JOURNAL OF SUSTAINABLE NATURAL RESOURCES
e-ISSN: 2716-7143

J-SuNR

Vol. 6 No. 2 (2025) 39-45
https://publisher.uthm.edu.my/ojs/index.php/j-sunr

Assessing the Taxonomic Accuracy of Mobile Plant Identification Applications among Tropical Plant Species

Kishen Shrii Raam Sivanathan[1], Salasiah Mohamad[1]*, Ooi Im Hin[2], Thachayni Dharmaraja[3]

[1] *Centre of Research of Sustainable Uses of Natural Resources, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia Pagoh Campus, Pagoh Education Hub, KM 1, Jalan Panchor, 84600, Muar, Johor Darul Takzim, MALAYSIA*

[2] *Suriana Conservation Botanical Garden, 368, Titi Serong, Mukim 4, 11000 Balik Pulau, Pulau Pinang, MALAYSIA*

[3] *Jabatan Taman Botani Pulau Pinang, Pavilion Building, Jalan Kebun Bunga, 10350 George Town, Pulau Pinang, MALAYSIA*

*Corresponding Author: salasiah@uthm.edu.my
DOI: https://doi.org/10.30880/jsunr.2026.06.02.004

Article Info

Received: 23 October 2025
Accepted: 14 December 2025
Available online: 31 December 2025

Keywords

Mobile plant apps, mobile ecology tools, tropical plant taxonomy, on-site identification

Abstract

Plant identification through mobile apps has gradually grown in popularity over time. With the emergence of a variety of plant identification applications, problems arise in terms of misidentification of plant species through these applications. Hence, this research aims to assess the accuracy of mobile applications designed for identifying tropical plant species, which are essential for biodiversity research and conservation in tropical regions. The study tested five selected tropical plant identification applications, in particular PlantNet, PlantSnap, iNaturalist, PictureThis, and LeafSnap, against a reliable botanical database at the Penang Botanical Garden, using a varied sample of 100 plant taxa, including trees, shrubs, and herbaceous plants. The evaluation of the applications' accuracy was conducted at three taxonomic levels: species, genus, and family. The results indicated that PlantNet achieved the highest accuracy at the species level, while iNaturalist performed best at the genus level. The proposed procedure emphasizes key factors including lighting conditions, image focus, viewing angles, plant morphological characteristics, and the inclusion of relevant metadata. The findings highlight the potential of mobile plant identification applications as valuable tools for biodiversity documentation and conservation, while also emphasizing the importance of proper image acquisition techniques to enhance identification reliability.

1. Introduction

Plants are among the most abundant organisms on Earth, with an estimated 500,000 land species, many of which thrive in the tropics where diversity is especially high [1]. This elevated diversity, largely due to favorable environmental factors such as abundant sunlight, rainfall, and nutrient-rich soils, is referred to as the latitudinal diversity gradient. Plant identification plays a vital role across various fields, including agriculture, medicine, ecological research, and biodiversity conservation. However, traditional methods of plant identification, which require trained taxonomists to assign taxonomic labels, face challenges such as financial limitations and a shortage of taxonomic experts, known as “taxonomic impediment” [2, 3, 4]. Additionally, fluctuating environmental and climatic conditions in tropical regions make the identification process even more challenging [5].

The advent of mobile plant identification applications marks a significant step forward in the field of botany, offering an alternative to the traditional methods. These mobile applications leverage image recognition and machine learning technologies, enabling users to identify plant species quickly and easily using smartphone cameras [6]. This accessibility removes the need for specialised botanical knowledge and makes plant identification accessible to a broader audience. Mobile identification apps can analyse plant organs, their characteristics, and even complex images, thereby decentralising the identification process and making it easier for users to engage with nature and appreciate plant diversity. Furthermore, these apps contribute valuable data on plant abundances and distributions, which can assist scientists in managing ecosystems and biodiversity [4,6].

Despite their potential, mobile plant identification apps have seen limited application within tropical forest ecosystem due to the vast diversity of plant species in these regions, making accurate identification challenging [1, 3]. Few studies have examined the taxonomic accuracy of these applications for tropical species, though such research is essential to assess their effectiveness. This study seeks to evaluate mobile applications’ performance in identifying tropical plants accurately, especially for species with well-documented databases, and to establish a procedure for effective tropical plant photography, which may enhance app accuracy in these biodiverse regions.

2. Methodology

2.1 Identification of Key Online Plant Identification Applications

The objective of the study was to identify the top five key mobile apps for plant identification by assessing them based on five essential criteria. These criteria included features and functionality, such as the provision of extra plant information, interactive tools, and compatibility with both Android and iOS devices. Usability and interface were evaluated with an emphasis on user-friendliness and offline capabilities to enhance accessibility. The affordability and availability of each application were also considered to ensure they were reasonable and widely distributed. User reviews and ratings from platforms including the Google Play Store and Apple App Store were utilised to assess customer satisfaction. Furthermore, an analysis of the marketing strategies used by developers was conducted to gain insight into how they promoted the app’s advantages. Following this assessment, the apps that made the shortlist underwent further in-depth testing.

Table 1 *Top 5 online plant identification applications available online*

Application	Logo	Developer Information	Origin	Year of Release	Number of users	Number of plants identified
PlantNet	Pl@ntNet	CIRAD, INRA, INRIA, IRD, and Tela Botanica	France	2010	Over 12 million users	Over 20,000 plant species
PlantSnap	PlantSnap	PlantSnap, Inc.	USA	2017	Over 35 million users	More than 600,000 plant species
PictureThis		Glority	China	2018	Over 50 million users	Approximately 17,000 species
iNaturalist	iNaturalist	Jointly managed by California Academy of Sciences and National Geographic Society	USA	2008	Over 5 million users	Specific number is unavailable as it includes plant and animal data

J. of Sustainable Natural Resources Vol. 6 No. 2 (2025) p. 39-45

Application	Logo	Developer Information	Origin	Year of Release	Number of users	Number of plants identified
LeafSnap	LeafSnap	Collaboration between Columbia University, University of Maryland, and Smithsonian Institution	USA	2011	Over 1 million users	Approximately 90 tree species in the USA

2.2 Study Site and Reference Database

To guarantee accuracy and consistency in the evaluation of plant identification applications, a dependable database was necessary. The Penang Botanical Garden was selected as the research location because of its extensive record-keeping system that employs the BRAHMS (Botanical Research and Herbarium Management System) database. Established in 2014 with assistance from the Forest Research Institute Malaysia (FRIM), this system is acknowledged as one of the most precise databases available. The BRAHMS database, along with its thorough herbarium records, was created under the supervision of FRIM's Flora Biodiversity Program. Additionally, the limited number of studies carried out at the Penang Botanical Garden underscored its importance as an underappreciated yet vital research site. A permit was acquired from the garden authorities to carry out the study in August – September 2024 and utilising its detailed plant species database for consistent testing.

2.3 Testing of Selected Plant Identification Applications Against an Established Database

The precision of the five plant identification apps was evaluated against the reliable database supplied by the botanical garden. Specifically, the established botanical database software, BRAHMS, served as a point of reference to check the accuracy of the five plant identification apps used in the botanical garden. A sample of 100 plant taxa was utilised for this study. This included trees, herbaceous plants, and shrubs, with a focus on recognising tropical plant species. Each application was assessed with the sample size, and the outcomes were noted and documented. Both the respective formulae used for calculating the accuracy and inaccuracy rates for each application have been listed as follows:

$$Accurary\ rate(\%) = \frac{Number\ of\ Accurate\ Identifications}{Total\ Number\ of\ Identifications} x\ 100 \tag{1}$$

$$Inaccurary\ rate(\%) = \frac{Number\ of\ Failed\ Identifications}{Total\ Number\ of\ Identifications} x\ 100 \tag{2}$$

The effectiveness of the plant identification applications was evaluated by determining the accuracy and inaccuracy percentages of each application against a pre-established database. These percentages represent the share of correct and incorrect identifications for each application. To compute these rates, the precision of each identification was first examined. The levels used to determine precision included accurate to species, accurate to genus, accurate to family, and incorrect identifications. The total number of identifications was compiled to derive the respective rates. This involved dividing the count of correct or incorrect identifications by the overall total and then converting that figure into a percentage. Subsequently, the percentages for each application were compared to identify which application was the most effective for precise plant identification.

2.4 Selection of Key Morphological Characteristics for Formation of an Accurate Plant Identification Procedure

To create an efficient procedure for plant identification, the features of the top mobile plant identification apps were examined in detail. Observations focused on how well the app performed with various morphological traits of plants. These morphological observations included vegetative traits, such as leaf shape, bark texture, and branching patterns, along with reproductive traits, which covered flowers and fruits. Subsequently, a standardised procedure for identifying plants through mobile applications was developed based on the findings from morphological observations.

3. Results and Discussion

3.1 Evaluation of Taxonomic Accuracy

The taxonomic accuracy of five widely used mobile plant identification applications—PlantNet, PlantSnap, PictureThis, iNaturalist, and LeafSnap—was evaluated using 100 tropical plant taxa comprising trees, shrubs, and herbaceous species. Each plant sample was independently assessed using all five applications, and the identification results were compared against verified taxonomic records obtained from the BRAHMS database at the Penang Botanical Garden. The overall accuracy of each application at the species, genus, and family levels is presented in Table 2 while selected examples of identification outcomes from each application are provided below.

Table 2 *Overall results of data testing and analysis using the top 5 plant identification applications*

Plant Identification Applications	Accuracy rate (%)			Inaccuracy rate (%)
	Species	Genus	Family	
PlantNet	39	25	14	22
PlantSnap	22	28	27	23
PictureThis	32	27	19	22
iNaturalist	32	30	10	28
LeafSnap	26	26	22	26

At the species level, PlantNet achieved the highest accuracy rate of 39%, followed by PictureThis and iNaturalist, each with an accuracy of 32%. LeafSnap recorded an accuracy of 26%, while PlantSnap possessed the lowest accuracy at species level, 22%. These findings suggest that PlantNet is especially effective for identifying tropical plant species, likely due to its comprehensive database and emphasis on biodiversity, alongside a comprehensive tutorial about photography of plant organs [7].

At the genus level, however, iNaturalist recorded the highest accuracy rate at 30%, closely followed by PlantSnap at 28% and PictureThis at 27%. LeafSnap and PlantNet showed slightly lower accuracy rates at 26% and 25%, respectively. The more optimal performance of iNaturalist at this taxonomic level indicates that its identification algorithm is better at recognising broader plant features that are common among genera [9]. The similar accuracy rates among the applications at this level suggest that identifying genera is typically less difficult than identifying species. Nevertheless, the decrease in PlantNet's accuracy at this level in comparison to its species-level performance implies that its algorithm may focus more on specific details rather than overall characteristics. The relatively low accuracy of PlantSnap indicates challenges in recognising specific species traits, which may result from its dependence on a more generalised database [9].

Identification of plant species at the family level has yielded results where PlantSnap (27%) and LeafSnap (22%) outperformed the other apps. iNaturalist, which was highly effective in identifying genus and species, only achieved 10% accuracy at the family level, suggesting a possible weakness in recognising family traits. This difference in performance may stem from iNaturalist's focus, which emphasises detailed identification at the species and genus levels rather than broader taxonomic categories. PlantSnap's superior performance at the family level demonstrates its capability to effectively generalise plant characteristics [10].

Upon reviewing the inaccuracy rates, iNaturalist had the highest at 28%, while PlantSnap followed closely at 23%, and LeafSnap recorded 26%. PlantNet, PictureThis, and LeafSnap all displayed an equal inaccuracy rate of 22%. These results indicate that although iNaturalist excels in specific taxonomic categories, it tends to make more mistakes overall, potentially due to its dependence on user-submitted images and feedback. The reduced inaccuracy rates of PlantNet and PictureThis highlight their reliability, especially in identifying species and genera [11].

In summary, PlantNet exhibited consistently high accuracy at all taxonomic levels, making it a trustworthy option for tropical plant identification. iNaturalist also showed good performance, especially at the genus level, although its rates of inaccuracy were significant. PictureThis demonstrated a balanced level of accuracy across various taxonomic levels, making it appropriate for general use. LeafSnap and PlantSnap showed less consistent results, suggesting that there is potential for enhancements in both their databases and identification algorithms. [7] [8].

J. of Sustainable Natural Resources Vol. 6 No. 2 (2025) p. 39-45

3.2 Recommended Procedure for Tropical Plant Photography to Improve Identification Accuracy

The success of tropical plant identification applications particularly PlantNet, iNaturalist, PictureThis, PlantSnap, and LeafSnap largely relies on the caliber or quality and uniformity of the images submitted by users. The suggested photography guidelines focus on essential elements of photo capturing to improve the precision of these apps, considering their distinct advantages and drawbacks, as well as their inherent accuracy.

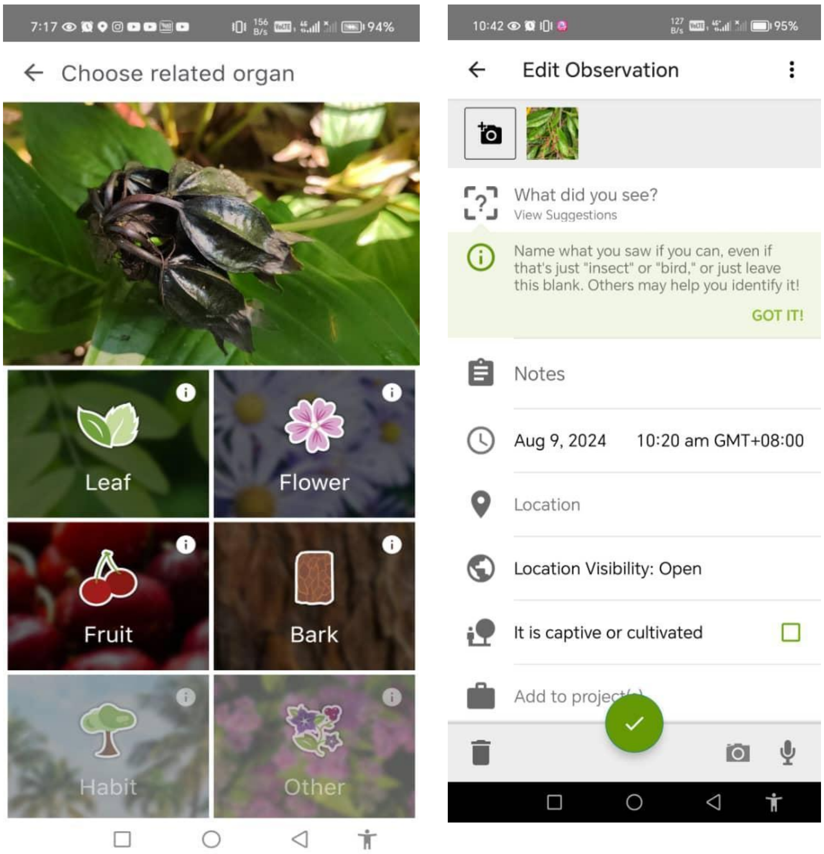
Effective lighting is a crucial aspect for clearly capturing plant characteristics. Utilising natural, soft light minimises glare and shadows, which are frequent sources of inaccuracies for applications such as PlantNet and iNaturalist, relying on precise visual information to identify subtle structural features [1]. Excessive brightness can hide key traits, particularly impacting apps such that PictureThis and PlantSnap, which have difficulty with high light levels [9].

Maintaining sharp focus is another crucial factor, as blurred images hinder the ability of all apps to recognise patterns accurately. This is especially critical for LeafSnap, which emphasises leaf morphology, and for PlantSnap, which exhibits lower accuracy when the image lacks clarity [8]. Additionally, using a plain or contrasting background isolates the plant from distracting elements, allowing the algorithms in PlantNet and LeafSnap to better process key features [8]. For iNaturalist, a natural background can also provide contextual ecological data, which is integrated into its identification system [11].

Taking photographs from various angles of the plant improves the accuracy of identification. Aerial shots, side views, and detailed close-ups of key diagnostic features such as flowers, fruits, and stems are especially useful for applications such as PlantNet and iNaturalist, which emphasise structural and organ-specific characteristics [1]. It is important to capture the undersides of leaves for LeafSnap, as this application focuses on leaf traits during the identification process. Including a reference for scale, such as a coin, a hand, or a ruler, is crucial for apps such as PlantSnap and PictureThis, which often have difficulties with size-related traits [9].

The procedure highlights the significance of capturing images of plant parts, including flowers, fruits, leaves, and stems, as these typically possess the most recognisable taxonomic characteristics. Key organs of the plant are given priority during the identification process. The ideal work flow would involve beginning with photos of the bark of the sample, followed by back and front images of leaf patterns, inflorescence, fruit, and lastly an overall image of the sample. PlantNet and iNaturalist significantly enhance their results with detailed images of specific organs, while PictureThis and PlantSnap achieve better accuracy when several organs are present in the image [8].

Ultimately, including metadata such as location, habitat type, and collection date significantly enhances the accuracy of identification. For instance, iNaturalist integrates geographic and ecological information into its machine learning framework, making metadata a crucial component of its identification methodology [11]. Likewise, PlantNet leverages regional databases to improve its matching process, highlighting the importance of location data (Figure 1) [10]. Although PictureThis and PlantSnap are primarily focused on images, metadata still aids species verification by aligning the images with established regional plant distributions.



(a) **(b)**

Fig. 1 *Metadata provided by (a) PlantNet; and (b) iNaturalist*

By adopting this procedure, users can enhance the performance of all the assessed applications. PlantNet and iNaturalist, which already demonstrate high accuracy levels, gain the most from organised image and metadata submissions. Nevertheless, even applications with lower accuracy, such as PictureThis, PlantSnap, and LeafSnap, can see better outcomes when this method is consistently applied. Therefore, this method provides a uniform guideline for photographing tropical plants, tackling the intrinsic challenges associated with the biodiversity and complexity of tropical vegetation.

4. Conclusion

To conclude, assessing mobile plant identification apps and creating a procedure or methodology for photography of tropical plant species highlights the vital importance of obtaining high-quality images and relevant metadata for improving accuracy. Applications such as PlantNet and iNaturalist perform exceptionally well when they receive clear, well-lit images that showcase multiple perspectives, specific plant parts, and contextual information. PlantNet is highly suited for conservation efforts. Meanwhile, PictureThis, PlantSnap, and LeafSnap demonstrate enhanced effectiveness under similar conditions. The established procedure, which addresses factors such as lighting, focus, background, scale, and ecological metadata, serves as a practical resource for users seeking to maximise app performance. By tackling the complexities of tropical biodiversity, this methodology fosters more dependable taxonomic identifications, aiding efforts in research, education, and conservation. In terms of recommendations, implementation of metadata into these applications looks to be essential as apps that possess such features proven to be more reliable. This is the case for both PlantNet and iNaturalist. Besides that, specialisation between applications also can be an improvement as some applications such as PlantNet and iNaturalist are more suited to conservation and research, while the other three applications look to be more tutored to gardening. Lastly, strategic collaboration between the Malaysia Biodiversity Information System (MyBIS) and existing mobile plant identification applications would significantly enhance the overall accuracy and reliability of plant identification, particularly through the integration of comprehensive floral and taxonomic data from Malaysia. Such integration would not only strengthen regional biodiversity documentation and conservation efforts but also contribute valuable, high-quality data to global plant identification platforms, thereby supporting international research, cross-border biodiversity monitoring, and global conservation initiatives.

Acknowledgement

We would like to acknowledge the Penang Botanical Garden for granting permission (approval letter reference: JTB/PP/02/152 (73)) and providing valuable support to this study, as well as for contributing access to their tropical plant species database used in this project.

Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Kishen Shrii Raam Sivanathan, Salasiah Mohamad;* ***data collection:*** *Kishen Shrii Raam Sivanathan;* ***analysis and interpretation of results:*** *Kishen Shrii Raam Sivanathan, Salasiah Mohamad, Ooi Im Hin, Thachayni Dharmaraja;* ***draft manuscript preparation:*** *Kishen Shrii Raam Sivanathan, Salasiah Mohamad. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Corlett R. T. (2016). Plant diversity in a changing world: Status, trends, and conservation needs. *Plant Diversity, 38*(1), 10–16.

[2] Cope, J. S., Corney, D., Clark, J. Y., Remagnino, P., & Wilkin, P. (2012). Plant species identification using digital morphometrics: A review. *Expert Systems with Applications, 39*(8), 7562-7573.

[3] Otter, Mayer, and Tomaszewski. (2021). Swipe right: A comparison of accuracy of plant identification apps for toxic plants. *Journal of Medical Toxicology*, *17*(1), 42–47.

[4] Bawingan, P. A., Montevirgen, E. M., Canuto, P. P. L., Lucas, L. E. and Pumaras, J.C. (2024). Plant identification mobile apps: users' difficulties and impressions. *Asian Journal of Biology Education,* 16 (1), 1515

[5] Tripathi, S., Bhadouria, R., Srivastava, P., Singh, R., & Sanayaima Devi, R. (Eds.). (2023). *Ecophysiology of Tropical Plants: Recent Trends and Future Perspectives* (1st ed.). CRC Press.

[6] Siddiqua, A., Kabir, M. A., Ferdous, T., Ali, I. B., & Weston, L. A. (2022). Evaluating plant disease detection mobile applications: Quality and limitations. *Agronomy, 12*(8), 1869.

[7] Schmidt, R. J., Casario, B. M., & Zipse, P. C. (2022). An analysis of the accuracy of photo-based plant identification applications on fifty-five tree species. *Arboriculture & Urban Forestry, 48*(1), 27-35.

[8] Anyomi, K. (2023). How consistent are citizen science data sources? An exploratory study using free automated image recognition apps for woody plant identification. *Canadian Journal of Forest Research, 54* (3), 0203.

[9] Shapovalov, Y. B., Shapovalov, V. B., & Bilyk, Z. I. (2020). Comparing Google Lens recognition accuracy with other plant recognition apps. *Proceedings of the 1st Symposium on Advances in Educational Technology (AET 2020), 2* (1), 20-33.

[10] Chung, Y., Chou, C. A., & Li, C. Y. (2021). Central attention and a dual-path convolutional neural network in real-world tree species recognition. *International Journal of Environmental Research and Public Health, 18*(3), 961.

[11] Coşkunserçe, O. (2024). Use of a mobile plant identification application and the out-of-school learning method in biodiversity education. *Ecology and Evolution, 14* (1), e10957