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Mangrove Honey Bees: A Food and Nutrition Security Solution for Coastal Communities Affected by Climate

Retno Hestiningsih*, Moh Arie Wuryanto, Sri Yuliawati, Henry Setiawan, Dwi Sutiningsih, Meira Nur Aini

Universitas Diponegoro, Indonesia

*Corresponding author: retnohestiningsih@live.undip.ac.id

Abstract
Climate change has caused significant impacts on coastal areas, particularly in the form of tidal flooding, coastal abrasion, and environmental degradation, which in turn affect food and nutrition security as well as the socio-economic conditions of local communities. This community service activity aimed to strengthen food and nutrition security while enhancing the adaptive capacity of coastal communities to climate change through the sustainable utilization of mangrove ecosystems by implementing mangrove honey bee cultivation in Tugu District, Semarang City. The program employed a participatory community-based approach that included socialization activities, a one-day technical training on mangrove honey bee cultivation, the establishment of a community business group, and the assessment of participants' knowledge improvement using pretest and posttest methods. The results indicated an increase in participants' knowledge following the training, accompanied by improved community awareness regarding the importance of mangrove conservation and the economic potential of mangrove honey as a nutritious food source. Furthermore, the program successfully facilitated the formation of a mangrove honey bee management group oriented toward sustainable business development. Based on these findings, it can be concluded that mangrove honey bee cultivation has strong potential as an effective climate change adaptation strategy to support food and nutrition security as well as the economic resilience of coastal communities. The recommendations emphasize the need for continuous mentoring, strengthening of community business institutions, and the integration of mangrove conservation programs with local economic development to support the implementation of nature-based community service models in coastal areas.

Keywords: mangrove, honey bees, food security, nutrition, climate change

INTRODUCTION

Climate change represents a major global environmental challenge, with coastal regions being among the most vulnerable to sea-level rise, tidal inundation, and shoreline erosion. These pressures not only lead to the degradation of coastal ecosystems but also pose serious threats to food security, nutritional adequacy, and the economic stability of coastal populations. Mangrove ecosystems play a vital role in both mitigating and adapting to climate change due to their remarkable ability to capture and store carbon, commonly referred to as "blue carbon" (Donato et al., 2011; Alongi, 2012). As one of the most carbon-dense forest ecosystems in tropical regions, mangroves make a significant contribution to global climate change mitigation efforts (Murdiyarso et al., 2015; Hamilton & Friess, 2016).

In Indonesia, mangrove ecosystems are of particular importance because of their vast distribution and substantial carbon reserves. Recent research indicates that Indonesian mangroves have strong potential for carbon sequestration and emission reduction, underscoring their strategic role in both national and global climate mitigation initiatives (Handayani et al., 2023; Arifanti et al., 2022). Nevertheless, despite their ecological value, mangrove ecosystems continue to face degradation caused by land-use conversion, unsustainable exploitation of resources, and limited integration between conservation initiatives and local livelihood systems. This situation highlights the urgency of adopting conservation strategies that simultaneously promote environmental sustainability and community well-being.

Increasingly, mangrove conservation and restoration efforts emphasize ecosystem-based and community-oriented approaches. Incorporating livelihood-supporting activities into mangrove conservation frameworks has been shown to strengthen community participation and enhance long-term sustainability. One promising but still underutilized option is the development of beekeeping within mangrove ecosystems. Mangrove vegetation provides continuous nectar sources that support honey production without compromising ecological integrity. As such, beekeeping represents a nature-based solution that aligns conservation goals with income generation and improvements in food security (Harianja et al., 2023).

Empirical evidence further supports the viability of mangrove-based honey production as an alternative livelihood for coastal communities. A study conducted in Sabancuy, Mexico demonstrated that honey production within mangrove ecosystems could generate substantial additional income while maintaining ecological sustainability (Cahuich-Campos et al., 2025). Likewise, initiatives to enrich flowering plant diversity to support stingless bees (Trigona spp.) in mangrove ecotourism areas in Indonesia have been shown to enhance both ecosystem sustainability and local livelihoods (Dewi et al., 2025). These findings suggest that mangrove-based beekeeping has considerable potential to strengthen food security, nutrition, and economic resilience in coastal regions.

Despite these opportunities, the use of mangrove honey bee cultivation as a strategy for climate change adaptation and food security remains limited, particularly in community-based contexts in Indonesia. Previous studies have largely focused on ecological valuation, carbon stock assessment, or technological approaches such as remote sensing for blue carbon monitoring (Kuenzer et al., 2024), while fewer have emphasized participatory capacity-building models that actively involve coastal communities. Key constraints include limited technical expertise, weak local institutions, and insufficient linkage between conservation programs and economic development opportunities.

Accordingly, this community service-based study seeks to address these gaps by implementing and evaluating a participatory mangrove honey bee cultivation program within a coastal community in Indonesia. The study prioritizes capacity building, knowledge dissemination, and institutional strengthening as key strategies to support food security, nutrition, and economic resilience while simultaneously promoting mangrove conservation. The novelty of this work lies in its integration of mangrove-based beekeeping as a climate change adaptation strategy within a community empowerment framework, offering practical insights for the development of nature-based solutions in vulnerable coastal areas.

METHOD

Mangrove Honey Bee Cultivation Training

The main challenges identified within the coastal communities of Tugu District, Semarang City, included limited technical knowledge related to mangrove honey bee cultivation, weak organization of community-based enterprises, and high vulnerability of food and nutrition security resulting from climate change impacts. To overcome these challenges, a community-based capacity-building approach through participatory training and field mentoring was considered the most suitable strategy. Community training has proven effective in enhancing skills, raising awareness, and encouraging the adoption of sustainable livelihood practices, particularly in environmentally vulnerable regions.

This community service initiative adopted a participatory approach that combined environmental education, technical capacity building, and community empowerment. The intervention was designed to strengthen food and nutrition security while improving the adaptive capacity of coastal communities to climate change through the development of mangrove honey bee cultivation. The program was implemented in Tugu District, Semarang City, a coastal area characterized by rehabilitated mangrove ecosystems.

The training program consisted of three core components: socialization and education, technical cultivation training, and institutional strengthening. Socialization activities were carried out through focus group discussions and interactive lectures involving local government officials, fisher groups, women's organizations, and community leaders. The materials addressed the ecological roles of mangroves, the nutritional and health benefits of mangrove honey, and the long-term economic prospects of mangrove-based beekeeping.

Technical training on mangrove honey bee cultivation was conducted through a one-day intensive workshop that integrated classroom instruction with hands-on field practice. The training introduced bee species suitable for mangrove environments, particularly Apis cerana and stingless bees (Tetragonula spp.). Participants were trained in hive construction, colony transfer, routine maintenance, and hygienic honey harvesting methods. Field-based practical sessions were held directly within mangrove areas to enhance experiential learning.

To ensure program sustainability, institutional strengthening was emphasized through the establishment of a joint community business group responsible for managing mangrove honey production. Participants also received basic instruction in simple financial management, product processing, packaging, labeling, and digital marketing. This institutional component aimed to promote collective action, expand market access, and support long-term economic sustainability.

Program effectiveness was assessed using a pretest–posttest design to measure changes in participants' knowledge following the training. Monitoring activities included regular observations of bee colony development and honey yields. The integration of participatory training, field-based implementation, and continuous mentoring was expected to support sustainable mangrove conservation while enhancing household food security, nutrition, and economic resilience. The modules are listed in Table 1.

Table 1. Training Modules in the Mangrove Honey Bee Cultivation Program

Activity	Modules	Tutor Group
Activity-1	Introduction to Climate Change Impacts on Coastal Areas and the Role of Mangroves	Academicians
Activity-2	Ecological Functions of Mangrove Ecosystems and Food Security	Academicians
Activity-3	Introduction to Mangrove Honey Bees (Apis cerana / Stingless Bees)	Beekeeping Practitioners
Activity-4	Hive Construction and Colony Management	Beekeeping Practitioners
Activity-5	Honey Harvesting, Processing, and Hygiene Standards	Practitioners
Activity-6	Group-Based Business Management and Product Marketing	Academicians
Activity-7	Field Practice in Mangrove Area	Practitioners

Table 1 outlines the training modules implemented as part of the mangrove honey bee cultivation program. The training was delivered through a one-day intensive format that integrated classroom-based instruction with hands-on field practice in the mangrove area. Training was allocated to address the ecological, technical, and economic dimensions of mangrove honey bee cultivation.

The classroom sessions addressed key topics such as the impacts of climate change on coastal regions, the ecological functions of mangrove ecosystems, and the potential of mangrove honey as a source of food and income. Practical sessions focused on hive construction, colony management, hygienic honey harvesting techniques, and basic marketing strategies for honey products. Field-based practice accounted for the largest portion of the training to ensure experiential learning and enable participants to directly apply the knowledge within the mangrove ecosystem.

Participant Recruitment

The training program targeted members of coastal communities in Tugu District, Semarang City, including fisher groups, women's groups, and community representatives residing in areas adjacent to mangrove forests. Participants were recruited through coordination with local community leaders and village authorities to ensure the involvement of active community members engaged in coastal-based livelihoods. All participants were residents of the program area and took part in the training on a voluntary basis.

Training Assessment

The effectiveness of the training was evaluated using a pretest–posttest design to assess changes in participants' knowledge of mangrove ecosystems, honey bee cultivation practices, and the economic potential of mangrove honey. The same structured questionnaire was administered before and after the training. The assessment focused on participants' basic understanding of the materials presented by the facilitators, with improved posttest scores indicating an increase in knowledge following the training intervention.

Location and Time

The training activities and field practice were carried out in a coastal area of Tugu District, Semarang City, Indonesia, in 2025. This location was selected due to the presence of rehabilitated mangrove ecosystems and its high vulnerability to climate change impacts, making it an appropriate

setting for the implementation of a mangrove-based livelihood adaptation program. The reasons to choose this location are:

The selection of this location was based on several key considerations. First, in terms of ecosystem suitability, the mangrove area in Tugu District offers favorable ecological conditions for mangrove honey bee cultivation, particularly due to the abundance of mangrove vegetation that serves as a natural source of nectar. Second, accessibility was a major factor, as the site is easily reached by local residents, allowing for high levels of attendance and active participation throughout the training program. Third, the proximity to the mangrove ecosystem enabled direct field exposure, allowing participants to observe and practice honey bee cultivation techniques within the actual environmental setting, thereby strengthening experiential learning.

The training activities were conducted in a single session involving community members from coastal settlements located adjacent to mangrove areas. The one-day training format was intentionally designed to maximize participant engagement while minimizing interference with participants' daily livelihood activities.

RESULT AND DISCUSSION

Should The community service program on mangrove honey bee cultivation offered an integrated approach to strengthening food and nutrition security while enhancing the adaptive capacity of coastal communities to climate change. The program emphasized improving participants' knowledge, technical skills, and awareness related to mangrove ecosystem conservation and its productive utilization through beekeeping activities. The key outcomes of the program are outlined below.

Knowledge Transfer

The primary component of the program was participatory knowledge transfer through structured training activities. The training was designed to provide practical and applicable insights into mangrove ecosystems, mangrove honey bee cultivation techniques, and the economic prospects of mangrove honey. The one-day intensive program combined classroom-based instruction with hands-on field practice conducted within the mangrove area. Most of the training content was delivered through interactive lectures and group discussions to promote active participation. This participatory learning approach enabled participants to ask questions, exchange local knowledge, and connect the training materials with their everyday livelihoods. The documentaion can be seen in Figure 1.

Figure 1. Training Mangrove Honey Bee Cultivation

Mangrove Ecosystem Awareness

An important outcome of the training was the increased awareness among participants regarding the ecological significance of mangrove ecosystems. The training materials highlighted the role of mangroves in coastal protection, climate change mitigation, and the provision of essential ecosystem services. Participants developed a clearer understanding that mangrove conservation is closely associated with sustainable livelihoods and food security.

Group discussions revealed that many participants initially viewed mangroves merely as coastal vegetation. After the training, however, they recognized mangroves as productive ecosystems capable of supporting environmentally friendly economic activities such as honey production.

Technical Skills in Mangrove Honey Bee Cultivation

Technical capacity building formed a major part of the program. Participants were introduced to honey bee species suitable for mangrove environments, hive construction methods, colony

management practices, and hygienic honey harvesting techniques. Practical training was carried out directly in the mangrove area, allowing participants to apply the techniques under real field conditions.

Hands-on field practice strengthened participants' understanding of appropriate hive placement, routine maintenance, and colony monitoring. This experiential learning process was crucial in ensuring that participants could independently implement the techniques following the training.

Figure 2. Field practice of hive installation in the mangrove area

Group-Based Business Orientation

In addition to technical skills, the program enhanced participants' understanding of collective business development. Participants were encouraged to establish a joint business group to manage mangrove honey production in a sustainable manner. Training topics included basic financial record-keeping, product processing, packaging, labeling, and simple marketing strategies.

This component aimed to promote mangrove honey production as a community-based enterprise rather than an individual effort, thereby improving economic resilience and competitiveness in the market.

Figure 3. Group discussion on mangrove honey business development

Assessment Test Result

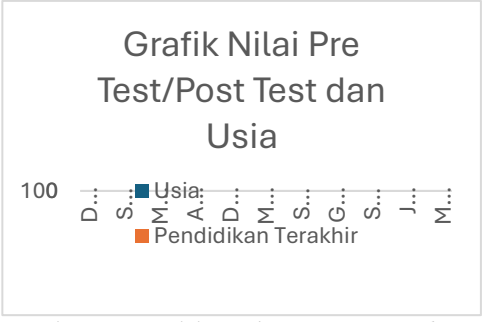

Figure 4. Participants' assessment result

Training effectiveness was evaluated using a pretest-posttest assessment to measure changes in participants' knowledge levels. The results showed an improvement in participants' understanding of mangrove ecosystems, honey bee cultivation techniques, and the economic value of mangrove honey after the training.

Participants demonstrated better performance in answering questions related to the training materials during the posttest compared to the pretest, indicating that the knowledge transfer process

was effective in enhancing their cognitive understanding.

CONCLUSION

Informal education in short class as the used method has fulfilled the objective of this community service. Through the training, the palm oil plantation smallholders increase their knowledge of plantation replanting and increases their awareness about replanting. The training combines in class learning and field experience. It is not delivered by academicians only, but also palm oil field expert. This method makes farmers more understand the material that has been taught. The knowledge about palm oil plantation replanting can overcome the risks related to replanting. This achievement will be the first step to plan and execute the replanting activity.

To continue the result of this community service, we suggest other opportunities for the next community service, there is the assistance of plantation replanting activity, and of course, it will involve many parties. This activity will be better if followed by other training for plantation smallholders such as increasing palm oil plantation productivity and establish sustainable palm oil plantation.

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