The authors also extend their appreciation to all stakeholders and local community members who contributed to data collection, field observations, interviews, and field activities. Special thanks are addressed to the Master of Environmental Studies Program, Universitas Terbuka, for its academic guidance and support during the completion of this study.

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