The analysis of habitat characteristics of *Anaphalis javanica* at Kalipait Waterfall, Ijen Geopark

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Abstract. *Anaphalis javanica* is one of the protected plant species. However, over time, its existence has been threatened by several factors, including anthropogenic factors (illegal collection during hiking activities and socio-cultural events), fires (both natural and human-induced), and natural factors (volcanic activity producing ash). Kalipait Waterfall, which is part of the Ijen Geopark, features unique characteristics with its water flow originating from the Ijen crater, resulting in high sulfate content. This area has become an attractive tourist destination frequently visited by both domestic and international tourists. This study aims to understand the habitat characteristics of Anaphalis along the Kalipait Waterfall stream. This research serves as a foundation for the conservation of *A. javanica*. A quantitative vegetation approach was employed using ten plots, each measuring 2 × 2 m. Data collection involved documenting the species identity and the corresponding number of individuals within every sampled plot. Abiotic factors encompass the measurements of elevation, slope, temperature, and humidity. The data were analyzed by calculating the Importance Value Index (IVI), followed by Principal Component Analysis (PCA) conducted with PAST software. A total of 375 plants were found, which are Asteraceae, Poaceae, Polypodiaceae, and Phytolaccaceae. The species with the highest Importance Value Index (IVI) is Arundinella fuscata (47,71%).

1 Introduction

Mountain ecosystems are recognized as biodiversity hotspots, harboring many specialized and endemic species that are highly sensitive to environmental gradients and human disturbances.

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Within these habitats, members of the genus *Anaphalis* (Asteraceae) are iconic pioneer plants, particularly *Anaphalis javanica*, often referred to as "edelweiss" in Indonesia. These species are adapted to high-altitude, open volcanic substrates and play an important role in early successional dynamics while also bearing significant cultural and conservation value [1, 2]. These species contribute to the stability of montane vegetation communities by colonizing open, disturbed, or rocky substrates and facilitating early successional processes following volcanic disturbance [3]. Ecologically, Anaphalis species are stress-tolerant plants that thrive under conditions of intense solar radiation, low nutrient availability, and fluctuating temperature regimes [4].

The genus Anaphalis (Asteraceae), commonly known as edelweiss or everlasting flower, represents an important group of montane herbaceous species that play a key ecological role in high-elevation ecosystems across tropical and temperate regions. In Indonesia, Anaphalis is considered an endemic genus with several species distributed throughout volcanic mountain systems such as Mount Lawu, Mount Bromo, Mount Semeru, and Mount Ijen [5, 6]. Quantitative ecological surveys on Anaphalis spp. in Java have demonstrated that these species typically occur at elevations between 2,000 m and 3,000 m a.s.l., with optimal abundance in areas characterized by well-drained volcanic soils, moderate to high light intensity, and low canopy cover [7].

Despite their ecological and symbolic importance, *Anaphalis* populations are threatened by habitat alteration, tourism pressure, and collection activities. Their distribution is strongly influenced by abiotic factors such as soil properties, light intensity, wind exposure, and moisture availability. Waterfalls and riparian corridors, such as Kalipait Waterfall in the Ijen Geopark, present unique microclimatic and edaphic conditions that may support localized *Anaphalis* populations, yet such habitats remain poorly studied [2, 8].

The Kalipait Waterfall, located within the Ijen Geopark in Banyuwangi Regency, East Java, represents one of the most distinctive volcanic environments in Indonesia. The Ijen volcanic complex is characterized by the presence of Kawah Ijen, an active crater lake with extremely acidic conditions (pH < 0.5) and high concentrations of sulfate (SO_4^{2-} ≈ 70,000 mg/L) and chloride (Cl^- ≈ 21,000 mg/L) ions [8,9]. These hyperacidic fluids originate from magmatic degassing processes involving SO_2 and HCl and subsequently flow through seepage channels forming the Banyupait–Kalipait River system [10]. As the acid water descends downstream, pH levels gradually increase (2.5–3.5 near Kalipait; ≈ 4.0 downstream), but sulfate concentrations remain high relative to unpolluted mountain streams [9,10].

Recent studies in tropical montane ecosystems indicate that microclimatic variables—including vapor pressure deficit, cloud/fog incidence, and soil moisture—strongly influence plant distribution and abundance along elevational gradients [11, 12]. These findings highlight the importance of detailed habitat characterization for species of conservation concern. This study aims to describe the habitat characteristics of *Anaphalis* sp. at Kalipait Waterfall. This research contributes to the understanding and protection of montane *Anaphalis* populations and informs management strategies in Ijen Geopark.

2 Materials and Methods

2.1. Study Site

This research was conducted at Kalipait Waterfall, which is located within the Ijen Geopark, East Java, Indonesia (± 8°03′S, 114°14′E) (Fig. 1). The site is characterized by a volcanic ecosystem with unique abiotic conditions influenced by sulfur emissions, steep slopes, and varying light intensities.

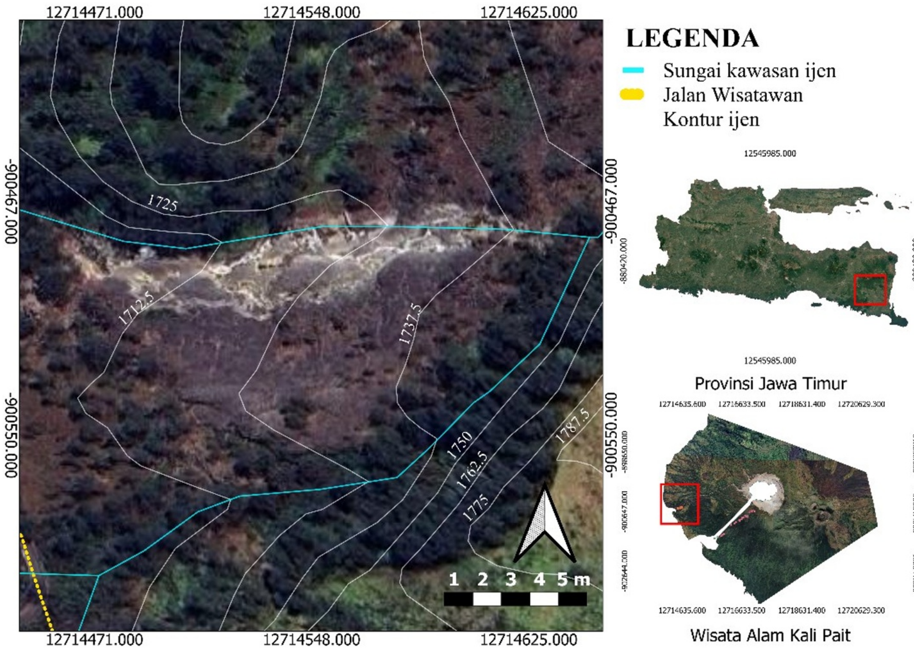

Fig. 1. Sampling Research Location

2.2. Sampling Methods

A quantitative vegetation approach was employed using 10 plots, each measuring 2 × 2 m. The plots were systematically placed along a transect line covering representative microhabitats around the waterfall area. Abiotic factors such as air temperature and humidity were recorded in situ using portable sensors. Plants were identified at the Botany Laboratory, Biology Education Department, Universitas Jember.

2.3. Data analysis

Community structure and species diversity were analyzed using quantitative ecological indices, including density, relative abundance, and the Importance Value Index (IVI). Abiotic factors encompass the measurements of elevation, slope, temperature, and humidity. Species richness, Shannon–Wiener diversity index (H′), and Pielou’s evenness index (E) were also calculated to evaluate community composition and distribution patterns. Principal Component Analysis (PCA) was performed using PAST version 4.05 software to identify the association patterns among species.

3 Results and Discussion

The findings of this study reveal important patterns in the vegetation community structure of the Ijen Crater Nature Tourism Park, characterized by the dominance of several key species and the presence of two major groups, namely ruderal pioneer vegetation and semi-natural montane vegetation. These results underscore the role of both abiotic and biotic factors in shaping species distribution and provide a foundation for understanding the ecological dynamics of tropical montane ecosystems.

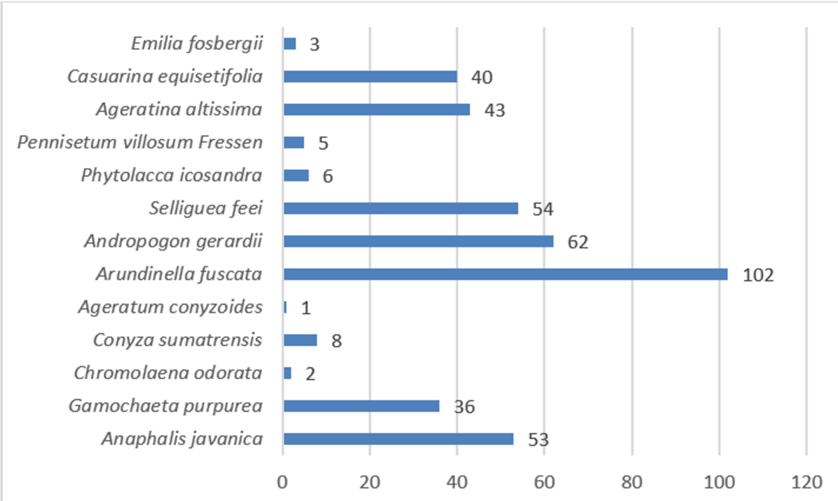

Fig. 2. The total abundance was 364 individuals across 13 species

The vegetation community at the study site is strongly dominated by *Arundinella fuscata*, which accounted for 24–25% of all individuals sampled (n=102). This dominance likely arises from its superior ability to adapt to abiotic stresses typical of high-elevation environments: intense solar radiation, temperature fluctuations, and low soil fertility. These traits are common among dominant graminoid species in montane habitats [13, 14].

Following *A. fuscata* in abundance are *Andropogon gerardii*, *Selliguea feei*, and *Anaphalis javanica*. The substantial presence of *Anaphalis* (often known as Edelweiss) is particularly significant; studies in Indonesia [15, 16] show that Anaphalis spp. tend to occur in high altitude montane zones (often 1500-2200 m a.s.l.), with cooler temperatures, moderate to high humidity, and certain soil types such as loamy or silty loam. The habitat preferences align with those observed in your analyses, where *Anaphalis* abundance is correlated negatively with temperature and positively with moisture [17].

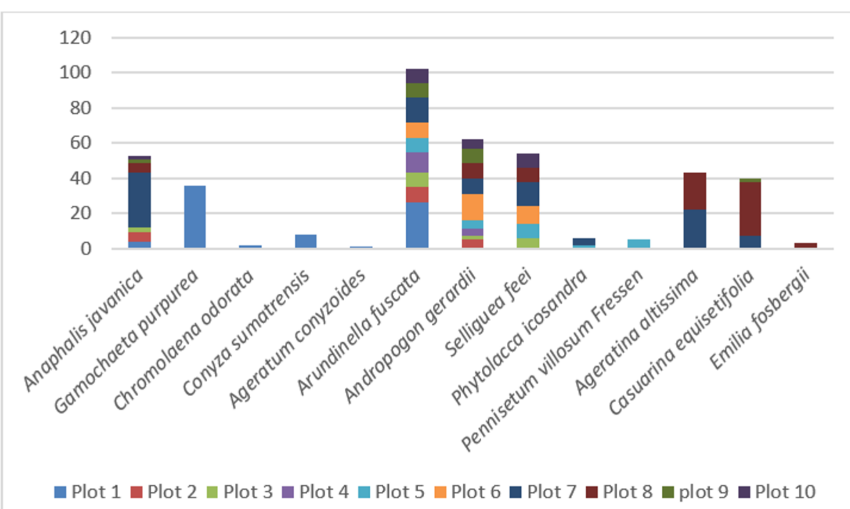

Fig. 3. The number of species per plot

Within the open tropical montane community, the four most dominant species were *Arundinella fuscata*, *Andropogon gerardii*, *Selliguea feei*, and *Anaphalis javanica.* Together, these species contributed approximately 65% of the total individuals recorded, demonstrating a pronounced dominance within the community structure. The dominance of these four primary species reflects their adaptation to extreme abiotic conditions in open tropical montane habitats. Their ability to survive and thrive under nutrient-poor soils, direct sunlight exposure, and microhabitat moisture that supports epiphyte growth constitutes a key factor in their dominance. Understanding the interactions among these species is crucial for conservation efforts and the management of tropical montane ecosystems. *Anaphalis margaritacea* in early successional stages on nutrient-poor substrates, such as waste rock piles. The species' ability to thrive in these conditions is attributed to its efficient nutrient acquisition strategies and resilience to abiotic stresses [18].

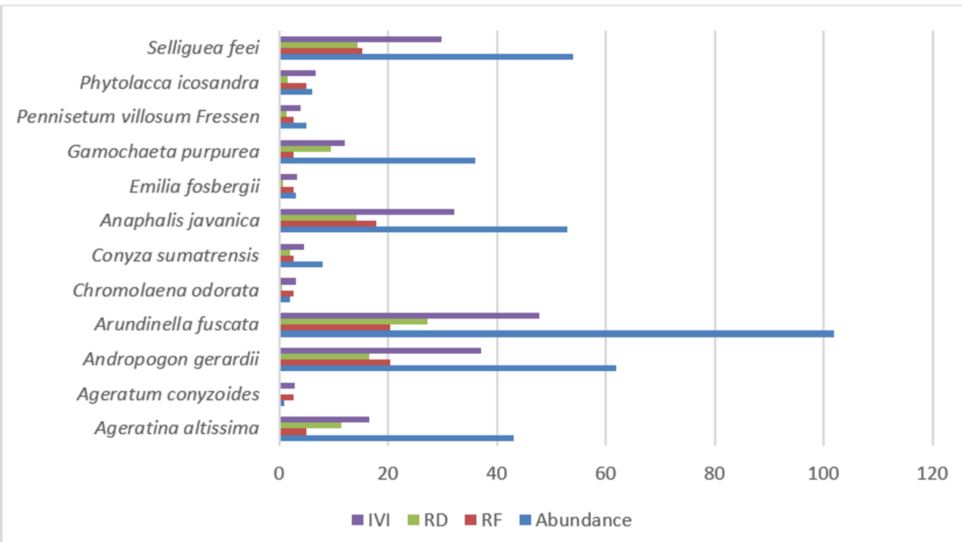

Fig. 4. Important Value Index (IVI), Relative Frequency (RF), Relative Density (RD), and Relative Dominance (RDo), Abundance

A. javanica exhibited relatively high IVI and total values (Fig. 4). The presence of *Selliguea feei* indicates that the environment still provides sufficient microhabitat moisture to support the growth of characteristic montane epiphytes. Meanwhile, *A. javanica* plays a significant ecological and conservation role, as it is an iconic species of montane regions and is often used as an indicator of montane ecosystem health. Despite its lower density compared to grasses, *A. javanica* shows relatively high IVI values, suggesting that this species maintains a stable frequency and ecological role within the community.

A. javanica, face threats from habitat loss and human activities. Traditional Ecological Knowledge (TEK) indicates that Javanese edelweiss is perceived as very rare, with declining populations [19]. *Anaphalis javanica* (commonly referred to as Javanese edelweiss), are increasingly vulnerable to habitat degradation, unsustainable harvesting, and tourism-related disturbances. Traditional Ecological Knowledge (TEK) among local mountain communities recognizes *A. javanica* as a rare and culturally significant plant, symbolizing purity and resilience. Despite its ecological and cultural importance, populations of *A. javanica* have shown marked declines across montane ecosystems in Java. A major contributing factor is the unsustainable collection of flowers as souvenirs and decorative items, which disrupts natural regeneration and recruitment.

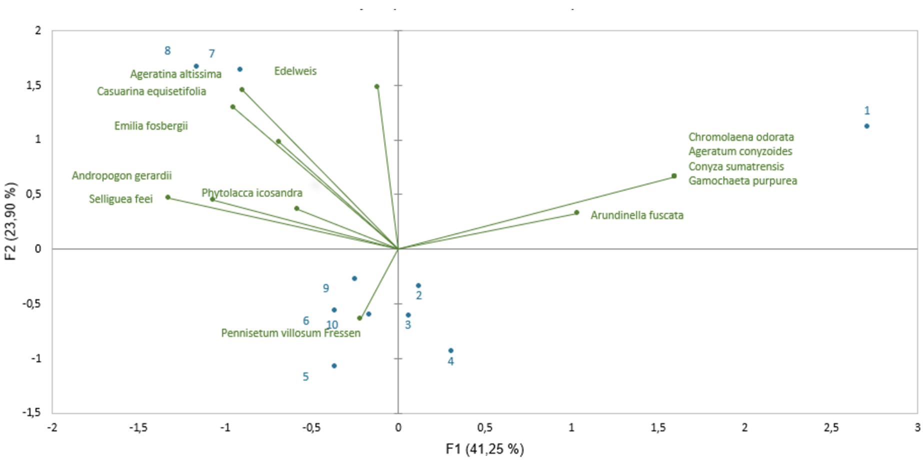

Fig. 5. Grouping of community structure was performed through PCA biplot analysis

A. javanica, Casuarina equisetifolia, and *Ageratina altissima* are frequently found in association within open tropical montane habitats. These species are capable of thriving in nutrient-poor soils and under extreme abiotic conditions. *A. javanica* can successfully adapt to exposed volcanic substrates, which also facilitate the growth of species such as *A. altissima* that exhibit rapid colonization on nutrient-deficient soils. This indicates a positive association among the three species, likely driven by their shared tolerance to extreme abiotic conditions and their ability to dominate disturbed open areas [2]. *Anaphalis* species, including *Anaphalis margaritacea*, which occur at elevations of 2,500–3,500 m above sea level. These species exhibit specific adaptations to low temperatures and high humidity and play a crucial role in maintaining the stability of montane ecosystems. Ageratina altissima is native to North America but has become invasive in Asia and Europe. In Austria, *A. altissima* is an invasive plant. *A. altissima* invades tall-herb vegetation living in areas with mesic to wet humidity. [20, 21].

Chromolaena odorata, Ageratum conyzoides, and *Conyza sumatrensis* are well-known ruderal and invasive plants frequently found in disturbed habitats, such as open areas, road edges, and abandoned agricultural land. They exhibit a high adaptive capacity to extreme environmental conditions and can effectively compete with native species within ecosystems. *C. odorata* reproduces rapidly through abundant seed production and wind dispersal. In addition, *C. odorata* releases allelopathic compounds that inhibit the growth of surrounding plants. These traits allow C. odorata to dominate disturbed areas and suppress the regeneration of native species [22].

Native to Tropical America, *A. conyzoides* has expanded its range globally, presumably introduced through the ornamental plant trade. The species has since become naturalized and widely distributed across tropical, subtropical, and temperate regions. Its current distribution encompasses South America, significant portions of Africa, Southern and Eastern Asia, and extends into Europe, including Eastern Austria [23]. *A. conyzoides*, *C. sumatrensis* are pioneer species that grow rapidly in disturbed habitats. Its adaptability to fluctuating environmental conditions makes it an effective invasive species [24]. The association of these three species indicates the formation of dominant plant colonies in disturbed habitats, which can inhibit native species regeneration and affect the structure of plant communities. Understanding the interactions between these invasive species and native vegetation is critical for effective ecosystem management.

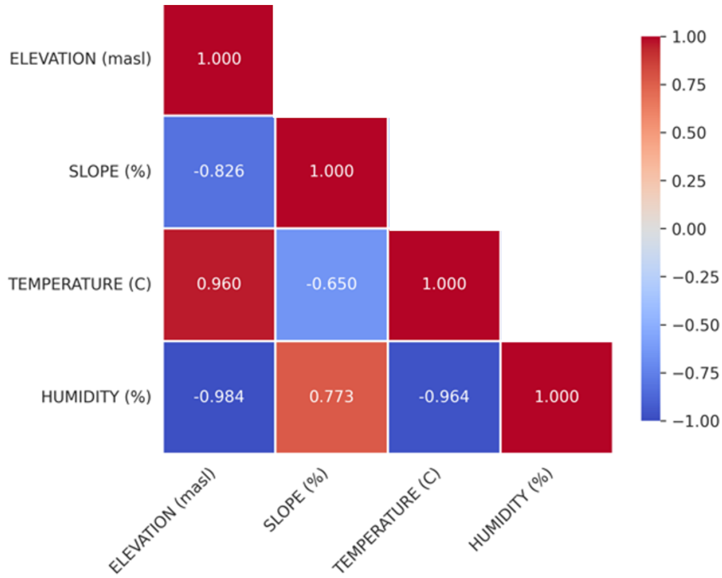

Fig. 6. Correlation among abiotic factor

A highly significant relationship exists among the abiotic factors influencing the habitat of Javanese Edelweiss. Anaphalis javanica was observed at elevations ranging from 1751 to 1772 meters above sea level (masl), with the study site (Kalipait waterfall) recording an average temperature of 17.3 ºC and average humidity of 67.7%. Statistical analysis of the study area revealed strong correlations between key environmental variables: a strong positive correlation was found between Elevation and Temperature ($r = 0.960$, $p < 0.001$), while both Elevation and Humidity ($r = -0.984$, $p < 0.001$) and Temperature and Humidity ($r = -0.964$, $p < 0.001$) exhibited strong negative correlations. These environmental characteristics align well with the known habitat requirements of *A. javanica*.

As an endemic species typically distributed across high-altitude regions, *A. javanica* shows optimal growth in volcanic ash deposits and specific soil types, conditions prevalent in areas such as Mount Papandayan [25]. This ecological adaptation to mountainous environments explicitly suggests that altitude is a significant determinant limiting and defining its habitat. Altitude is also known to influence vegetation distribution in complex ways, as vegetation at higher elevations tends to exhibit greater sensitivity to temperature changes compared to that at lower altitudes [26, 27, 28].

Specifically, air temperature is identified as a highly crucial abiotic factor determining the growth of *A. javanica* [29], and is even reported to be the most dominant variable influencing the species' population density [30]. The significance of temperature’s influence lies in its dual mechanism—both direct and indirect—on physiological processes. Directly, temperature regulates all vital plant functions by controlling internal chemical processes. Furthermore, humidity and temperature often interact complexly; in some regions, antagonistic effects between the two factors may influence vegetation activity, while in others, synergistic effects may occur [31, 32].

4 Conclusion

This study confirms that the habitat characteristics at Kalipait Waterfall support the persistence of Anaphalis javanica, with 364 individual plants from 13 species recorded and community structure dominated by *Arundinella fuscata* (24–25%, n = 102). Although less abundant, *A. javanica* demonstrated a notable ecological role reflected by its relatively high IVI. The species thrives at 1751–1772 masl, with an average temperature of 17.3 °C and humidity of 67.7%, and these abiotic factors showed strong correlations, particularly between elevation and temperature ($r = 0.960$, $p < 0.001$) and elevation and humidity ($r = –0.984$, $p < 0.001$). These findings highlight the critical importance of specific microclimatic conditions for *A. javanica* and emphasize the need for targeted conservation within the Ijen Geopark.

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References

1. M. Rahalus, M. Kumaunang, A. Wuntu, J. Pontoh, Barcode DNA Edelweis (*Anaphalis javanica*) berdasarkan gen matK. *J. MIPA* 4(2), 131–136 (2015).
2. A. Fajrina, Mansyurdin, Syamsuardi, Analysis of putative hybrid between *Anaphalis longifolia* and *A. javanica* in Mount Talang, West Sumatra based on anatomical characteristics. *Makara J. Sci.* 21(1), 1–7 (2017). https://doi.org/10.7454/mss.v21i1.7532
3. E. Roziaty. Ecological succession and the role of edelweiss vegetation in volcanic ecosystems. Biodiversitas. 2020;21(8):3657-3665.
4. Missouri Botanical Garden. Anaphalis margaritacea species profile. Plant Finder Database. 2019.
5. Roziaty E, Wijaya K. Diversity and distribution pattern of Anaphalis sp. on the Cemoro Sewu climbing track of Mount Lawu, East Java. EurAsian J BioSci. 2019;13:1143-1150.
6. Oo T N, et al. The distribution and habitat profiles of Anaphalis spp. Int J Sci Mgmt Stud. 2021;4(5):45-55.
7. Wijaya K, Roziaty E. Elevational distribution and sunlight correlation of Anaphalis sp. in Mount Semeru. Jurnal Biologi Indonesia. 2020;16(2):89-97.
8. S. Poovitha, N. Stalin, R. Balaji, M. Parani, Multi-locus DNA barcoding identifies *matK* as a suitable marker for species identification in *Hibiscus* L. *Genome* 59(11), 831–838 (2016). https://doi.org/10.1139/gen-2016-0072
9. Takano B, et al. Bathymetric and geochemical investigation of Kawah Ijen crater lake. J Volcanol Geotherm Res. 2004;134:295-312.
10. Yudiantoro D F, et al. Distribution of acidic conditions in river water from the Ijen area. Int J Adv Sci Eng Inf Technol. 2021;11(6):2341-2348.
11. C.J. Still, P.N. Foster, S.H. Schneider, The hydroclimatic and ecophysiological basis of cloud forest distributions under current and projected climates. *J. Ecol.* 105(2), 511–524 (2017). https://doi.org/10.1111/1365-2745.12608
12. N.G. Gotsch, Vapor pressure deficit predicts epiphyte abundance across an elevational gradient in a tropical montane region. *Plant Ecol. Divers.* 10(3), 283–293 (2017). https://doi.org/10.1080/17550874.2017.1307582

13. D.C. Nepstad, et al., Interactions among Amazon land use, forests, and climate. *Phil. Trans. R. Soc. B Sci.* 363, 1737–1746 (2020). https://doi.org/10.1098/rstb.2007.0036
14. Mehta, N., & Chawla, A. (2024). Eco-physiological trait variation in widely occurring species of Western Himalaya along elevational gradients reveals their high adaptive potential in stressful conditions. *Photosynthesis Research*, 159(1), 29-59. https://doi.org/10.1007/s11738-018-2637-4.
15. F.Y. Ade, L. Hakim, E.L. Arumingtyas, R. Azrianingsih, Habitat *Anaphalis* spp. in tourism area in Bromo Tengger Semeru National Park, East Java. *J. Pembang. Alam Lestari* 10(2) (2019). https://jpal.ub.ac.id
16. H. Prakasa, A. Zawani, W.A. Guci, S. Edi, Analisis habitat (*Anaphalis longifolia* (Blume) Blume ex DC.) di Sumatera Utara. *JBIO: J. Biosains* 4(2) (2018).
17. Thapliyal, N., Bhojak, P., Sekar, K. C., Bisht, K., Mehta, P., Arya, D., & Joshi, S. (2025). Potential drivers of plant diversity and composition in high-altitude alpine regions of Himalaya. *Community Ecology*, *26*(1), 85-103. https://doi.org/10.1111/j.1461-0248.2010.01552.x.
18. S. Taurines, et al., Facilitating early boreal forest succession on waste rock using Ramial Chipped Wood mulch: A five-year study. *Forest Ecology and Management 561* (2024). https://doi.org/10.1016/j.foreco.2024.121860
19. D. Susanto, P. Nugroho, S. Numata. Traditional ecological knowledge for monitoring *Anaphalis javanica* (DC.) Sch.Bip. (Asteraceae) in Bromo Tengger Semeru National Park, Indonesia. *Environ. Monit. Assess.* 196, 717 (2024). https://doi.org/10.1007/s10661-024-12869-8
20. K.R. Paulus, J.M. Marshall, Competitive interactions between two non-native species (Alliaria petiolata [M. Bieb.] Cavara & Grande and Hesperis matronalis L.) and a native species (Ageratina altissima [L.] R.M. King & H. Rob.). *Plants* 11, 374 (2022). https://doi.org/10.3390/plants11030374
21. F. Essl. The distribution of Ageratina altissima (L.) R. M. King & H. Rob. in Austria. BioInvasions Records 14(1): 13–18 (2025).
22. R. Singh, P. Kumar, S. Singh, Chromolaena odorata: A review of its biology, ecology, and management. Invasive Plant Sci. Manag. 12(3), 141–157 (2019). https://doi.org/10.1017/inp.2019.22
23. Kaur, A, et al. Ecology, biology, environmental impacts, and management of an agro-environmental weed Ageratum conyzoides. *Plants*, 12, 2329 (2023).
24. P. Kumar, R. Singh, S. Sharma, Conyza sumatrensis: An invasive species in tropical ecosystems. Ecol. Manag. Restor. 22(2), 98–107 (2021). https://doi.org/10.1111/emr.12432
25. L. Amalia, W. L. Hakim, M. Miranti, D. I. Putri, & T. Kristianti. (2019). Comparing the Javanese Edelweiss (*Anaphalis javanica*) density in Tegal Alun, Tegal Bungbrun and Pondok Saladah of Mount Papandayan. *Journal of Physics: Conference Series*, *1402*(3), 033032. https://doi.org/10.1088/1742-6596/1402/3/033032
26. J. Tao, Xu, T., Dong, J., Yu, X., Jiang, Y., Zhang, Y., Huang, K., Zhu, J., Dong, J., Xu, Y., & Wang, S. (2018). Elevation-dependent effects of climate change on vegetation greenness in the high mountains of southwest China during 1982–2013. *International Journal of Climatology*, *38*(3), 1400–1412.
27. B. He, Y. Li, F. Gao, H. Xu, B. Wu, Yang, P., Ban, J., Liu, Z., Liu, K., Han, F., Ma, Z., & Wang, L. (2025). Response of vegetation to climate change along the elevation gradient in High Mountain Asia. *Journal of Arid Land*, *17*, 1215–1233.
28. X. Tai, H. E. Epstein, & Li, B. (2020). Elevation and climate effects on vegetation greenness in an arid mountain-basin system of Central Asia. *Remote Sensing*, *12*(10),

1665. https://doi.org/10.3390/rs12101665
29. A. Aliadi, E. Djamhuri, & Zuhud, E. (1990). Kemungkinan pada penangkaran Edelweis (*Anaphalis javanica*) (Bl. Boerl.) dengan stek batang. *Jurnal Media Konservasi*, *3*(1), 37–45.
30. D. Wahyudi. (2010). *Distribusi dan kerapatan edelweis (Anaphalis javanica) di Gunung Batok Taman Nasional Bromo Tengger Semeru*. (Skripsi tidak dipublikasikan). Universitas Islam Negeri Maulana Malik Ibrahim, Malang.
31. M. Sun, P. Sun, N. Liu, Zhang, L., Yu, Z., Feng, Q., Smettem, K., & Liu, S. (2024). Alternating dominant effects of temperature and precipitation along elevational gradient on the alpine and subalpine vegetation activities in southwestern China. *Forest Ecology and Management*, *554*, 121668. https://doi.org/10.1016/j.foreco.2023.121668.
32. Nugroho, S. A., & Salim, A. (2024, May). Identification and Potential of Secondary Metabolism of Weeds as Bio Herbicides in Environmentally Friendly Citrus Cultivation. In *IOP Conference Series: Earth and Environmental Science*.1338(1), 012013). IOP Publishing.