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A STUDY ON THE ADAPTATION OF PLANTS IN THE SAND DUNES OF GLAGAH VILLAGE TO SUPPORT TOURISM DESTINATIONS IN KULON PROGO REGENCY

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ABSTRACT

Sand dunes are natural landscapes formed by geological processes along dry coastal areas. Adaptation is a biological mechanism that enables plants to survive, reproduce and respond to environmental changes. The survey was conducted using transect surveys, direct observation and recording of the diversity of plant species adapted to the coastal dune area of Glagah Village. The study identified 11 adapted tree species, including waru (*Hibiscus tiliaceus*), keben (*Barringtonia asiatica*), ketapang (*Terminalia catappa*), orak-arik (*Acacia auriculiformis*), bintaro (*Cerbera odollam*, *Cerbera manghas*), cemara laut (*Casuarina equisetifolia*), jambu monyet (*Anacardium occidentale*), kelor (*Moringa oleifera*), pule (*Alstonia scholaris*) and trembesi (*Samanea saman*). The main vegetation of the beach includes: balaran (*Ipomoea pes-caprae*), preketekan (*Spinifex littoreus*), krandan (*Canavalia ensiformis*), pandan duri (*Pandanus tectorius*) and widoro (*Ziziphus mauritiana*).

Key words : Survey, Plant species, Beach, Sand dunes, Glagah village.

Introduction

One type of coastal ecosystem is sand dunes, which are natural landscapes formed by geological processes along dry coastal areas. The sand dunes, located in the coastal area of Glagah Village, Temon Subdistrict, Kulon Progo Regency, were formed by sand deposits carried by the Progo River, which originated from an active volcanic eruption. Over thousands, even millions of years, sediment from mountain sands was consistently carried by rivers into the Indonesian ocean, forming sand dunes.

Deposits of sand mixed with iron-rich sand (wedi malelo) and highly saline seawater, which during the dry season are carried inland by ocean waves and wind, forming natural sand dune formations. Plant adaptation is a biological mechanism that enables plants to survive, reproduce, and respond to extreme environmental changes. Adaptations such as changes in morphology, physiology and behavior enable plants to survive and thrive. Advances in agricultural techniques for managing

sand dunes, shrimp farming, and the construction of YIA Airport have caused the sand dunes to become less steep and eventually disappear, allowing invasive plant species to adapt. This incident is closely linked to the botanical knowledge of the local communities in the surrounding area. Cotton (1996) ethnobotanical enquiry into the tradisional botanical knowledge (TBK) of extant peoples is dependent on the effective application of a number of key anthropological and botanical methodologies.

Natural barriers in the vegetation structure of sandy beaches include: *Ipomoea pes-caprae*, *Canavalia maritima*, and *Spinifex littoreus* (Batoro, 2017). In the northern part of the dunes, the vegetation includes: pandan (*Pandanus tectorius*), singkil (*Premna* sp.), biduri (*Calotropis gigantea*), *Carex* sp., and widoro (*Ziziphus mauritiana*), leading to the sporadic formation of sand dunes that can reach heights of 2–6 meters (Batoro, 2017; 2018). Sporadic sand dune formations, spaced 400–500 meters apart, border grasslands consisting of community-

owned land with a wide variety of distinctive and unique biodiversity. Land-use changes took on a unique character following the development of coastal tourism, coastal agriculture, breakwaters, and YIA Airport; reforestation was carried out in an effort to withstand sea waves and winds.

Materials and Methods

The research was conducted through surveys and direct observations using a transect method along the coastline of the sand dunes in Glagah Village, Temon Subdistrict. Flora species were recorded and identified directly; when collection was difficult, specimens were prepared for the herbarium and stored at MUBR UB Malang (de Vogel, 1987; Batoro, 2017). Data on the adaptation of invasive plant species were recorded and identified for comparison based on research conducted by Batoro *et al.* (2017; 2018a,b; 2019) and forest rehabilitation data from the Ministry of Environment and Forestry's Directorate General of Protected Forest Management in Kulon Progo.

Results and Discussion

The species composition of the natural coastal vegetation directly bordering the sea includes: *Canavalia maritima*, *Spinifex littoreus* and *Carex* sp., *Ipomoea pes-caprae*, ciplukan (*Physalis* sp.), *Pandanus tectorius*, and widuri (*Calotropis gigantea*) (Fig. 1a,b,c). The species listed above have adapted because they require specific habitats, high elevations, and high salinity levels. The coastal structure along the shoreline and the sand dunes exhibit nearly identical patterns and structures, a finding supported by previous research (Batoro, 2017).

The morphological characteristics of coastal species include strong roots and stems, thick leaves and tolerance to high salinity; they are generally vines or trees. Coastal barriers, which are distinguished by the structure of the shoreline and consist of various tree species, can withstand ocean waves and wind, as well as prevent the displacement of sand caused by wind and waves (Batoro, 2018). The *Canavalia maritima* is a vine; coastal communities use its seeds to make tempe, while its flowers are used as a vegetable in *gudangan* or *pecel* (Batoro, 2017; Batoro, 2018).

The endemic *Physalis* sp. is found throughout the sandy coastal area of Karangwuni Village, while Glagah Village is located north of the sand dune, edible ripe fruit, sweet salty taste; by the local community it is used as fruit, medication for high blood pressure, heart disease, malaria and diabetes mellitus (Batoro, 2021). The identification of plant species diversity can be aided by transfer learning and deep learning (Musyaffa *et al.*, 2024),

while its management utilizes the Internet of Things and Fuzzy Sugeno Logic, IoT (Widia *et al.*, 2025).

The boundary between the beach and the sand dune area consists of mounds that differ in both the dominant species and the diversity of their flora. The natural vegetation behind the coastal structures (dunes) acts as a barrier on the sand dunes, including *Pandanus tectorius*, *Premma* sp., *Calotropis gigantea*, *Carex* sp., Cyperaceae, *Spinifex littoreus*, Poaceae, Asteraceae, *Ziziphus mauritiana* and *Morinda citrifolia*. The presence of these plant species leads to the sporadic formation of sand dunes that can reach heights of 2–6 meters and extend up to 500 meters from the shore (Batoro, 2017).

Batoro *et al.* (2018) describe the coastal vegetation structure at Trianggulasi Beach in Alas Purwo National

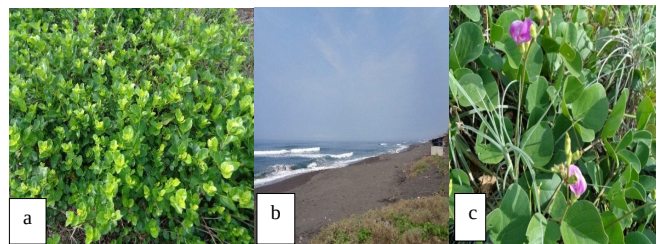


Fig. 1 : a. Singkil (*Premma* sp.) plants. b. The structure of Glagah Beach and c. *Canavalia maritima*.

Park (TNAP) which served as a control site for the study as consisting of *Ipomoea pes-caprae*, *Canavalia maritima*, *Carex* and *Spinifex littoreus*. Meanwhile, the vegetation behind the beach includes: dudulan (*Scaevola taccada*), *Pandanus tectorius*, *Hibiscus tiliaceus*, *Barringtonia asiatica*, *Terminalia catappa*, *Cerbera odollam*, *Cerbera manghas*, *Calophyllum inophyllum*, *Cycas rumphii* and *Eupatorium trifolium*. The diversity of flora along the northern sandy coast of Java shares similarities with that of the southern coast, including: *Casuarina equisetifolia*, mimba (*Azadirachta indica*), and *Acacia arabica*. *Ipomoea prescaprae*, *Terminalia catappa*, *Lannea coromandelica* and *Calotropis gigantea* (Batoro and Wiyono, 2021).

The diversity of shrubs on the sand dunes of Glagah Village includes: *Premma* sp., *Jatropha curcas*, *Calotropis gigantea*, *Stachytarpheta jamaicensis*, *Blumea balsamifera*, *Urena lobata*, *Mimosa pudica*, *Hyptis suaveolens*, *Sida rhombifolia*, *Lantera camara*, *Leucas javanica*, *Isotoma longiflora*, *Euphorbia hirta*, *Euphorbia heterophylla*, *Ageratum conyzoides*, *Urena lobata*, *Crotalaria striata*, *Hyptis suaveolens*, and *Amaranthus spinosus* (Fig. 2a,b,c). Varieties of vines: *Passiflora foetida*, *Spinifex littoreus*, *Centrosoma pubescent* and *Cassytha filiformis*. The diversity of tree

species includes *Acacia auriculiformis*, *Pandanus tectorius*, *Ziziphus mauritiana*, *Zyzygium cumini*, *Morinda citrifolia* and *Moringa oleifera*.

Various dune herbaceous plants in the central area up to the edge of the cultivated fields: tlepok (Asteraceae), *Cyperus rotundus*, *Cyperus brevifolius*,

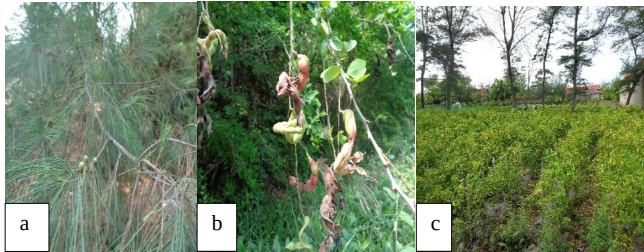


Fig. 2 : Introduced plants on sand dunes. a. *Casuarina equisetifolia*, b. Fabaceae and c. tourist sites and cultivated plants.

Euphorbia hirta, *Tridax procumbens*, *Mimosa pudica*, *Hyptis suaveolens*, *Sida rhombifolia*, *Euphorbia heterophylla*, *Leucas javanica*, *Passiflora foetida*, wulu asu (Cyperaceae), *Tridax procumbens*, *Eragrostis amabilis*, *Cynodon dactylon*, *Eleusine indica*, alang-alang (*Imperata cylindrica*), *Dactyloctenium aegyptium*, *Cynodon dactylon* and *Cyperus rotundus*. Presence of the breakwater has caused the structure of the cemplongan/lagoon to become fragmented, so that the current flowing toward the sea at that location can be utilized for water-based tourism (Fig. 3a,b). Similarly, breakwaters, if properly managed, can serve as sites for water-based tourism and fishing, but they require strict supervision (Fandeli, 2002).

The closure of the lagoon off the sea has caused changes in the lagoon's biodiversity; for example, the diversity of algae (Chlorophyceae), fish, and shrimp has changed and become limited. Similarly, the transformation of the natural sand dune environment into a cultivated landscape including shrimp ponds, agricultural crops and tourism ventures has had certain consequences.

The government has carried out reforestation efforts to increase biodiversity, including the following species:



Fig. 3 : a. Breakwater. b. Cemplongan/lagoon a unique and beautiful sight.

Terminalia cattapa, *Cerbera manghas*, *Casuarina equisetifolia*, *Samanea saman*, *Switenia macrophylla*, *Pterocarpus indicus* and *Gliricidia sepium*, *Jatropha curcas*, *Acacia auriculiformis*, *Hibiscus tiliaceus*, *Anacardium occidentale*, *Moringa oleifera*, pule (*Alstonia scholaris*), *Lagerstroemia speciosa*, *Pithecellobium duce*, *Barringtonia asiatica*. The 2019 rehabilitation of sand dune forests and coastal lands in Kulon Progo, Yogyakarta including a project in the village of Glagah involved several species, such as *Casuarina equisetifolia*, *Calophyllum inophyllum*, *Pandanus tectorius*, *Terminalia cattapa* and *Barringtonia asiatica* and was carried out by the Ministry of Environment and Forestry's Directorate General of Protected Forest Management. This initiative is crucial for protecting tourist areas, local communities and YIA (Yogyakarta International Airport). It turns out that various tree species have adapted and are growing and thriving, resulting in an increasingly diverse dune flora.

The reforestation of the Australian pine, known as the Australian pine or beach sha oak (sea pine), a synonym for *Casuarina litorea* L. ex Fosberg & Sacht., is thriving; this is due to the fact that the environment has already undergone changes. When adding tree species to dune environments, it is important to select trees with strong, attractive branching that can withstand wind and ocean waves: *Scaveola taccada*, *Calophyllum inophyllum*, *Ziziphus mauritiana*, *Pandanus tectorius*, *Terminalia cattapa*, *Samanea saman* and *Cerbera manghas*, will be highly beneficial (Halle, 1978; Batoro, 2017).

Increasing plant biodiversity on beaches and sand dunes can attract a diverse range of bird species to the area. However, this can cause interference with aircraft flight (Suripto and Fitriana 2013; Batoro, 2018; Widodo *et al.*, 2020). Flora diversity also provides food sources and shelter for organisms such as sand lizards, gagak (*Corvus enca*), gemak (*Turnix sylvatica*), turtle doves, and deruk (*Streptopelia chinensis*); this is further illustrated by the utilization of sea snails (Lisarni *et al.*, 2015; Rahmatuloh, 2020).

In several locations that have been converted to farmland and are currently under cultivation, the following crops have been recorded: *Cocos nucifera*, *Manihot utilisima*, sweet potato (*Ipomoea batatas*), gedang (*Musa paradisiaca*), *Gynura divaricata*, chili peppers (*Capsicum frutescens*, *Capsicum annum*), watermelon (*Citrullus lanatus*), *Arachis hypogaea*, *Solanum melongena* and dragon fruit (*Hylocereus polyrhizus*). The diversity of these cultivated plants can significantly benefit the local economy and contribute to environmental conservation in the region. Similarly, the bentongan

technique is used for crop cultivation is pohong, broil beans, soybeans, and climbing cassava, as well as for conservation purposes. Social capital is the foundation of sustainable community-based agriculture and is the strongest factor linking socioeconomic dominance (Ambayoen *et al.*, 2024). Can the social capital of Glagah village support the development of tegalan and sand dune agriculture, as well as tourist destinations?

The existence of natural sand dunes has been affected by development, so the relevant authorities (the government) have introduced innovations such as sand mounds, sand pits and breakwaters, which are expected to provide support and slow down the impact of ocean waves, strong winds, and tsunamis. Monitoring and evaluating the success of reforestation in several case studies of sand dune ecosystems, along with increased biodiversity, are expected to test and enhance species integrity in natural sand dune ecosystems. Tree adaptation has progressed very well following the government's construction of breakwaters, lagoons, tourist attractions, dune farming, and forest rehabilitation. An Internet of Things (IoT)-based methane monitoring and control system approach may help demonstrate strong potential for sustainable and cost-effective management of the final waste disposal site at the Glagah coastal tourist destination (Widia *et al.*, 2025; Koto *et al.*, 2025).

Conclusion

Changes to the sand dune landscape resulting from the expansion of dune agriculture, shrimp farming, the construction of breakwaters, tourism activities, and the construction of YIA Airport have enabled several tree species to adapt successfully. It was found that 15 families and 24 tree species are being conserved to support tourism at Glagah Indah Beach and YIA Airport.

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