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DIGITIZING TREE INVENTORY USING GIS FOR EFFECTIVE LANDSCAPE MONITORING IN PUNCAK ISKANDAR, PERAK, MALAYSIA

Suzanah Abdullah[1], Nur Huzeima Mohd Hussain[2]*, Izrahayu Che Hashim[3], Haslina Hashim[4]

[1,2,3,4] *Department of Built Environment Studies and Technology, College of Built Environment,*
UNIVERSITI TEKNOLOGI MARA, PERAK BRANCH,
32610 SERI ISKANDAR, PERAK, MALAYSIA

Abstract

Conventional inventories may struggle to comply with long-term planning and adaptability in changing landscape planning and management. Therefore, digitizing inventories through a GIS-integrated system enhances better platform foresight, offering efficiency, and accuracy with advanced technologies in assisting landscape planning and management. This information aids in making informed decisions about tree care, preservation, and landscape design, promoting sustainable management practices and enhancing the overall quality of the environment. This study's objective is to collect accurate and detailed spatial data on tree locations and attributes within a specified area for efficient analysis and visualization. This study adopted Geographic Information System (GIS) technology to record, analyse, and visualise the collected data, enabling spatial analysis, mapping, as well as informed decision-making. The aim of this study is to provide a robust and reliable tool for the community, professionals, planners, and arborists to effectively manage, monitor, and preserve trees towards sustainable land use practices, and a resilient environment.

Keywords: tree, inventory, GIS, landscape, management

[2] Senior Lecturer at Universiti Teknologi MARA Perak Branch. Email: nurhu154@uitm.edu.my

INTRODUCTION

A tree inventory plays a vital role in assessing the composition and distribution of trees within a landscape, identifying areas with high tree density or species diversity. This information aids in developing strategies for tree planting initiatives, ensuring balanced urban green spaces, and enhancing the overall aesthetic appeal and functionality of the environment. Conventional tree inventory requires more time, energy, and budget with insufficient access and accuracy. This situation has subsequently led to challenges in managing and maintaining tree functions, conditions, and their looks in the environment. Hence, initiating effective tree inventory through technology enables effective monitoring of tree health, and identifying trees in need of maintenance or treatment. By documenting maintenance activities and tracking their outcomes, the inventory facilitates proactive tree management, reducing the risk of tree-related hazards and promoting the longevity of trees (Hamzah et al, 2020).

In landscape management, a tree inventory provides valuable insights into the diversity, distribution, and overall health of trees within a specific landscape. By understanding the composition of tree species, landscape professionals can make informed decisions about tree planting initiatives, ensuring a balanced and resilient ecosystem. Additionally, a tree inventory enables the identification of areas with insufficient tree coverage, allowing targeted interventions to enhance the aesthetic appeal and functionality of the landscape. Conducting a tree inventory for landscape purposes is crucial for effective landscape management, urban planning, and ecological studies.

A tree inventory for landscape in a Geographic Information System (GIS) is considered as a comprehensive approach in collecting and managing data about trees within a specific landscape using spatial analysis and visualization tools. With advancements in geospatial technologies, GIS platforms are increasingly utilized to create GIS-based tree inventories. GIS also provide a powerful framework for spatial data analysis, visualization, and integration with other landscape datasets. By incorporating tree inventory data into GIS, it is possible to assess the spatial relationships between trees and other landscape features, identify patterns, and make data-driven decisions for urban planning and management. According to research by Abdullah S. et al (2021) and Liu et al. (2018), GIS-based tree inventories have become increasingly important in monitoring landscape management due to their ability to integrate spatial data and provide a comprehensive understanding of tree resources. By utilizing GIS technology, the inventory data can be effectively analysed, mapped, and visualised, as well as facilitating data-driven decision-making processes.

The integration of GIS technology into tree inventories allows for accurate mapping and spatial analysis of tree distribution patterns within the landscape (Chen et al., 2019). This spatial perspective provides valuable insights for identifying areas with high or low tree density, supporting targeted tree

planting initiatives, and enhancing the aesthetic appeal of the landscape. Furthermore, the use of GIS in tree inventories enable the assessment of the spatial relationships between trees and other landscape features. This information can assist urban planners in identifying suitable locations for parks, green spaces, and urban forests, contributing to the creation of sustainable and liveable environments (Chen et al., 2019).

In addition to landscape monitoring, GIS-based tree inventories play a crucial role in ecological studies. The integration of ecological data, such as biodiversity and habitat information, with tree inventory data in GIS, allows for comprehensive assessments of ecosystem dynamics and the impact of land management practices (Liu et al., 2018). The integration of GIS technology into tree inventories for landscape management provides a powerful framework for analysing and visualizing spatial data. This approach facilitates informed decision-making, supporting urban planning, enhancing the aesthetic appeal of the landscape, and promoting ecological sustainability. This study explores the application and perspectives of GIS in landscape architecture. It discusses how GIS technology can enhance various aspects of landscape architecture, including design, planning, and analysis.

Tree Inventory in GIS Applications

The integration of Tree Inventory in GIS applications presents a powerful approach for effective landscape management and planning, offering numerous benefits such as spatial analysis, visualization, and informed decision-making (Kant & Srinivasan, 2020). The Tree Inventory incorporation into GIS applications offer a wide range of practical uses, including urban planning, ecological analysis, and informed tree management, leading to sustainable landscape practices, and improved environmental quality (Shendy & Eldebaiky, 2021). The importance of GIS-based tree inventory lies in its ability to provide accurate and comprehensive data on tree species, locations, and attributes, enabling effective management, planning, and decision-making processes in the field of urban forestry and landscape management (Zhao et al., 2020; Almeida et al., 2020; Ciesiolka et al., 2021).

Tree inventory in GIS applications involve the integration of Geographic Information System (GIS) technology to collect, manage, analyse, andvisualise data on tree species, locations, and attributes. This approach enables efficient inventory management, spatial analysis, informed decision-making, and enhanced landscape planning and management (Etemad & Pourghasemi, 2020). Moreover, for urban tree inventory, GIS allows for the systematic collection and management of tree-related data such as species, size, health condition, and location. This information can be georeferenced and stored in a spatial database, providing a comprehensive inventory of urban trees.

GIS-Based for Landscape Architecture

GIS-based applications in landscape architecture have gained significant importance in Malaysia, providing valuable tools for spatial planning, site analysis, as well as sustainable development, ultimately contributing to the enhancement of the country's urban and natural landscapes (Sulong, 2017).

The integration of GIS technology in landscape analysis and planning has revolutionized the field of landscape architecture, allowing for data-driven decision-making, efficient spatial analysis, and comprehensive visualization (Yang et al., 2021). It involved the integration of geospatial technologies with detailed information about tree species, locations, attributes, and maintenance history. This inventory serves as a valuable tool for landscape professionals, urban planners, and arborists to make informed decisions regarding tree management, urban greening initiatives, and ecological studies. By leveraging the power of GIS, the tree inventory enables efficient data analysis, mapping, and visualization, enhancing the understanding and effective utilization of tree resources for sustainable land use planning and environmental conservation.

MATERIAL AND METHOD

The research area encompasses a residential neighbourhood known as Puncak Iskandar, located in Perak. It spans an expansive 61.523-hectare area situated at latitude 4º 22’ 26.4” N and longitude 100º 57’ 30.24” E (Figure 1). Puncak Iskandar, situated in Seri Iskandar, is recognized as a highly desirable residential neighbourhood due to its contemporary layout, innovative housing designs, and diverse range of residential options to meet the needs of its residents. The methodology for this study is structured into three distinct stages: data acquisition, data processing, and the presentation of results.

Figure 1: Study Area Located at Puncak Iskandar, Seri Iskandar, Perak
Sources: Google Earth Pro, 2021

UAV-Based (Aerial Imaging) Data Acquisition for Puncak Iskandar Residential Areas

The data acquisition phase of this study involved an experimental approach using the UAV DJI Phantom 4 Pro to capture comprehensive imagery of Puncak Iskandar area. A total of 990 images were captured during this phase, ensuring a thorough coverage of the entire Puncak Iskandar region. The UAV was flown at an altitude of 150 meters, which provided an optimal perspective for data collection. This altitude has allowed for a stereo camera view, meaning that the images captured had enough overlap and perspective to enable 3D reconstruction or in-depth analysis in subsequent processing. To facilitate the flight planning process, the DJI Go software was utilized, enabling seamless wireless communication between the software and the UAV's remote controller. Additionally, before the flight mission, the percentage of images overlap was carefully set, ensuring optimal image capture at the designated 150-meter flying altitude.

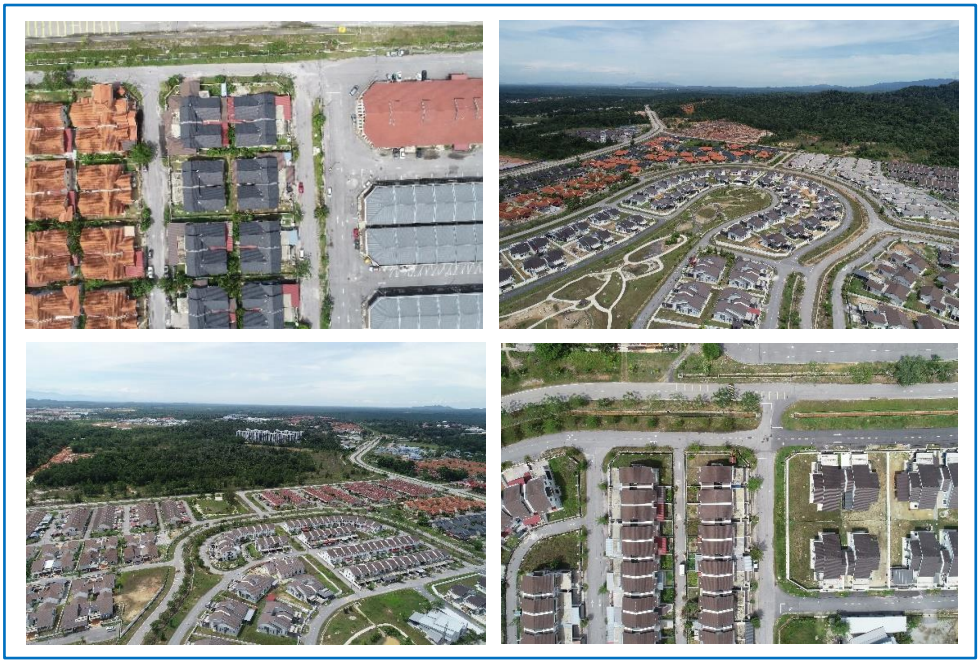

Figure 2: The Aerial Images were obtained from the UAV Technology

Data Processing Workflow for Puncak Iskandar UAV Images

UAV (Unmanned Aerial Vehicle) image processing can be used to generate orthophotos, which are high-resolution, georeferenced images that have been orthorectified to remove distortions caused by terrain and camera perspective. Orthophotos are commonly used in various fields, including agriculture, land surveying, urban planning, and environmental monitoring. This study utilized orthophotos to conduct an inventory of tree landscaping in Puncak Iskandar. Orthophotos, which are high-resolution, georeferenced images, were employed to accurately identify and mapped the trees present in the area. The orthophotos were likely generated using UAV image processing techniques, as mentioned earlier. The process of generating an orthophoto from UAV imagery involved several steps. These images were then processed using specialized software to perform photogrammetric calculations.

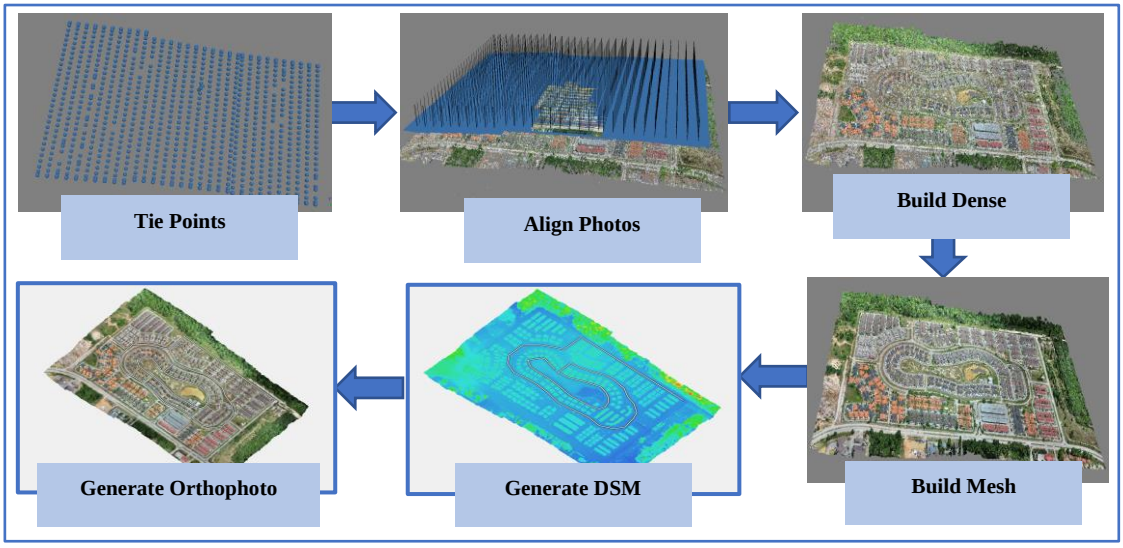

Figure 3: UAV Image Processing to Generate Orthophoto

By analysing the orthophotos, this study was able to identify and quantify the tree cover in Puncak Iskandar. This information could be valuable for various purposes, such as urban planning, environmental management, and landscape design. The inventory of tree landscaping can help assess the distribution, density, and health of trees in the area, allowing for informed decision-making regarding preservation, maintenance, or potential enhancements to the urban greenery.

Tree Locations for Inventory in Puncak Iskandar Using UAV Imagery

The study is aimed to mapped inventory tree locations in Puncak Iskandar by using UAV imagery. By utilizing UAV technology and imagery analysis techniques, this study was identified and mapped the locations of trees in the area. The UAV imagery provided a comprehensive and high-resolution view of the landscape, allowing for accurate delineation and georeferencing of tree locations. Figure 4 depicts the inventory of six tree species conducted within the Puncak Iskandar area.

Figure 4: Location of Tree Inventory at Puncak Iskandar, Perak

The images showcased the identified tree species, providing visual representation and information about the diversity of trees present in the study area. This inventory played a significant role in understanding the composition and distribution of tree species within Puncak Iskandar, contributing to effective landscape management and conservation efforts. The accurate geolocation of tree positions, obtained through the use of UAV imagery and geospatial analysis techniques, allowing a comprehensive understanding of the tree population in Puncak Iskandar. This information can be utilized for various purposes, including land management, conservation planning, and ecological assessments. The visualization presented in Figure 4 served as a valuable reference for further analysis and decision-making related to the inventory of tree locations in Puncak Iskandar.

RESULT AND DISCUSSION

The results highlighted several key applications of the tree inventory in GIS for landscape management and planning. Firstly, it enabled the identification of tree species diversity and distribution patterns, facilitating targeted conservation efforts and promoting biodiversity in the landscape. Additionally, the inventory supported effective tree management by providing information regarding tree

health, age, and maintenance requirements, allowing for proactive planning of pruning, removal, or replanting activities.

Figure 5 illustrated tree Mapping locations and analysing their spatial patterns at Puncak Iskandar provided valuable information about the distribution and arrangement of trees within the area. By using GIS and spatial analysis techniques, the tree inventory data can be visualised and analysed to identify clusters, patterns, and relationships among the trees. By mapping the tree locations, it became possible to understand the spatial extent and coverage of the tree population in Puncak Iskandar. This information helped in assessing the overall tree density and identifying areas with high or low concentrations of trees. Furthermore, spatial analysis techniques can be applied to assess the spatial relationships between trees and other features or attributes, such as infrastructure, land cover, or environmental variables. This analysis can reveal potential impacts or dependencies between trees and their surroundings, aiding in urban planning, risk assessment, or green infrastructure planning. Overall, mapping the tree locations and analysing their spatial patterns at Puncak Iskandar will provide valuable insights into the distribution, arrangement, and relationships of trees within the area. This spatial perspective support informed decision-making for tree management, conservation, and landscape planning initiatives.

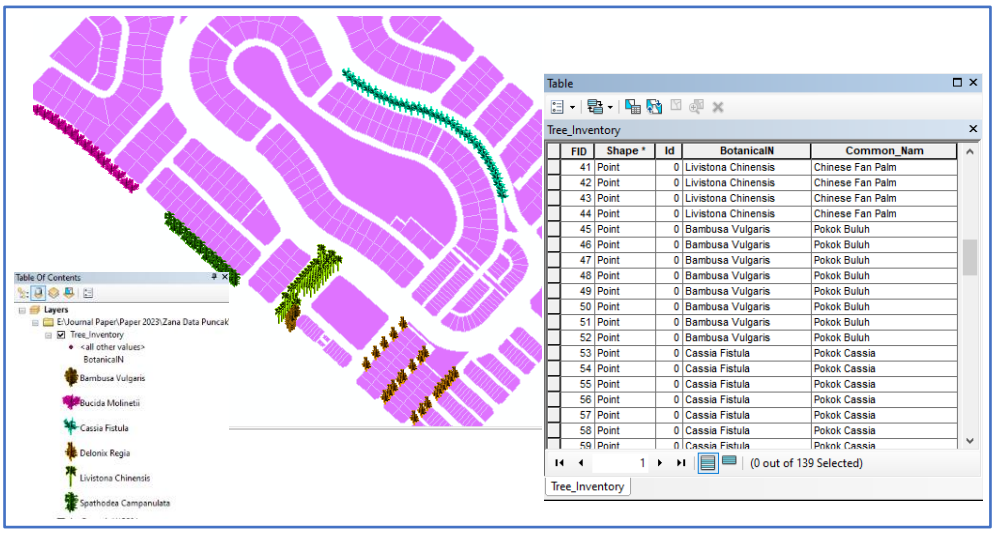

Figure 5: Mapping the Tree Locations and Analysing Tree Spatial Patterns

To ensure effective management and organization of inventory data during a tree inventory for landscaping purposes, it is crucial to establish a structured and well-organized database. This database served as a central repository for storing and managing the collected inventory data, enabling efficient data storage, retrieval, and analysis (Figures 6 and 7). A properly

structured database will facilitate easy access to information, promote data integrity, and support seamless management of the tree inventory throughout the landscaping project. By implementing a well-designed database, the inventory data can be efficiently stored, easily accessed, and effectively updated throughout the project. A structured database enabled seamless data retrieval, accurate data analysis, and informed decision-making, ensuring the success of the tree inventory and facilitating efficient management of the landscaping project.

Moreover, the integration of tree inventory data into GIS facilitated risk assessment and management. By analysing factors such as tree stability, proximity to infrastructure, and susceptibility to pests or diseases, areas with a higher risk of tree failure or hazards were identified. This information guided targeted tree maintenance activities, minimizing risks to public safety and infrastructure damage.

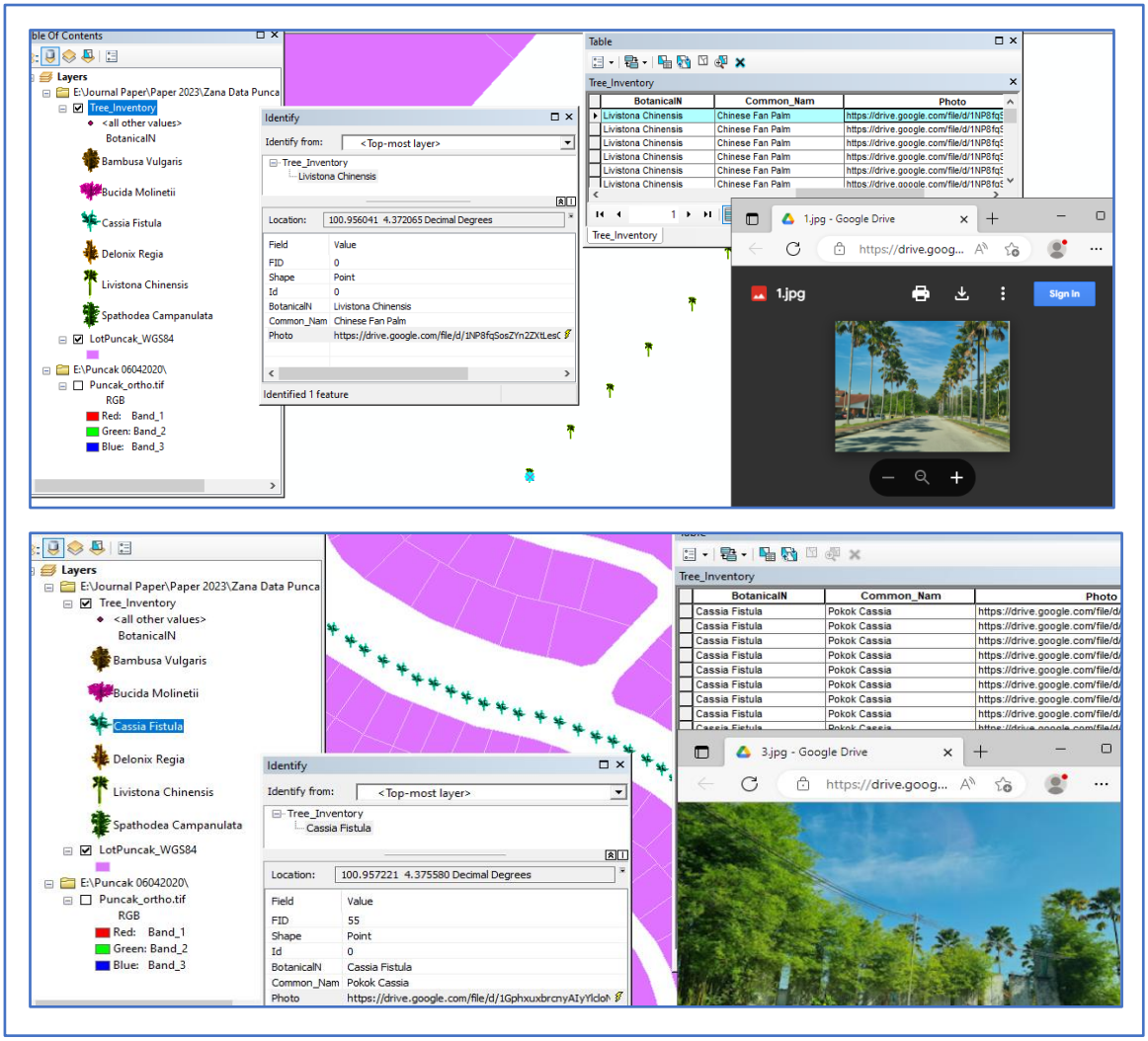

Figure 6: Databases for Tree Inventory Landscaping

Overall, the results emphasized the significance of integrating tree inventory data within GIS for effective landscape management and planning. The application of GIS provided a spatially informed approach in understanding and managing the tree population, promoting sustainable and resilient landscapes, and enhancing the overall quality of urban environments.

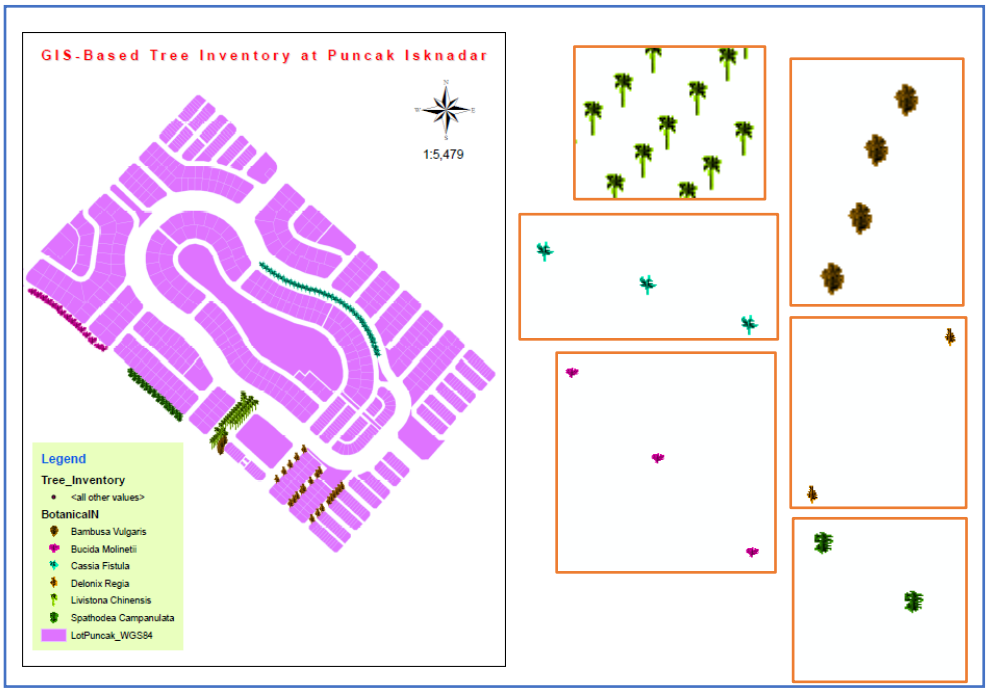

Figure 7: Databases for Tree Inventory Landscaping

CONCLUSION

The utilization of tree inventory within a GIS framework unlocks significant potential for effective landscape management and planning. By integrating tree data into GIS, a comprehensive database of plants and planting designs in community areas are digitized and analysed to better assist the identification of tree species diversity, distribution patterns, and spatial relationships, aiding in targeted conservation efforts and promoting biodiversity within the landscape. Moreover, GIS-based tree inventory supports efficient tree monitoring by providing essential information on tree health, age, and maintenance requirements, enabling proactive planning of maintenance activities. In conclusion, by unlocking the potential of tree inventory in GIS, a more resilient, green, and vibrant landscape planning towards a resilient community and environment is achievable.

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REFERENCES

Abdullah, S., Abdul Rashid, M. F., Tahar, K. N., & Osoman, M. A. (2021). Tree Crown Mapping Based On Unmanned Aerial Vehicle (UAV) Towards A Green Sustainable Residential. *Planning Malaysia Journal*, *19*(16). https://doi.org/10.21837/pm.v19i16.955

Almeida, C. M., Horta, A., Almeida, A., Vaz, T., & Castanho, R. A. (2020). The importance of GIS-based tree inventories for urban forest management. *Urban Forestry & Urban Greening,* 48, 126579. https://doi.org/10.1016/j.ufug.2019.126579

Chen, F., Xie, G., Wang, S., Yang, J., & Zhang, Z. (2019). GIS-based urban tree inventory and assessment: A case study in Nanchang, China. *Urban Forestry & Urban Greening*, 44, 126386.

Ciesiolka, C. A. A., & Sousa, S. M. (2021). GIS-based tree inventories: Importance and applications for landscape planning and management. *Journal of Environmental Planning and Management,* *64*(8), 1385-1407. https://doi.org/10.1080/09640568.2020.1828997

Etemad, A., & Pourghasemi, H. R. (2020). Tree inventory in GIS applications: Current trends and future directions. *Ecological Informatics,* 60, 101156. https://doi.org/10.1016/j.ecoinf.2020.101156

Hamzah, H., Othman, N., & Mohd Hussain, N. H. (2020). Setting The Criteria For Urban Tree Vandalism Assessment. *Planning Malaysia Journal*, *18*(14). https://doi.org/10.21837/pm.v18i14.815

Kant, S., & Srinivasan, R. (2020). GIS-based tree inventory for urban landscape management. *Journal of Urban Forestry & Urban Greening*, 49, 126642. https://doi.org/10.1016/j.ufug.2020.126642

Liu, C., Zhuang, Q., & He, H. S. (2018). A spatially explicit, robust, and scalable framework for tree inventory. Environmental Modelling & Software, 99, 154-164.

Shendy, O. F., & Eldebaiky, M. A. (2021). Integration of GIS and tree inventory for urban landscape planning and management. *The Egyptian Journal of Remote Sensing and Space Sciences,* 24(2), 301-310. https://doi.org/10.1016/j.ejrs.2020.02.002

Sulong, I. (2017). The role of GIS in landscape architecture: A case study in Malaysia. *Procedia Engineering*, 198, 888-896. https://doi.org/10.1016/j.proeng.2017.07.143

Yang, C., Cao, Q., & Zhang, Y. (2021). GIS-Based Landscape Architecture: Applications and Perspectives. *ISPRS International Journal of Geo-Information*, *10*(4), 257. https://doi.org/10.3390/ijgi10040257

Zhao, Z., Liu, Y., & Meng, Q. (2020). Tree inventory in GIS applications: A comprehensive review. *ISPRS International Journal of Geo-Information*, *9*(9), 530. https://doi.org/10.3390/ijgi9090530

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