Jurnal Manajemen Hutan Tropika, *32*(1), 40–50, January 2026
EISSN: 2089-2063
DOI: 10.7226/jtfm.32.1.40

Scientific Article
ISSN: 2087-0469

Potential Distribution of Tropical Native Gayam Forest Tree (*Inocarpus fagifer* Forst.) to Cope with the Drought Hazards in Yogyakarta Landscape

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Received May 5, 2025/Accepted August 27, 2025

Abstract

Yogyakarta's landscape is known for having experienced drought hazard. At the same time, there is a native tropical tree that has the ability to store the water and cope with the emerging drought. In this regard, this study is aiming to evaluate the potential distribution of the tropical native gayam forest tree (Inocarpus fagifer *Forst.*) *to cope with the drought in the Yogyakarta landscape. Samplings of* I. fagifer *covered four districts* (*Sleman, Kulonprogo, Bantul, and Gunung Kidul*) *and one city* (*Yogyakarta City*) *and implemented from January to March 2025. The potential distribution was estimated using MaxEnt. The drought was estimated using remote sensing. The resulting model gained an AUC of 0.804, confirming that* I. fagifer *can adapt to low rainfall and has the potential to inhabit areas with drought. Bantul, Sleman, and Kulonprogo were districts where the* I. fagifer *potential distribution areas exceeded almost five to seven times the drought areas. This information can be used as a baseline and recommendation from village to district levels to start to mainstream and disseminate the planting of tropical native trees as a nature-based solution to cope with the drought hazards across Yogyakarta's landscape.*

Keywords: *AUC, MaxEnt, model, remote sensing*

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Introduction

The gayam tree (*Inocarpus fagifer* Forst.) is known as an endemic species of the region in Asia–Pacific and a significant element in conventional agroforestry systems, including in tropical Southeast Asian regions. *I. Fagifer* is also referred to as the Tahitian (or Polynesian) chestnut. This species has widespread distribution in the territory of Indonesia, inhabiting forests. *I. fagifer* belongs to the Fabaceae family and is a tree-shaped plant, reaching 20 m in height, with a canopy diameter of around 15–16 m. *I. fagifer* leaves are dark green, and the leaves are alternately arranged. Young *I. fagifer* fruit is green and changes color to yellowish green when ripe. The shape of the fruit is round and plate-shaped with a thickness of around 1–2 cm. The fruit skin has clear veins, the seed skin is fibrous, and the seeds contain seed flesh (endosperm) (Sosef & van der Maesen, 1997). Mature trees that are 10–15 years old will produce fruit every year, and each tree can produce more than 1000 fruits (Wawo et al., 2011). This species has been used by the people due to its value as an edible and commercial tree (Setyowati & Wawo, 2015; Rohama & Zainuddin, 2021).

I. fagifer plants are found to be able to live from lowland areas in coastal areas to an altitude of 500 m above sea level, including in the small rivers. *I. fagifer* plants prefer clay soil instead of sandy soils. This species avoids sandy soil with large particle sizes. *I. fagifer* has strong root systems that can penetrate deeper into the soils and store water. Due to this feature, *I. fagifer* is known to have the potential to store water. *I. fagifer* contributes to water conservation in its ecosystem, especially through its large root system and erosion control efforts. Its extensive, interconnected roots aid in stabilizing the soil, reducing surface runoff, and encouraging water penetration. Furthermore, the species' existence in forests supports the general health of the ecosystem, which can tangentially aid with water conservation. The extensive network of *I. fagifer* lateral roots reduces runoff and allows more water to infiltrate the soil, replenishing groundwater resources (Müller, 2024).

In Indonesia, the Yogyakarta landscape is known as a region that experienced drought due to the soil types that regulate the soil hydrology and affect the water storage capacity (Guo et al., 2021). Yogyakarta's landscape is divided into two distinct landscapes. The first are the mountainous and highland landscapes located in the north and the lowland landscapes located in the south. Combined with the karst layers, the southern part of the regions of Yogyakarta has experienced prolonged droughts. In Gunungkidul District (Saptutyningsih & Nurcahyani, 2022), there are at least 18 subdistricts that have experienced droughts. Droughts were characterized by high air temperature, low rainfall, and low water content in plants and soil (Kismiantini et al., 2021). This condition is also worsened by the lack of trees that can store water. Similar to the Gunung Kidul, the Kulonprogo District was also experiencing drought. The water scarcity is observed in 35 villages in Kulonprogo District, as reported by Hendrayana et al. (2021). Reduction in rainfall is also

EISSN: 2089-2063 ISSN: 2087-0469
DOI: 10.7226/jtfm.32.1.40

responsible for the drought in Kulonprogo (Ikhsan et al. 2024).

The current study has emphasized the importance of potential distribution modeling. As a result, numerous methods have been established to analyze the potential distribution of species on a geographic scale. One widely used technique is machine learning-based species distribution modeling (SDM), which estimates the potential spatial distribution of various organisms, ranging from crops (Dong et al., 2023) to vegetation (Sánchez Pérez et al., 2023), animals (Stephenson et al., 2022), and ticks. SDMs employ a variety of methods to assess habitat suitability, including Biomapper, Bioclim, and Domain using a climatic approach, and MaxEnt (Maximum Entropy) using a machine learning approach. Statistical approaches are represented by generalized linear models (GLM) and generalized additive models (GAM). Each machine learning tool has its own unique set of advantages and disadvantages. Following Marcer et al. (2013), SDM is one of the most popular and effective methods to model habitat suitability. Some of the advantages of SDM, as noted by Fois et al. (2018), include the capacity to determine the environmental factors having significant contributions, high precision of predictive results, reproducibility, the need for only species presence data, and its effectiveness in estimating the potential spatial distribution even with limited data.

I. fagifer is a native species to Yogyakarta, and at the same time, Yogyakarta is threatened by drought. Information about the *I. fagifer* potential distribution is still lacking, while this information is very important to whether the *I. fagifer* potential distribution is overlapped with the areas threatened by droughts. Then, there is a significant gap in understanding *I. fagifer*'s potential to cope with the drought. If there is an overlapping potential distribution of *I. fagifer* with drought, then this species can be used to cope with the drought. The aim and the novelty of this study are using SDM to map the *I. fagifer* potential distribution and remote sensing to map the drought across Yogyakarta landscapes. The result then will benefit the drought management and also the agriculture sectors.

Methods

The research was implemented in Yogyakarta from January to March 2025. The study methodology followed methods applied by Semu et al. (2021), consisting of species occurrence recording, environmental variable analyses, model evaluation, and remote sensing analyses to assess the drought. The method to predict and develop a model visualizing the potential distributions of *I. fagifer* comprised several steps and initiated first with the species occurrence recording, modeling, model evaluation, and percentage contribution to assess the environmental variables with the most contributions.

Study area This study was carried out throughout Yogyakarta Province in four districts (Sleman, Kulonprogo, Bantul, and Gunung Kidul) and one city (Yogyakarta City) (Figure 1, Table 1). Yogyakarta's geo-coordinates were S7.2° to S8.3° latitude and E110.0° to E110.9° longitude. The hills to the east and west, the sea and the coast to the south, and the highlands to the north all encircle Yogyakarta. Yogyakarta's southern regions were karst, meaning they had little surface water and were dry (Putra & Nurjani, 2021). Yogyakarta experiences rainfall ranging from 718.0 to 2,992.3 mm annually. In the northern regions of Sleman District, heavy rainfall was recorded. While minimal rainfall was noted in the southern parts of Gunungkidul and Bantul Districts, Sleman District saw precipitation rates of up to 2,992.3 mm year^{-1}. The southern areas of Gunung Kidul District had the lowest rainfall, at 197.6 mm year^{-1}.

According to Hakim and Yuliah (2018), Yogyakarta is recognized for its diverse vegetation. Yogyakarta is home to at least 805 plant species, comprising 110 families in terrestrial areas, 12 families in aquatic ecosystems, and four protected families. At least 33 plant species are considered very rare, including *I. fagifer*. In Javanese culture, the name *I. fagifer*, or gayam, refers to more than just a tree. It is a symbol with philosophical meaning, cultural worth, and practical applications in everyday life.

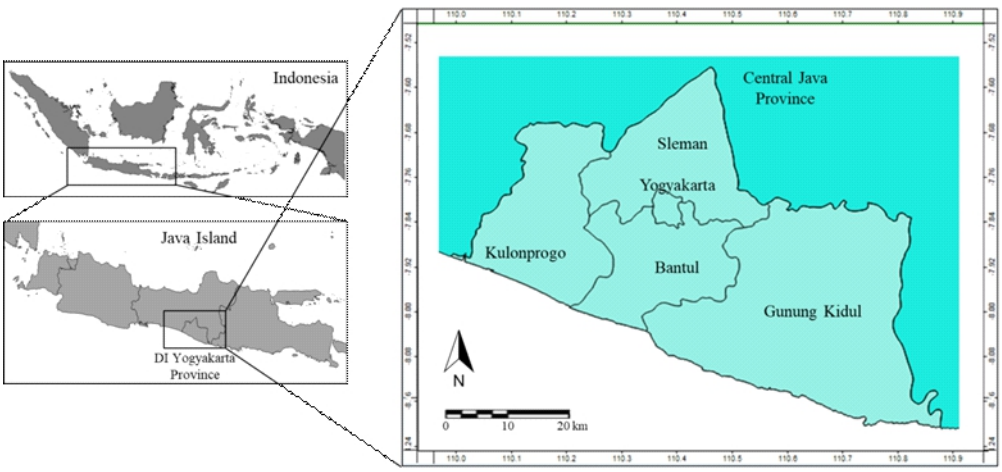

Figure 1 Map indicating the study area locations in city and districts within Yogyakarta Province.

***I. fagifer* occurrence surveys and recordings** From January to March 2025, ground surveys or field explorations were undertaken, along with literature reviews and database checks, to survey and document the presence of *I. fagifer* in Yogyakarta in Yogyakarta City, Kulonprogo, Sleman, Bantul, and Gunung Kidul districts. The occurrence of *I. fagifer* was detected and sampled through random direct visual field observation, also known as a visual encounter survey (VES), and a database retrieved from literature reviews sourced from published reports and journal articles provided by government agencies, including the Indonesian Ministry of Environment and Forestry and the Agriculture and Forestry Agency. Random sampling protocol and VES were strategically applied by first defining the sample population, determining the appropriate sample size, and visiting forests, plantations, parks, household yards, and green areas near roadside places where *I. fagifer* might be planted, following information provided by the Agriculture and Forestry Agency and local people knowledgeable on the presences of *I. fagifer*. The sample size included all trees planted. The geographical coordinates of *I. fagifer's* presence in the field were verified using a Garmin Etrex 30 Global Positioning System (GPS). The data were translated to Microsoft Excel and saved as CSV files for use in habitat suitability modeling using MaxEnt. The tree species identification guideline for *I. fagifer* was following available identification keys (Backer & van den Brink, 1963; Partomihardjo et al., 2014).

***I. fagifer* environmental variables** This study incorporated various environmental variables (Table 2) according to Phillips et al. (2006; 2017). The variables include the climatic, physical, and geographical variables. The climatic variables are maximum and minimum temperature and precipitation. The physical variables are wind and solar radiation. The elevation variable represents the geographical variable. Those variables were collected from the database of global climate known as WorldClim (www.worldclim.org, the new version 2.0) (Hijmans et al., 2005) that has been applied broadly in potential distribution modeling (Khanum et al., 2013), adjusted to regional scales (Poggio et al., 2018), and is extensively applied in the Asian region (Rana et al., 2017). Those variables were presented in the raster formats as ASC files. Edaphic variables assessed in this study were dominant soil types and the water storage capacity of each district. The values for edaphic variables were referred to literature reviews (Nurjanah et al., 2022).

Table 1 Areas of city and districts within Yogyakarta Province

City and districts	Areas (km^2)
Yogyakarta	32.8
Sleman	574.82
Kulonprogo	586.27
Bantul	508.85
Gunung Kidul	1,485.36

***I. fagifer* potential distribution analysis** This study applied the potential distribution analysis using MaxEnt packages version 3.4.4 retrieved fromhttps://biodiversityinformatics.amnh.org/open_source/maxent/. This package is so far known as a versatile platform to model the potential distribution of species. To operate the MaxEnt, it involves the *I. fagifer* occurrence data in the CSV format. This file, combined with the environmental layer that has been described before, consists of minimum and maximum temperature, precipitation, wind, solar radiation, and elevation variables. Within the model, the impact and percentage contribution of each environmental variable on the *I. fagifer* potential distribution model were calculated using a Jackknife test (Promnikorn et al., 2019). Jackknife analysis was applied to calculate the contribution of each environmental variable to the potential distribution model. Some environmental variables resulted from Jackknife analysis that having a percent contribution nearly to 0, indicating a lack of contribution to the model, and were eliminated. Those eliminated environmental variables were neither variables with a small average contribution of less than 6% nor having permutation importance of less than 6% (Wei et al., 2018). The percentage contribution and permutation are considered as two significant factors for measuring and determining the environmental variable's contribution as well as importance to the MaxEnt model. For evaluating the performance of the model, the receiving operating area under the curve (AUC) area as threshold-independent and sensitivity, specificity, The true skill statistic (TSS), and Kappa as threshold-dependents were applied. AUC values have ranges of 0 (least suitability) to 1 (most suitability). The resulting model is considered inaccurate and contains uninformative data if it has an AUC value less than 0.5. While the resulting model is considered excellent and explanatory if it has an AUC value more than 0.5 and nearly 1.0.

The potential distribution map resulting from MaxEnt models was visualized in GIS for presentation and additional study (Hijmans et al., 2012). Following Wei et al. (2018), degrees of habitat suitability on the MaxEnt model map can be divided into five suitability levels, including 0 = unsuitable, 1 = low suitability, 2 = medium suitability, 3 = high suitability, and 4 = very high suitability.

Table 2 Environmental variables with their units (Huang et al., 2024)

Environmental variables	Sources	Format	Unit
Maximum temperature	www.worldclim.org	Data represented in in raster format	°C
Minimum temperature	www.worldclim.org	Data represented in in raster format	°C
Precipitation	www.worldclim.org	Data represented in in raster format	mm
Wind	www.worldclim.org	Data represented in in raster format	m s^{-1}
Solar Radiation	www.worldclim.org	Data represented in in raster format	kJ m^{-2} day^{-1}
Elevation	www.worldclim.org	Data represented in in raster format	m
Drought	Sentinel 2	Data represented in in raster format	dimensionless

EISSN: 2089-2063
ISSN: 2087-0469
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Drought distribution analysis The drought over the study area was measured with the assistance of remote sensing and satellite imagery data (Table 2). The satellite imagery was retrieved from Sentinel 2. Bands used to calculate the drought were Band 8 and Band 11. Band 8 is the near infrared, and Band 11 is shortwave infrared. The drought was calculated based on the Equation *[1]* (Gao, 1996; Varghese et al., 2021).

$$\text{Drought} = \frac{B\,8 - B\,11}{B\,8 + B\,11} \qquad [1]$$

The prediction map resulting from drought calculation was imported into GIS for presentation and additional study. Drought has ranges of 0–1, with values nearly 0 representing severe drought and nearly 1 representing no drought.

Results

This section presented *I. fagifer* potential distribution and drought distribution analysis. The section also elaborated on the environmental variables that affect the distribution of *I. fagifer*. This section is followed by calculations of how *I. fagifer's* potential distribution can overlap the areas that experienced drought.

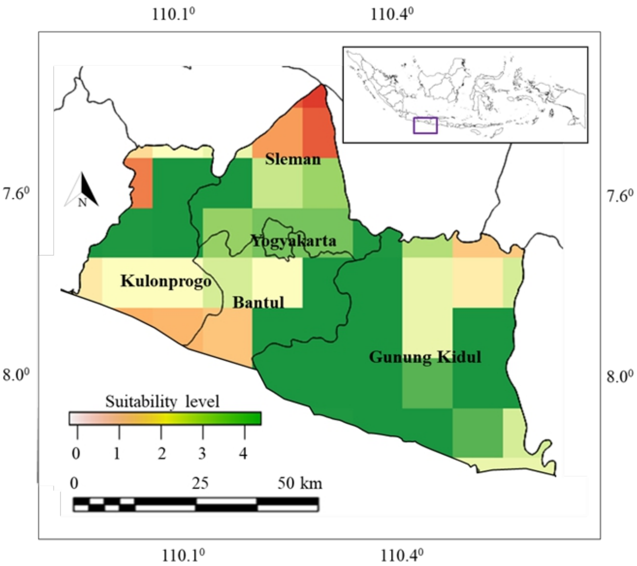

Figure 2 *Inocarpus fagifer* potential distribution within Yogyakarta Province (0: unsuitable,1: low suitability, 2: medium suitability, 3: high suitability, 4: very high suitability).

***I. fagifer* potential distribution** The results show that *I. fagifer* has the potential to spread across Yogyakarta landscapes (Figure 2). In Kulonprogo District, the north and east are potential for *I. fagifer*. In Sleman District, the southern areas are potential for *I. fagifer*. Most areas of Yogyakarta City are considered potential. In Bantul District, only the east side is suitable. In Gunung Kidul, the west side bordered by Bantul to the south has potential for *I. fagifer*. Based on the calculations (Table 3), the districts that have high potential for *I. fagifer* distribution are Gunung Kidul, followed by Kulonrogo District. More than half of the areas of Gunung Kidul, or equal to 66.85%, or 992.98 km², have potential for *I. fagifer*. Most areas of Yogyakarta City are also having potential, while the size of this city makes it not significant as a percentage. The district that had areas with no potential for *I. fagifer* was Bantul. This district has a high percentage of areas not suitable, reaching 20.07%, higher than other districts.

MaxEnt modeling of *I. fagifer* potential distribution using minimum and maximum temperature, rainfall, wind, solar radiation, and the elevation variables explained the spatial distribution of Gayam trees across the Yogyakarta Province landscape with AUC = 0.804, indicating that the resulting model is excellent and explanatory (Figure 3, Table 4). Based on Jackknife analysis (Figure 4) elaborating each environmental variable contribution to the resulting model, precipitation informed a large portion of the variation (51.5%) in the said model, followed by wind (22.5%). Among other variables, elevation, solar radiation, and maximum temperature have fewer contributions to the *I. fagifer* potential distribution.

Figure 5 provides response curves showing the environmental variable influences on the probability of *I. fagifer* potential distribution. Started from the most influential variables, that is, the precipitation. From the response curves, it is clear that the *I. fagifer* can adapt to the environment with low rainfall since the optimum potential distribution was reached at rainfall as low as 50 mm, and the potential distribution is declining if the rainfall is increasing. The second influential variable is the wind. According to the model, the optimum potential distribution was reached at wind speeds less than 3.5 m s^{-1}, and more than that, the potential distribution will decrease. *I. fagifer* can adapt to the low-temperature environment, and it can survive with temperatures as low as 5 °C. *I. fagifer* is a lowland species since an elevation of more than 500 m will limit its distribution.

Table 3 Areas of *Inocarpus fagifer* potential distribution in districts and city within Yogyakarta Province according to five suitability levels (0: unsuitable,1: low suitability, 2: medium suitability, 3: high suitability, 4: very high suitability) and their percentages in comparison to total areas

City and districts	Suitability levels in km²									
	4		3		2		1		0	
Yogyakarta	32.52	99.14%	0	0	0.28	0.86%	0	0	0	0
Sleman	221.20	38.48%	221.03	38.45%	809	1.45%	61.40	10.68%	63.10	10.97%
Kulonprogo	242.67	41.39%	24.59	4.19%	202.03	34.46%	82.62	14.09%	34.36	5.86%
Bantul	203.97	40.08%	99.52	19.55%	100.00	19.65%	105.36	20.07%	0	0
Gunung Kidul	992.98	66.85%	99.83	6.72%	351.07	23.63%	41.48	2.79%	0	0

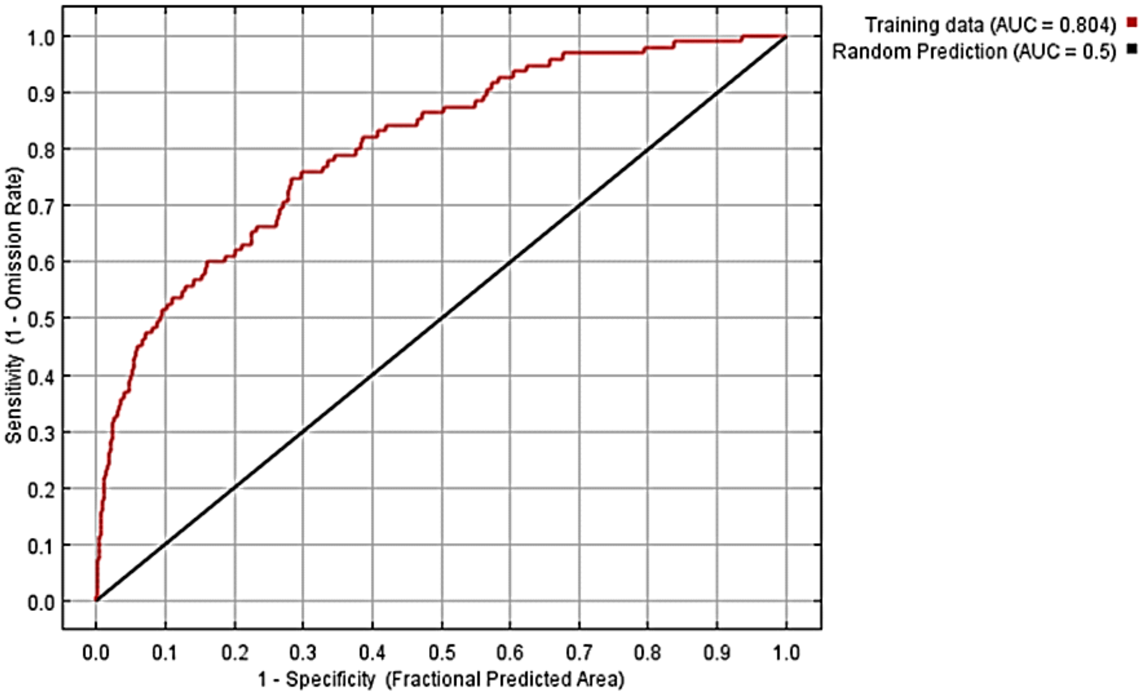

Figure 3 The receiving operating area under the curve (AUC) for the model.

Table 4 The evaluation variables

Evaluation variables	Threshold-independent	Threshold dependent			
	Area under the receiver operator (AUC) curve	Sensitivity	Specificity	The true skill statistic	Kappa
Values	0.804	0.678	0.664	0.342	0.307

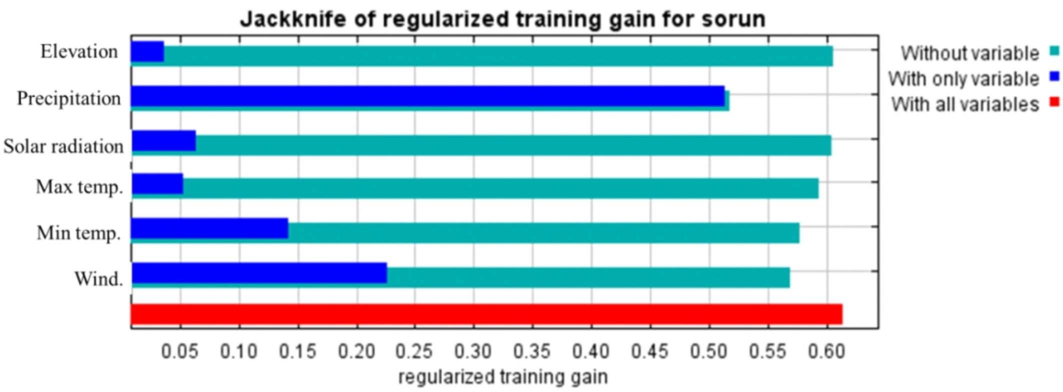

Figure 4 The MaxEnt model displays the significance of variables used in training the distribution model of *Inocarpus Fagifer* based on the Jackknife test.

Drought distribution The results of drought estimation using remote sensing in Figure 6 show there are at least three areas that experienced severe drought across Yogyakarta landscapes. First are areas on the east side of Kulonprogo that bordered the Bantul Districts. Second are the southern parts of Sleman District, including Yogyakarta City. The last areas are the central parts of Gunung Kidul District. This study only calculated areas of the district with drought at high levels. According to Table 5, the districts that have the largest areas with drought at high levels are Gunung Kidul and Kulonprogo, followed by Sleman District. The impacted areas are 257.11 km², 42.61 km², and 31.82 km². Yogyakarta landscapes were characterized by the dominance of Regosol and Latosol soil types. These soil types have low water storage ability.

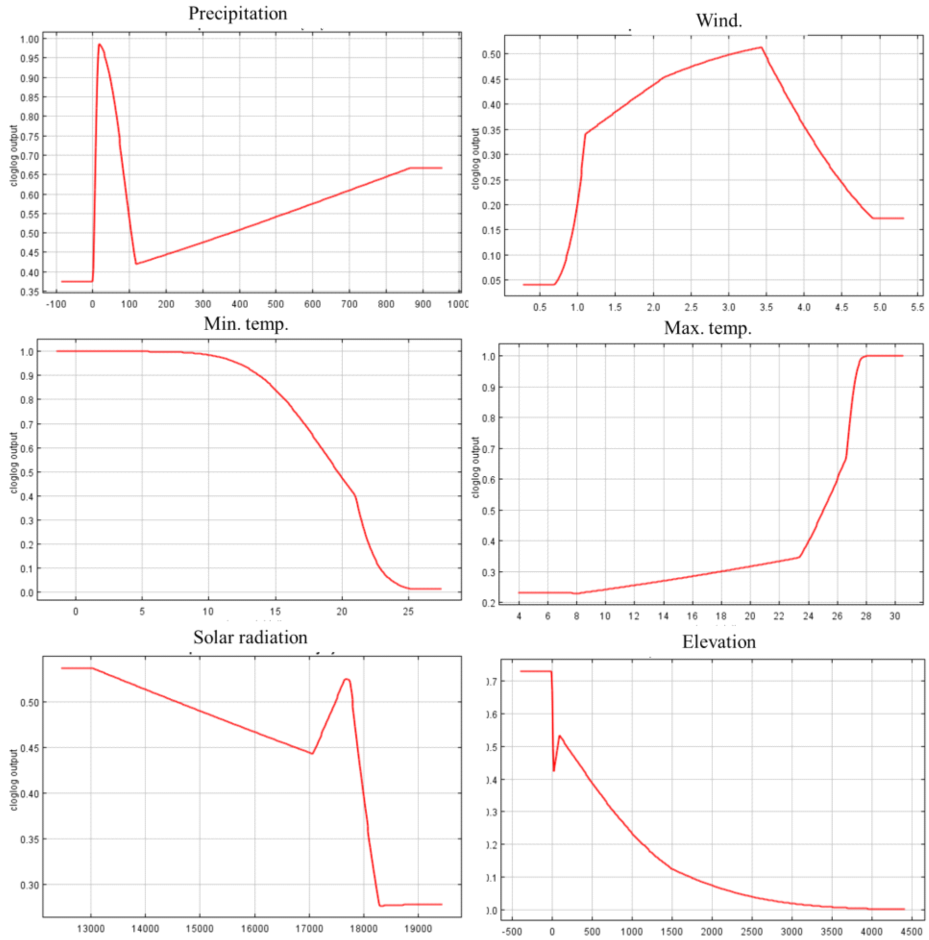

Figure 5 Response curves showing influences of environmental variables on *Inocarpus fagifer* potential distribution probability.

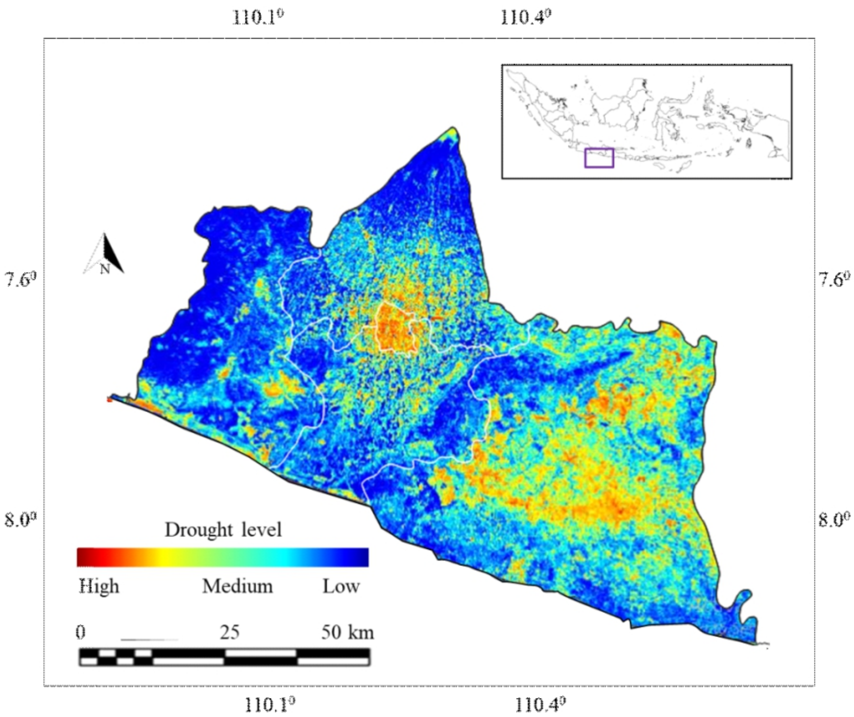

Figure 6 Drought potential distributions within Yogyakarta Province.

Jurnal Manajemen Hutan Tropika, *32*(1), 40–50, January 2026
EISSN: 2089-2063
DOI: 10.7226/jtfm.32.1.40
Scientific Article
ISSN: 2087-0469

Table 5 Areas in city and districts within Yogyakarta Province experiencing high drought and their percentages in comparison to total areas

City and districts	Areas in km^2	Areas in percentages
Yogyakarta	24.52	74.75
Sleman	31.82	5.53
Kulonprogo	42.61	7.26
Bantul	25.50	5.01
Gunung Kidul	257.11	17.30

Table 6 Dominant soil types, soil water storage capacity, and ratios of areas in city and districts within Yogyakarta Province having high *Inocarpus fagifer* potential distribution divided by drought potential distributions areas

City and districts	Dominant soil types	Soil water storage capacity	Areas of *Inocarpus fagifer* potential distribution at high suitability levels	Areas of drought potential distribution	Ratios
Yogyakarta	Regosol	Low	99.14%	74.75%	1.32
Sleman	Regosol	Low	38.48%	5.53%	6.95
Kulonprogo	Latosol	Low	41.39%	7.26%	5.70
Bantul	Regosol	Low	40.08%	5.01%	8.00
Gunung Kidul	Latosol	Low	66.85%	17.30%	3.86

Ratio of *I. fagifer* potential distribution and drought distribution The ratio of *I. fagifer* potential distribution to drought distribution is gained by dividing the percentage of areas of *I. fagifer* potential distribution at high suitability levels by the percentage of areas of drought potential distribution. The result is available in Table 6. From Table 6, it can be observed that the potential distribution areas for *I. fagifer* are always exceeding the areas of drought, and this indicates that *I. fagifer* potential distribution areas can cover the drought areas. Bantul, Sleman, and Kulonrogo were districts where the *I. fagifer* potential distribution areas exceeded almost five to seven times the drought areas. The lowest was Yogyakarta City since the drought areas are almost closed to *I. fagifer* potential distribution areas.

Discussion

In the Yogyakarta landscape, the *I. fagifer* was not associated with solar radiation since this variable has fewer contributions in comparison to other variables. This species is a shade-tolerant plant; it means that it can inhabit landscapes where the sunlight and even sun penetration are very low and limited. Species belonging to the Fabaceae family are known for their adaptability to low sun penetration. The adaptation to low-light environments was related to the phenotypic plasticity, with significant survival against shade being displayed by Fabaceae species that had the greatest variations in the ratio of leaf area (Marchin et al., 2009). Smith et al. (2023) have confirmed the changes in leaf area ratio following dynamics of sun penetrations. *I. fagifer* is known to be limited by the wind at a maximum of 3.5 m s^{-1}. This explains the absence of this species in the northern areas in Sleman District that are near the Merapi Mountain. The hilly parts are having strong winds, and it can reach up to 22.2 m s^{-1}. Strong winds have the potential to damage the poles, seedlings, and even the trees of *I. fagifer* (Gardiner, 2021).

The ability of species to withstand dry environments and low rainfall is related to the sizes and numbers of stomata. In drought-prone areas, species will have adaptations by having smaller stomata and fewer numbers of stomata (Hill et al., 2014). Stomata have roles in regulating the water loss and gain through evapotranspiration. In a dry environment, by having smaller and fewer stomata, the excessive water loss can be limited. In Fabaceae, the stomata are varied as responses to the environment (Susilowati et al., 2022).

I. fagifer is considered a versatile species for coping with drought. This species can be planted in various micro-habitats, including yards and home gardens. Then this species is a promising plant to cope with drought at household levels. Despite *I. fagifer* occurring in almost all areas of the Yogyakarta landscape with potential distribution reaching more than 50%, this species is limited by elevation. It means that this species' absence in hilly and mountainous areas explains this species' absence in northern Sleman. This area is hilly parts of Merapi and not suitable for this species.

The *I. fagifer* potential to cope with the drought across the Yogyakarta landscape elaborated on in this study agrees with earlier research by Ku-Or et al. (2020) and is in agreement with the utilization of trees to conserve water in soil as recommended by Maridi et al. (2011). Plant species belonging to Fabaceae have been reported to be able to cope with the drought due to their ability to store the water (Table 7). All studies have reported that Fabaceae species native to tropical areas have the ability to store water in their roots, stems, and leaves. Latosol and regosol soils with a low capacity to store water define the Yogyakarta terrain. In order to reduce water loss and improve water intake, plants use a variety of morphological, physiological, and biochemical adaptations to Latosol and Regosol soil drought conditions. Developing deep and broad root systems, decreasing leaf size and surface area, changing stomatal activity, and boosting water storage capacity are some examples of these adaptations (Huzsvai & Rajkai, 2009). Fabaceae species were very efficient in consuming water and increasing the amount of water stored. *Pisum sativum* only consumed 40% of stored water and saved the rest of the 60% (Morin et al., 2022). For instance, *Anadenanthera colubrina* has the capacity to store water in the trunks (Alzate-Marin et al., 2025).

The drought distribution analyses in this study confirm that Gunung Kidul is a district that has the largest areas

Table 7 Studies on species belongs to Fabaceae that has ability to cope drought and store the water

Species	Regions	References
Albizia lebbeck	Thailand	Ibeh & Akinyele (2024)
Bauhinia saccocalyx	Thailand	Yatar et al., (2024)
Dalbergia nigrescens	Cambodia, Lao PDR, Thailand, and Vietnam	Shao et al. (2022)
Sindora siamensis	Thailand	Kaewthongrach et al. (2019)
Inocarpus fagifer	Indonesia	This study

impacted by drought compared to other districts. One of the determinant factors influencing Gunung Kidul is the occurrence of a karst environment that is common across Gunung Kidul. *I. fagifer* was known to thrive and adapt to a karst environment. This example can be drawn from *I. fagifer* occupancy in the Dales Ramsar Site of Christmas Island (Hale & Butcher, 2010). In this site, a 10-ha monodominant stand of *I. fagifer* is present in this karst region. Then this indicates and supports that the *I. fagifer* is a potential species to cope with drought in Yogyakarta, where one of the drought-impacted areas was dominated by the presence of karst, as can be seen in Gunung Kidul.

The estimations of *I. fagifer* potential distribution are based on and limited to the climatic and geographic variables. Those variables include the precipitation, temperature, wind, and solar radiation. The elevation represented the geographic variables. Despite those variables that have been incorporated in this study, the particular edaphic and geological variables should be incorporated in the future (de Queiroz et al., 2012). It is recommended to incorporate the soil chemistry as edaphic variables and the type of soil as geological variables that also have roles in regulating the potential distribution. The study was implemented for three-month periods. Then it is recommended to expand the periods to gather and capture more seasonal variations.

Conclusion

This study confirms that areas suitable for *I. fagifer* overlapped with areas that experienced drought and were larger than areas that experienced the drought and have low water storage ability due to the Latosol and Regosol soil types, as the plant area to drought area ratio was mostly more than one. The drought areas are characterized by environmental variables that mostly provide benefits for *I. fagifer*. This study confirmed that the majority of the Yogyakarta landscape is suitable for *I. fagifer*. The exceptional areas are only the hilly parts of Sleman in the north. At the same time, some parts of Kulonprogo, Sleman, Yogyakarta, and Gunung Kidul are prone to drought. By comparing area coverages that are suitable for *I. fagife*r with drought areas, this study identifies that there is an overlap of those areas. To conclude, *I. fagifer* trees have potential as native tropical plant species that can be used to store the water and cope with the drought. *I. fagifer* is considered a versatile species.

Recommendation

This study has provided information on where the *I. fagifer* can be strategically planted to cope with the drought. This information can be used as a baseline and recommendation from village to district levels to start to mainstream and disseminate the planting of tropical native trees as a nature-based solution to cope with the drought disasters. Despite its wide coverage, some areas are identified as not suitable for *I. fagifer*. Those areas mostly are located in the northern parts of Sleman District.

Acknowledgment

We express our gratitude to the people of Yogyakarta and, in particular, the farmer community that has assisted this research during the surveys. This project is supported by a grand from the National Geographic Society.

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