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Enhancing Stakeholder Capacity for Effective Invasive Species Management in Conservation Areas

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Abstract One of the ecological challenges in managing conservation areas is the colonization and establishment of alien and/or native plant species, especially after forest disturbances. The capacity stakeholders to determine the invasiveness risk of these plant species groups and then management strategies to monitor changes in vegetation structure and species composition is critical. The community engagement program aims to improve the capacity of conservation area stakeholders to identify plant species, including invasive species, and assess the risk of invasive species. Focus group discussion (FGD) were conducted online and offline and targeted stakeholders of the Natural Resources Conservation Agency (Balai Konservasi Sumber Daya Alam–BKSDA) of Central Java Province. Three FGD sessions were held on the topics: (1) forest monitoring and invasion ecology, (2) plant species identification and invasive species monitoring techniques, and (3) vegetation and invasiveness risk analysis. During the discussion, target groups shared ideas and lessons learned related to managing invasive species in the field. The results showed a significant increase in the capacity of the target group (p=4.546e-09), as the average pretest score was 56.25 ± 13.68 compared to the average posttest score of 75.70 ± 20.27. The target group understands the definition of an invasive (alien) species, the factors that determine the success of this species invasion, and the positive and negative contributions alien species to the newly established ecosystem. Some gaps that need to be addressed relate to methods and criteria for identifying species invasiveness in invasive species risk analysis. As a follow-up, a practical training on invasive (alien) species risk analysis was conducted at different occasion and funding sources.

1. INTRODUCTION

Plant invasion is defined as the process by which native or non-native plant species expand their geographic range into ecosystems where they were not historically present (Booth et al., 2003). Half of the approximately 2,000 alien plant species introduced to Indonesia have become invasive plant species (Tjitrosoedirdjo, 2005). Invasive species include native and alien species that colonize an area on a large scale and could affect the ecological, economic and social aspects of that area. Invasive alien species are plants, animals, microorganisms, and other organisms that are not domestic to an ecosystem and could cause ecosystem and environmental damage, economic loss and/or adverse effects on biodiversity and human health (Convention on Biological Diversity, 2002; International Union for Conservation of Nature and Natural Resources, 2000).

In the management of natural ecosystems, species invasion is a critical problem due to its effects on global environmental change (Hulme et al., 2009; Vitousek, 1994).

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Invasion of alien species threatens biodiversity and native species (Abduh et al., 2021; Gordon, 1998; Kohli et al., 2009), which can alter the nutrient cycle, hydrological cycle, and energy balance of the invaded ecosystem (Mack et al., 2000). The invasion of *Acacia decurrens* into fire-damaged forest lands in Mount Merbabu National Park has altered the composition of native plant species (Purwaningsih et al., 2010). Cases of species invasion: (a) Sadengan open grass land of Alas Purwo National Park have been invaded by *Senna tora*, *Austroeupatorium inulifolium*, and *Lantana camara* (Hakim et al., 2005), (b) the savannah of Baluran National Park have been invaded by *Acacia nilotica* (Djufri, 2004), have threatened the abundance of banteng (Bos javanicus) that is prioritized for conservation. The invasions reduced the proportion of grass cover of the areas, which grass is a source of food for banteng (Djufri, 2004; Hakim et al., 2005).

Monitoring the changes in forest ecosystems is one of the strategies for preserving ecosystem functions. Such monitoring can be done through the active participation of individuals, groups and organizations (Soetomo, 2006; Zulkarnain, 1999). Peson Subah II Nature Reserve (NR), which was established to protect its lower mountain forests and water sources, also faces the problems of anthropogenic disturbances that change the structure and composition of the forest. Stakeholders of this conservation area have noted the dominance and colonization of several potentially invasive native and alien plant species that are prevalent in Peson Subah II NR. In 2022, as part of a joint research project with the Forest Ecology Laboratory, forest monitoring was carried out in the reserve area. During the monitoring project, we identified a gap in the capacity of stakeholders and the resources of regional managers of Peson Subah II NR in managing the invasion of (alien) species. Monitoring capacity, including monitoring in changes in forest structure, removal and development of sustainable use of invasive plant species, are key to conservation and management of forest resources. In addition, several other conservation areas in Central Java also faced similar issues, such as the anthropogenic disturbances, the risk of potentially invasive species, and differences in capacity to address these issues. Therefore, it is also important to map the ecological issues of other conservation areas to prevent species invasions on a larger scale.

The training of "Building Capacity of Conservation Area Stakeholders in Managing Invasive Species" aims to improve the capacity of the stakeholders to identify plant species, including the invasive species, and assess the risk of invasive species. The training was conducted as a focus group discussion (FGD) with stakeholders from several conservation areas around Central Java.

2. METHOD

The training was a community engagement program organized by the Forest Ecology Laboratory, Faculty of Forestry, Universitas Gadjah Mada, in 2023. The program consisted of two main phases: preparing training materials and conducting a focus group discussion. The training materials included herbariums, invasive plant species identification tools, and a training module. The herbarium and plant identification key were developed as part of the laboratory-based research project at NR Peson Subah II. The training module covered plant identification methods based on Tjitrosoepomo (1998), forest monitoring techniques, vegetation analysis, and risk analysis methods for potentially invasive (alien) plant species.

The focus group discussion was held on June 13, 2023, from 8:00 AM to 4:00 PM at Fave Hotel Semarang. The training disseminated the results of the laboratory research project conducted in NR Peson Subah II in 2022. To achieve a broader impact, stakeholders not only from NR Peson Subah II but also from other conservation areas under the Natural Resources Conservation Agency (BKSDA) of Central Java Province were invited. The participants included the head of the administrative subdivision, forest ecosystem specialists (pengendali ekosistem hutan–PEH), and forest rangers (polisi hutan–Polhut). Due to high interest in the training, online participation via Zoom was also organized. However, the limited availability of funding, which could only cover 20 meeting packages for the community engagement program, was a significant constraint.

The criteria used in this training module to classify plant as invasive species are: (a) plant species listed under the Minister of Environment and Forestry Regulation Number: P.94/MENLHK/SETJEN/KUM.1/12/2016 on Invasive Species, as one of basic regulations in Indonesia to classify plants and animals as invasive species, (b) invasive plants included in the list of the "100 of the World's Worst Invasive Alien Species" according to the Global Invasive Species Database (GISD), available at `http://www.iucngisd.org/gisd/100_worst.php`, (c) invasive plants recorded in the Invasive Species Compendium (ISC), available at `https://www.cabi.org/ISC`, and (d) invasive plants that are not found in the three criteria above, but are clearly invasive species in the field that have an impact on biodiversity and native ecosystems in an area (Soerjani et al., 1987; Weber, 2003).

The focus group discussion was organized into three main sessions: introduction to vegetation monitoring and invasion ecology, plant species identification and invasive species monitoring techniques, and vegetation analysis and invasive risk. To assess the target group's understanding of the material presented, evaluations were conducted at the beginning and end of the training using the Quizizz application. The questions used in both the pretest and posttest were identical.

To evaluate the improvement in ecological understanding and invasive species management among the target group, the difference between pretest and posttest scores was calculated and statistically analyzed using the Wilcoxon rank test. Additionally, to gain deeper insights into the target group's comprehension of invasive species materials, the accuracy rate of responses for each question and the change in response accuracy between the pretest and posttest were examined.

$$\text{Accuracy}(\%) = \frac{\text{Individual total score for correct and partially correct answers}}{(\text{Total quiz score} \times \text{number of target})}$$

$$\text{Change in accuracy}(\%) = \frac{\text{Post accuracy} - \text{Pre accuracy}}{Postaccuracy} \times 100\%$$

Changes in accuracy scores for each question are valuable for assessing whether the understanding of specific aspects of invasive species material has improved (indicated by positive change scores) or whether gaps in understanding persist (indicated by negative change scores) among the target group. This information serves as a crucial reference for planning and enhancing future training programs.

Following the presentation of each topic, a question-and-answer session was conducted. Upon completion of all presentations, the discussion panel primarily focused on mapping ecological challenges related to invasive species across different conservation areas and sharing lessons learned from various strategies and practical methods for controlling invasive species.

3. RESULT AND DISCUSSION

The opening session of the training was led by Prof. Erny Poedjirahojoe. Before the presentation of the first topic, the target group received a pretest to answer questions using the Quizizz application. The average pretest score was 56.25 ± 13.68 (mean ± SD) with a value range of 30–80. The pretest results show that about 40% of concepts related to invasive species are not well understood by the target group.

After the opening session, during an introductory presentation on vegetation monitoring and invasion ecology, Ni Putu Diana Mahayani highlighted the following points: (1) understanding the ecological study of an ecosystem forms the foundation for interpreting changes in the community structure of that ecosystem; (2) the ability to analyze biotic and abiotic environmental data is essential for inferring the ecological processes driving ecosystem changes; and (3) research on invasion ecology and invasive species risk analysis is crucial for developing appropriate management strategies for areas impacted by one or more invasive species.

Frita Kusuma Wardhani highlighted that the target group's ability to identify plant species remains limited to local names. However, relying on local names poses several challenges: they are understood only by the local community, they do not correspond to specific taxonomic categories, and the same taxon may have different names. This limitation in plant identification has been a significant obstacle for stakeholders in monitoring plant species, particularly invasive ones. To address this issue, one recommended approach is the development of a pocketbook containing a list of plant species specific to a particular conservation area, along with photographs of these plants. Creating such a pocketbook would require collaboration with specialists in plant taxonomy. This session also covered plant monitoring techniques employed by the target group in the field. Overall, the participants demonstrated a general understanding of various plant monitoring techniques.

Ryan Adi Satria's discussion on plant analysis and invasive plant risk emphasized two key aspects: invasiveness and management feasibility. One participant shared their experience in analyzing the threat posed by invasive plants to the ecosystem within their conservation area. However, understanding and applying multiple parameters in such analyses still require expert assistance and specialized skills, particularly to gather supporting data such as information on the potential for spread, the extent of infestation, and the development of management priority recommendations. To address these challenges, it is necessary to conduct technical training on invasive plant risk analysis. Additionally, exploring alternative management strategies for invasive species, such as repurposing them for other valuable uses, presents another potential focus for future training programs.

During the general discussion session, the target group highlighted various issues related to invasive species encountered in the field. Table 1 provides an overview of several field situations and the removal methods employed for species identified as invasive.

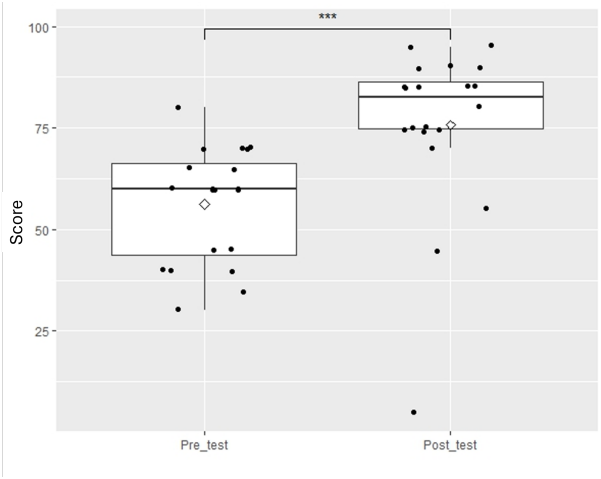

Figure 1 . Score comparison between pretest and posttest of target group, the *** sign indicates a significant difference (p = 4.546e-090)

After the training activity, the target group completed a post-test using the same questions as the pre-test. The average post-test score was 75.70 ± 20.27, with a range of scores from 45 to 95. Compared to the pre-test scores, there was a 55% increase in the average score, along with improvements in both the lower and upper score ranges. However, there was one instance where a participant appeared not to have completed the post-test (Figure 1). The significant increase in scores, with an average improvement of 26.06 ± 11.69 between the pre-test and post-test (p = 4.546e-09), indicates that the target group's capacity significantly improved after participating in the training (Figure 1).

Table 1 . Notes on Issues in the identification and management of invasive species in several conservation areas in Central Java

No.	Discussion Notes
1.	Approaches to determine whether or not changes occurred in forest community structure;
2.	The importance of exact matching of local names and scientific names;
3.	The pocket book of plant species, including invasive species, is necessary.
4.	It is essential to learn and be familiar using field tools of measurements that researchers can efficiently conduct their studies;
5.	Alternative approaches to invasive species are crucial, especially given the implications of climate change;
6.	Need for training on invasive risk analysis;
7.	In 2021, the encroachment in Peson Subah I Nature Reserve led to the spread of kuskuta and clampis plants;
8.	Incidents of alien species invasion in the Telogo Runcing Nature Reserve in 2010 with an abundance of catfish and in 2017 with an abundance of goldfish;
9.	Problems in the Mount Celeris Nature Reserve in 2011: (1) invasion by kecurutan plant, (2) forest fires caused an abundance of meru plant, (3) due to the encroachment, people have planted cottonwood, oil palm, and bamboo in abundance in this area;
10.	The large number of lianas in the Kembang Nature Reserve have caused the mortality of the mother tree;
11.	After Keling 1, 2, 3 Nature Reserve were encroached and looted, people started planting johar in 2009; forest ecosystem specialist (PEH) conducted ecosystem restoration in 2017 to eradicate abundant *kerinyu* and *putri malu* (*Mimosa pudica*) plants;

Table 2 . Accuracy of answers to each question among target group

No.	Question	Accuracy (%)		
		Pre	Post	Changes (Post-Pre)
1.	Species that are introduced into an ecosystem unnaturally, are categorized as?	67	71	6
2.	Species, both native and alien, that widely affect their habitat, causing environmental damage, economic loss, or harm humans, are categorized as?	81	76	-7
3.	Introduced species intentionally or unintentionally from outside their natural habitat, including species, subspecies, varieties, and races, including the whole organisms, body organs, gametes, seeds, eggs, and propagules that are able to live and reproduce in their new habitat, which then becomes a threat to biodiversity, ecosystems, agriculture, socio-economics and human health, at the ecosystem, individual and genetic levels are categorized as?	62	81	23
4.	Factors that influence the success of a species in invading a new ecosystem?	62	90	31
5.	What positive contribution can an alien species make to a newly invaded ecosystem?	33	57	42
6.	Some negative consequences that may occur due to the increase in the abundance of native species or the invasion of alien species into disturbed ecosystems are?	71	81	12
7.	Analyzing the risk of an invasive alien species entering an area or the spread of an alien species outside of its natural habitat, which may have potential negative impacts is known as?	95	76	-25
8.	Risk analysis of invasive plant species is determined based on?	43	38	-13
9.	Which of the following that is not a primary consideration in estimating the risk of invasion, namely?	67	81	17
10.	Estimation of management feasibility includes evaluation of aspects, except for?	14	48	71
11.	Management priorities are categorized as alert if they have reached the risk criteria of?	24	71	66
12.	How to carry out plant identification?	86	86	0
13.	What is the correct way to write Latin names/scientific names/botanical names?	29	48	40
14.	What is it called for the activity of collecting data/samples (specimens) in the field?	38	51	25
15.	What is the correct sequence of steps for preparing dry herbarium before storage?	29	81	64
16	The following photo is one of the species included in the list of invasive species in P.94/2016. What species is this?	52	76	32

Continuation of Table 2

No.	Question	Accuracy (%)		
		Pre	Post	Changes (Post-Pre)
17.	The following photo is one of the species included in the list of invasive species in P.94/2016. What species is this? (Figure)	62	81	23
18.	One of the disadvantages of dry collection is?	48	86	44
19.	Which statement is correct regarding writing scientific names?	48	67	28
20.	One of the advantages of wet collection is?	62	90	31

The change in accuracy scores for each question between the pretest and posttest provides insights into the target group's understanding of specific aspects of invasive species (Table 2). The average accuracy of all answers during the pretest was 53.65 ± 21.16%, which increased to 71.8 ± 14.99% during the posttest. However, questions 7 and 8, which focused on invasive risk analysis, showed a significant negative change in accuracy, indicating a gap in understanding. Accuracy for other questions varied, with positive scores reflecting an improvement in the target group's comprehension of the respective aspects addressed in the questions. The declining accuracy for certain questions highlights an urgent need to enhance stakeholders' capacity to effectively address invasive species challenges (Table 2).

In response to the identified needs, it was decided to conduct a follow-up training session focusing on technical aspects of vegetation analysis and risk analysis, to be held at a different time and supported by separate funding sources. The technical training demonstrated that stakeholders could successfully perform risk analyses for the 20 identified plant species. The results of the invasive plant risk analysis revealed that 1 species fell into the high-risk category, 2 species into the medium-risk category, and the remaining 17 species into the negligible-risk category. Meanwhile, the management feasibility analysis indicated that 1 species was categorized as having low feasibility, 1 species as medium feasibility, and 18 species as having very high feasibility. The final output of the risk analysis was a set of priority management recommendations: 2 species were recommended for "Prevent Spread," 1 species for "Manage the Site," and the remaining 17 species for "Monitor."

4. CONCLUSION

The training on "Enhancing Stakeholder Capacity for Effective Invasive Species Management in Conservation Areas" was a success, resulting in a significant improvement in participants' understanding of invasive species, identification methods, and invasive risk analysis. This was evidenced by a substantial increase in the average posttest score (75.70 ± 20.27) compared to the pretest score (56.25 ± 13.68) (p = 4.546e-09). An important takeaway from the training was the identified gap in the target group's understanding of invasive risk analysis. To address this, follow-up initiatives were implemented, including technical training sessions on invasive plant identification and risk analysis.

The overall impact and benefits of this training were highly significant in advancing adaptive management of invasive species, considering factors such as the management history of the areas, the colonization period of invasive species, habitat conditions, financial resources, and management feasibility. Given the ongoing dynamics of forest ecosystem disturbances, which directly affect ecosystem functioning and all aspects of life, similar training programs should be conducted on a larger scale to ensure broader and more effective capacity building.

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CONFLICT OF INTERESTS

All authors of this manuscript declare that there is no conflict of interest.

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