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Preservation of Rare Fruit Trees and Local Food Genetic Re-sources to Enhance UI GreenMetric Ranking at Universitas Negeri Malang, Indonesia

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Universitas Negeri Malang, Indonesia aspires to transform into a campus that promotes balance between mental and physical health. A healthy campus can provide green open space to meet existing oxygen needs and promote food security. The Green Metric World University Ranking, established by Universitas Indonesia (also known as UI GreenMetric), utilizes multiple sustainability criteria to evaluate and rank higher education institutions worldwide. The objective of this study is to enhance the ranking of UI GreenMetric by optimizing the green open space in Universitas Negeri Malang through the preservation of rare trees and local food genetic resources. The research design employs a quantitative descriptive approach, utilizing questionnaires and interviews. The study included focus group discussions and the implementation of planting rare trees and local food genetic resources on the Universitas Negeri Malang. Observations were utilized to determine the current state of rare trees and local food genetic resources at the university. Questionnaires were used through google forms and interviews conducted to

gather the perspectives of the university academic community regarding the conditions and optimization of green open space and the local food genetic resources implemented at Universitas Negeri Malang. The findings indicated that the involvement of the academic community in enhancing green open space through the preservation of rare fruit trees and local food genetic resources remains at a reasonable level. Planting rare plants requires the involvement of lecturers and students who volunteer in environmental activities. Conserved rare trees have a crucial role in maintaining carbon storage, generating oxygen (O_2), supplying local food genetic resources, and offering health advantages. The optimization of the green open space on campus is anticipated to enhance the environmental health of campus and contribute to food security, and also increase the UI GreenMetric ranking.

Keywords: green open space, rare trees, local food genetic resources.

Introduction

The rare trees are facing a higher level of threat due to the ignorance of their presence and the inadequate scientific knowledge about their population and ecology (Mastur, 2019; Mulyanie and Romdani, 2017). Trees may establish an ecosystem that supports the existence of various animal species. Trees serve a vital purpose in the cycle of life, from birth to death, benefiting the existence of living organisms (Wang et al., 2021; Yuanisyak et al., 2022). Trees create an optimal environment for animals by regulating temperature, humidity, and air quality through the production of oxygen. In addition, offering food in the form of fruits, foliage, and nectar. Even after the death of a tree, its role in preserving environmental balance remains, primarily as a carbon storage (Aliman et al., 2017; Xu et al., 2023; Yanthi et al., 2019). The vulnerability of rare trees in Indonesia to extinction can be related to several factors, namely: (1) excessive usage; (2) reduction of their habitat due to human expansion; (3) destruction of their habitat; (4) inadequate spread of seeds and flower pollination resulting from declining populations of distribution animals (Atici et al., 2021; Chappell and LaValle, 2011; Corlett, 2016).

In reality, rare fruit trees hold significant importance, as it contributes to the sustainability of the ecosystem for many different organisms. Furthermore, the advantages of this include: (1) the ability to regulate flooding; (2) regulation of temperature and humidity; (3) a habitat for diverse animal species; (4) prevention of air pollution; (5) purification of the air; (6) supply of clean water; (7) availability of a wide range of food sources (Sejati et al., 2021; Sumarmi et al., 2020).

Indonesia, with its high biodiversity, possesses many tree species, including fruit trees (Ramadhani et al., 2024; Rozaki, 2021). Unfortunately, there is currently a decreased demand for native Indonesian fruit trees due to factors such as their less sweet taste and smaller size. Hence, it is essential to restore the biodiversity of native Indonesian trees, particularly those that provide fruits. One of the efforts is to establish a garden specifically dedicated to conserving rare fruit trees.

Universitas Negeri Malang is implementing a conservation effort aimed at preserving rare fruit trees, namely local food genetic resources, for long-term food security. When properly implemented, the conservation program encourages consumption of local food genetic resources including various tubers, such as sweet potatoes (*Ipomoea batatas*), cassava (*Manihot esculenta*), taro (*Colocasia esculenta*), *gembili* (*Dioscorea esculenta*), *sukun* (*Artocarpus altilis*), *kluweh* (*Artocarpus camansi*), and jackfruit (*Artocarpus heterophyllus*). Large food security initiatives have the potential to improve food availability and exports, increase employment opportunities, reduce poverty, and enhance the welfare of communities through adequate food supply (Mulyanie and Romdani, 2017; Mastur, 2019; Sumarmi et al, 2020).

Universitas Negeri Malang is trying to establish a sustainable campus. The UI GreenMetric is a metric utilized to assess the degree of a university sustainability. This ranking system, developed by Universitas Indonesia (UI), evaluates several categories including setting and infrastructure, energy and climate change, waste management, water conservation, transportation, and education related to sustainability efforts (UI GreenMetric, 2024). It specifically examines the sustainable initiatives implemented by the university (Binta and Maulana, 2021). In order to achieve a high ranking in the UI GreenMetric framework, universities located in urban areas have to implement a specific strategy due to the lack of green open spaces in highly populated metropolitan environments (Atici et al., 2021). Thus, a

potential approach is to enhance the efficiency of the current green open spaces.

This research offers both theoretical and practical advantages. The primary objective of this research is to contribute to the current theoretical knowledge related to green open spaces including rare trees and the preservation of local food genetic resources, in line with the Sustainable Development Goals (SDGs). The practical benefits serve as a foundation for university leaders to formulate policies aimed at maximizing tactics in the development of campus green open spaces. Furthermore, it is important to enhance the involvement of the academic community in Universitas Negeri Malang in developing sustainable public areas to enhance the UI GreenMetric ranking.

Several studies have been conducted regarding green open spaces in campus areas, such as the green open space planning in Universitas Negeri Padang campus area (Aliman et al., 2017), the green open space at Politeknik Negeri Pontianak (Binta and Maulana, 2021), the green campus at the University of Florence, Italy (Fissi et al., 2021), the green campus management at St Petersburg State University, Russia (Abakumov and Beresten, 2023), and the local food genetic resources for green campus in Mahasarakham University, Thailand (Sribanasarn et al., 2024). However, there has been a lack of research on campus green open spaces that specifically focus on conserving rare fruit trees as a local food source, and this issue has not received much attention from university leaders. This research aims to achieve the following specific objectives: (1) identify the various types of rare trees present on Universitas Negeri Malang, (2) identify the local food genetic resources found on Universitas Negeri Malang, (3) identify the green open spaces by conserving the rare trees and local food genetic resources to improve the UI GreenMetric ranking, (4) identify the active involvement of the university academic community in developing campus green open spaces by preserving the rare trees and local food genetic resources to improve the UI GreenMetric ranking.

Literature Review

Rare trees

A rare tree is defined as a plant in the form of a tree that is so valuable that its survival must be ensured through conservation efforts. Conservation refers to the deliberate actions taken to preserve the variety of plant and animal species, as well as their ecosystems, in order to prevent their extinction. This includes efforts made within their natural habitat as well as outside of it (Corlett, 2016; Kanelli et al., 2024; Strayer and Dudgeon, 2010). Plants categorized as rare trees must be guarded if they possess the following characteristics: 1) a limited population size; (2) there has been a significant decrease in the population in the natural environment; (3) the range of this species is restricted and specific to a certain geographic area (endemic). Therefore, rare trees represent valuable natural assets with small populations or decreasing species numbers, and restricted distribution, making their sustainability crucial (Turner-Skoff and Cavender, 2019).

The classification of rare trees, as defined by the International Union for Conservation of Nature (IUCN), involves categorizing them in the IUCN Red List of Threatened Species, often known as the IUCN Red List. Species classified as rare under IUCN Red List version 3.1 status categories include: (1) Extinct (EX) is a conservation status assigned to species for which there is indisputable evidence that the last of the species has perished. (2) Extinct in the Wild (EW) is assigned to species that are exclusively found in captivity or outside of their natural habitat. (3) Critically Endangered (CR) is assigned to species that are at a high risk of becoming extinct in the near future. (4) Endangered (EN) is assigned to species that are facing a significant risk of extinction in their natural habitats in the future. (5) Vulnerable (VU) is assigned to species that are at risk of becoming extinct in the wild in the future. (6) Near Threatened (NT) is assigned to species that are potentially threatened or near to extinction, but do not meet the criteria for being classified as threatened. (7) Least Concern (LC) is assigned by the IUCN to species that have been assessed but do not meet the criteria for any other category. (8) Data Deficient (DD) is a classification given to a species when there is not enough information available to estimate its risk of extinction based on its distribution and population status. (9) Not Evaluated (NE) is a classification given to a species when it has not yet been assessed according to the previous requirements.

Green open space on campus

Universities are crucial in facilitating the achievement of sustainable development goals. Over the past 20 years, numerous higher education institutions have

actively engaged in sustainable practices across various areas, including education, research, university management, policy, and institutional experiences (Lozano et al., 2015; Selanon and Chuangchai, 2023). Recently, higher education institutions have taken on the responsibility of promoting environmental sustainability by enhancing their infrastructure to be environmentally friendly or commonly referred to as 'green campus' or 'green university' (Atici et al., 2021).

Universities generally begin their journey towards sustainability by implementing campus greening programs (Sonetti et al., 2016). The greening of the campus is conceptually related to the initiatives to enhance green open space commonly used in city planning. Green open space on campus, as defined by Ministerial Regulation No. 1 of 2007 regarding the Organization of Green Open Space in Urban Areas, serves as an educational tool by prioritizing the distribution and use of green areas on campus, it can also function as an outdoor learning space for students, commonly referred to as an open learning space (Suciyani, 2018). Green open space on campus serves multiple purposes. It not only addresses environmental issues (Binta and Maulana, 2021), but also contributes to the academic ranks of students and the overall success of the institution (Atici et al., 2021). The objective of a green campus is to establish an environmentally friendly atmosphere, promote sustainable education, and reduce environmental damage.

Universities play a crucial role in providing green spaces in cities that are often maintained properly. Following this principle, the selection of an appropriate species of plant will directly impact the expected production of the green space. Plants are recognized as landscape components that have a significant impact on both the aesthetic and ecological aspects of an environment (Feng et al., 2019). The aesthetic value of plants is derived from the combination of colors (leaves, stems, flowers), physical structure of plants (stems, branches, canopies), textures, and composition (MacKenzie and Gibbons, 2019). The selected plants must enhance the environment by effectively absorbing pollutants, creating a microclimate that is acceptable for the local population, and providing a physically comfortable atmosphere (Ives et al., 2016; Luna et al., 2018).

The implementation of environmentally friendly techniques on campuses worldwide is gaining significant attention (Abakumov and Beresten, 2023; Žalėnienė and Pereira, 2021). Green campuses, also referred to as environmentally friendly developments, are significant in promoting sustainable development on campuses (Pereira Ribeiro et al., 2021; Ruiz-Mallén and Heras, 2020). The concept of environmentally friendly sustainable development will influence the creation of a high-quality environment (Cheng et al., 2023; Fischer et al., 2023). Research has shown that the presence of green open spaces is a key part of creating a high-quality environment (Addas, 2023). Furthermore, prior study has demonstrated that green campus incorporates sustainable development across various aspects, including institutions, campus operations, teaching, research, community participation, and reporting (Fissi et al., 2021). Thus, green campuses prioritize not only the excellence of their education, but also aim to establish a greener campus environment.

Another purpose of a green campus is to provide educational and conservation value through the careful selection of specific species. The purpose of selecting plants for educational and conservation reasons is to enhance awareness and understanding of the homogeneity of local plant species, including those that are potentially rare or have already become rare (Wang et al., 2021). In order to enhance the quality of the campus environment, this research will focus on maximizing the green open spaces inside the campus area, specifically by incorporating rare plant species. This method aims to promote educational and conservation qualities. The selection of rare plant characteristics is based on both conservation factors and the goal of enhancing food security (Chappell and LaValle, 2011; Hubanks, 2021). In order to ensure that the later plant selections are both beneficial for food production and contribute to conservation efforts.

Conservation of rare plants and food security

Currently, there is a broad implementation of campus greening projects in universities worldwide. This Program substantially impacts on the ranking of higher education institutions regarding their green campus innovations (Sima et al., 2019). An effective strategy to promote campus greening projects involves prioritizing biodiversity, particularly by focusing on the cultivation and preservation of rare plant species. Prior research asserts that universities play an important role in advancing knowledge about variations in the natural environment and comprehending the ways in which attitudes are influenced by declining biodiversity (Ko, 2022).

Biodiversity is categorized into three levels, beginning with the smallest level known as genetic diversity, followed by species or individual diversity, and finally the environmental level. Biodiversity is currently faced with significant difficulties, including the degradation of ecosystems, climate change, and illegal hunting and trade (Kremen and Merenlender, 2018; Strayer and Dudgeon, 2010). The preservation of rare plants is crucial for ensuring the sustainability of biodiversity and mitigating the risk of these species becoming extinct (Corlett, 2016). Rare plants possess significant ecological, economic, and aesthetic value, and their presence can enhance the balance of the environment (Albrecht et al., 2016), so aligning with the educational objectives of the green campus as a sustainable innovation (Ko, 2022).

Rare plants that are widely recognized as famous and attractive, such as the *Rafflesia arnoldi*. This flower known in Indonesia as *bunga bangkai* (Corpse flower) or known globally as *titan arum*. The relationship between attention and knowledge of rare plants, as determined by their "fame" value, is what drives interest towards other possibly rare plants. The preservation of rare plants and their significant contribution to local food security (Hubanks, 2021) will be the focus of this research.

While the majority of the consumable food crops are typically plentiful, certain types of food crops are under risk of shortage or possibly extinction due to many factors, including climate change (Muluneh, 2021). The findings of our preliminary identification found that the local plants that necessitate attention and conservation include *kepel* (*Stelechocarpus burahol*), *wuni* (*Scaevola taccada*), *namnam* (*Cynometra cauliflora*), *menteng* (*Baccaurea racemose*), *gowok* (*Syzygium polycephalum*), *cempedak* (*Artocarpus integer*), and various other fruit plants. Several of the above plants are obscure and have been neglected by students. These findings align with previous studies that indicated that certain local residents are still in the initial phases of acknowledging and identifying rare (endemic) plants. Therefore, conservation efforts in small areas, particularly within the campus environment, are rarely carried out (Wang et al., 2021).

Considering the presence of rare plant species, along with their significance in terms of education and conservation, the UI GreenMetric developed by Universitas Indonesia focuses on three main areas: teaching and research in a sustainable environment, energy and climate change, and the development of green campus infrastructure (UI GreenMetric, 2024). Conservation of rare plants at Universitas Negeri Malang can significantly contribute to improving the UI GreenMetric ranking, as these three criteria have assessment weights of 15%, 21%, and 18%, respectively (Atici et al., 2021).

Methods

Research location

Universitas Negeri Malang is recognized as a leading campus that focuses on environmental conservation and strives to promote fair distribution of green open spaces. This area is located in the central part of Malang City, with approximate geographical coordinates of 7 57' 45" S and 113 37' 07" East. According to *Fig. 1*, Universitas Negeri Malang possesses a total area of 130,317 m² of green open space. This space contains a dense vegetation cover measuring 120,973 m² with a tropical climate, resulting in a higher rainfall rate. The average yearly rainfall, as determined by the analysis carried out by the Central Statistics Agency of Malang City, is 259 mm/day.

Universitas Negeri Malang covers around 32 hectares. Green open space, which consists of high-density vegetation, covers around 37.7% of the total area. Universitas Negeri Malang owns structures that occupy approximately 53.3% of the total land area. Universitas Negeri Malang has three campuses, including campus 1 located at Jalan Semarang 5 at Malang. Campus 2 is located at Jalan Kyai Ageng Gribig Malang, while campus 3 is located at Jalan Soekarno, Blitar. The current condition of the green open space on campus 1, Malang is shown in the following *Fig. 2*.

The planted vegetation on campus 2 covers a total area of 90,498 m². The total area of the open space is 338,782 m². The proportion of the total area of planted vegetation in the open space area is 27%. The current condition of the green open space on campus 2 is shown in the following *Fig. 3*.

The planted vegetation on campus 3 covers a total area of 9423 m². Total area of the open space: 27,882 m². The proportion of the total area of planted vegetation in the open space area is 34%. The current condition of the green open space on campus 3 is shown in the following *Fig. 4*.

Fig. 1. *Map of green open space areas at Universitas Negeri Malang*
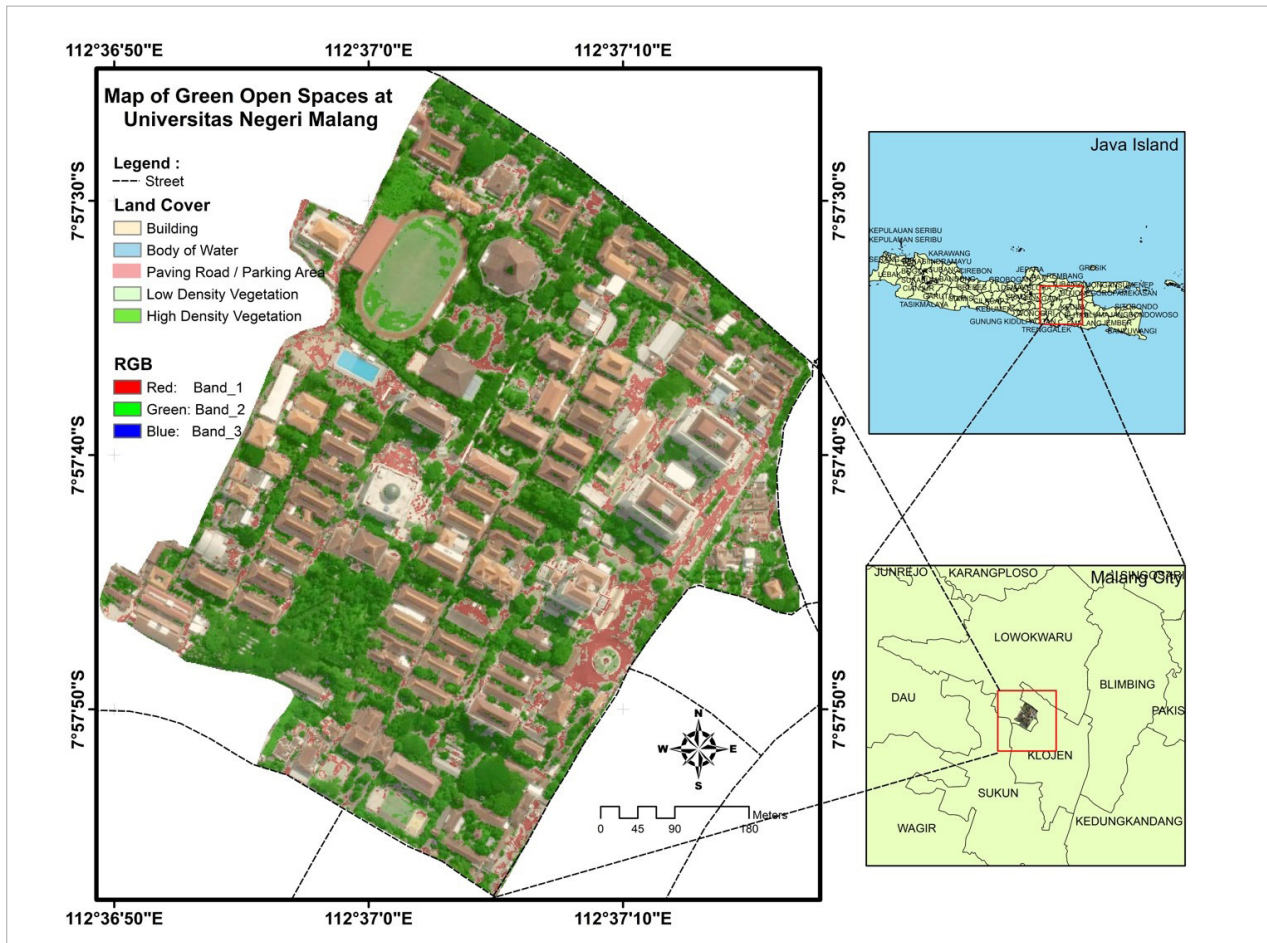

Fig. 2. *A) Google earth view of the campus 1 area; B) Green open space of Universitas Negeri Malang in campus 1*

Fig. 3. *A) Google earth view of the campus 2 area; B) Green open space of Universitas Negeri Malang in campus 2*

Fig. 4. *A) Google Earth View of the campus 3 area; B) Green open space of Universitas Negeri Malang in campus 3*

The planted vegetation on campus 3 covers a total area of 9489 m². The total area of the open space is 22,618 m². The percentage of the total area of planted vegetation to the overall open space area is 42%.

Research design

This study used a quantitative descriptive methodology through a survey technique. The quantitative aspect involves creating a questionnaire to assess the views and wants of the university residents regarding green open spaces on campus. The data collected from the questionnaire were further examined using descriptive analysis (Pilcher and Cortazzi, 2024). This study examines three variables: (1) the physical state of green open spaces, (2) the state of rare trees as green open spaces on the Universitas Negeri Malang campus, and (3) the state of local food genetic resources on the Universitas Negeri Malang campus area. The study included focus group discussions and the implementation of planting rare trees and local food genetic resources on the Universitas Negeri Malang campus. The sampling technique employed was stratified random sampling, which included students, lecturers, and staff.

Table 1. *Research questionnaire to assess the green open spaces and local food genetic resource at Universitas Negeri Malang*

Question	Statement
1	Currently, green open space at Universitas Negeri Malang is appropriate.
2	Currently, green open space at Universitas Negeri Malang is clean and organized.
3	I understand that Universitas Negeri Malang already has a strategic plan for green open space management.
4	At Universitas Negeri Malang, trees must be planted between buildings.
5	I highly support the existence of the forest at Universitas Negeri Malang, which is planted with a variety of rare trees.
6	I want to see the green open space at Universitas Negeri Malang transformed into a garden planted with flowers.
7	I recommend that the green open space at Universitas Negeri Malang keep the large trees that can provide oxygen and absorb pollution.
8	I like green open space at Universitas Negeri Malang in the form of tuber plants for food security.
9	I like green open space at Universitas Negeri Malang in the form of rare trees that can produce oxygen, reduce pollution, and yield edible fruit.
10	I dislike huge parking lots without trees.
11	I am very familiar with the tubers that are now grown at Universitas Negeri Malang.
12	I believe that tuber plants grown at Universitas Negeri Malang benefit for residents and others in need.
13	I have participated in planting a variety of tubers at Universitas Negeri Malang.
14	I will continue to engage in the university's food security project.
15	I have the ability to turn tuber plants into modern meals.
16	I can sell processed tuber products at Universitas Negeri Malang.
17	I can work with external organizations to sell the results of growing tubers at Universitas Negeri Malang.
18	I am very familiar with the types of rare trees planted at Universitas Negeri Malang.
19	I know that rare fruit trees grown at Universitas Negeri Malang have health benefits and make good herbal medicines.
20	I have knowledge of the market share for processed herbal medications among other parties.
21	I frequently lead students in the plant nursery project at Universitas Negeri Malang.
22	I frequently participate in the university's tree planting optimization project.
23	I frequently coordinate students in the tree planting optimization project at Universitas Negeri Malang.
24	I frequently work with other parties to optimize green open space at Universitas Negeri Malang.
25	I really want Universitas Negeri Malang to have a lot of Kalpataru trees, which are the icon on the university.

The observation approach was employed to ascertain the current state of rare trees and local food genetic resources at the university. The assessment of green open spaces and local food genetic resources at the university conducted through a combination of a questionnaire implemented with a google form, utilizing Likert scale, and interviews, given to 201 members of the university academic community, including students, lecturers, and staff. The Likert scale consists of 4 response levels: 1-highly disagree, 2-disagree, 3-agree, and 4-highly agree. This study primarily examined the results of the questionnaire that received a response of 4, indicating highly agree.

The optimization of green open spaces on urban campuses relies on four strategies: constructing vertical gardens, rehabilitating current green open spaces, maximizing the efficiency of buildings, and constructing vertical parking facilities. In implementing these strategies, land preparation begins with the careful removal of vegetation, particularly in areas where planting holes will be located. These planting holes should measure 50 x 50 x 50 cm, with spacing between

holes modified according to specific tree species and their anticipated canopy size at maturity, maintaining a minimum recommended planting distance of around 4 meters. Once the planting hole has been made, it is left uncovered for a few days. During this period, pipe installations are also installed to facilitate the irrigation of the tree seedlings that will be placed.

The process of analyzing data obtained from assessing physical conditions and measures through questionnaires involves the use of tabulation and calculation of percentages. Moreover, it is presented in the format of tables and graphs. Moreover, a comprehensive analysis is provided regarding the most recent study discoveries and literature evaluations.

Results and Discussion

Current condition of green open spaces on the Universitas Negeri Malang

Universities play a crucial role in sustainable and environmentally friendly development, known as green campuses (Pereira Ribeiro et al., 2021; Sugiarto et al., 2022). One of the higher education institutions in Indonesia that promotes the concept of a green and sustainable campus is Universitas Negeri Malang. The green campus at Universitas Negeri Malang has several programs based on the UI GreenMetric ranking and aims to become a higher education institution with a quality environment (Rachmadian et al., 2024). The green open space concept has become a program to create a quality environment (Dollah et al., 2023). This aligns with findings from previous research that indicating the green open space concept is an effort or approach to sustainable environmental management through green open space planning (Sari et al., 2023).

The green open space concept at Universitas Negeri Malang plays a role in preserving the environment. Additionally, previous research found that the utilization of green open spaces serves socio-cultural functions, especially in supporting the activities of the academic community as public or learning spaces (La Fua et al., 2022). Furthermore, green open spaces have ecological functions to control climate change (Rini et al., 2023; Sturiale and Scuderi, 2019). This is in line with the green open space concept at Universitas Negeri Malang, which has forests, parks, oxygen-producing trees, food security gardens, and oxygen-producing food security gardens

Furthermore, the academic community at Universitas Negeri Malang were surveyed about their preferred concept of green open space. The responses are shown in the following *Fig. 5*.

Based on the inf and appreciation for these botanical resources.

Fig. 5. *Concept for green open spaces*
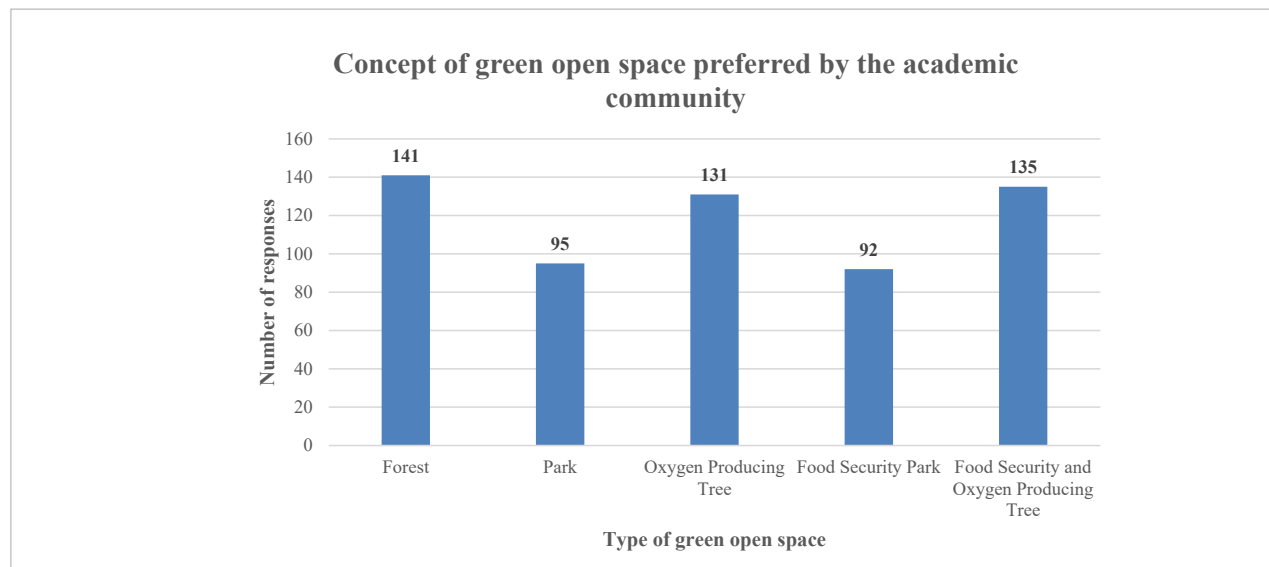
Diversity in green open space from fruit trees, herbal plants and rare trees

Through direct observation at the fruit garden area of Universitas Negeri Malang data was collected and reported in the following *Table 2*.

Table 2. *Rare trees in the fruit garden of Universitas Negeri Malang*

| No	Scientific and local names	Family	Total	Classification
1	*Diospyros balncoi ADC "Bisbul"*	*Eben*	4	Fruit tree
2	*Diospyros malabarica kostel "Kreco"*	*Eben*	4	Fruit tree
3	*Diospyros elebica bakh "Eboni/Kayu Hitam*	*Eben*	7	Rare tree
4	*Stelechocarpus burahol "Kepel"*	*Anon*	10	Fruit tree
5	*Syrgium jambos (L) Alston "Jambu Mawar"*	*Myrt*	5	Fruit tree
6	*S. Maleccense (L) "Jambu Darsono"*	*Myrt*	3	Fruit tree
7	*Pometia Pinanta J.R. Forst "Matoa"*	*Sapind*	5	Fruit tree
8	*Dillenia philipinesis rolfe "Sempur"*	*Dill*	5	Fruit tree
9	*Garcinia dulesi "Mundu"*	*Cluss*	1	Fruit tree
10	*Cynometra cauliflora "Nam-Nam"*	*Coes*	8	Fruit tree
11	*Manilkara kauki "Sawo Kecik"*	*Sapot*	2	Fruit tree
12	*Inoocaarpus Fogiferus "Gayam"*	*Papil*	1	Fruit tree
13	*Aquilaria filaria "Graharu"*	*Thym*	8	Rare tree
14	*Santala album "Cendana"*	*Sant*	3	Rare tree
15	*Mesua ferrea L "Nagasari"*	*Cluss*	5	Rare tree
16	*Arecca cathecu "Jambe Kuning"*	*Aree*	5	Rare tree
17	*A. Vestiaria Gisel*	*Aree*	2	Rare tree
18	*Heteraspothe elata schef*	*Aree*	5	Rare tree
19	*Hydarias tele pinangoides*	*Aree*	7	Rare tree
20	*Archanto phoenix alexandrae*	*Aree*	4	Rare tree
21	*Licuala spinosa*	*Aree*	4	Rare tree
22	*Rhopalablaste augusta "Kur-Kur"*	*Aree*	2	Rare tree
23	*Vietechia arecina becce*	*Aree*	2	Rare tree
24	*Cinnamommon iners reinw*	*Laur*	2	Rare tree
25	*C. verum "Keninggar"*	*Laur*	8	Rare tree
26	*C. burmanni "Kayu Manis"*	*Laur*	3	Rare tree
27	*Licuala grandis "Kol. Palem"*	*Aree*	3	Rare tree
28	*Thrinox radiota "Palem Bintang Mas"*	*Aree*	2	Rare tree
29	*Kigelia africana*	*Bign*	5	Rare tree
30	*Manif toa rosela*	*Sim*	3	Rare tree
31	*M. Scheffri "Bunga Sapu Tangan"*	*Coes*	1	Rare tree
32	*Firmina malayana "Munung"*	*Anon*	1	Rare tree
33	*Pytrocymbium javanicum "Sri Kintil"*	*Bign*	4	Rare tree
34	*Peltophorum pterocarpun "Saga Pohon"*	*Sim*	3	Decorative plant
35	*Polyathia lateriflora*	*Coes*	1	Rare tree
36	*Cresentia mirabilis ekman*	*Euph*	1	Rare tree
37	*Burcca javanica*	*Coes*	4	Herbal plant
38	*Brownea hybrida*	*Apoc*	2	Decorative plant
39	*Croton tigilium*	*Apoc*	1	Herbal plant
40	*Saraca indica "Asoka"*	*Myrt*	3	Decorative plant
41	*Parameria Laevigata "Kayu Rapet"*	*Sol*	1	Rare tree
42	*Kapsia flavida*	*Rut*	2	Decorative plant
43	*Eucalyptus deglupta "Kayu Pelangi"*	*Myrt*	2	Decorative plant
44	*Brunfelsia america L*	*Myrt*	2	Rare tree
45	*Muraya paniculata "Kemuning"*	*Myrt*	1	Rare tree
46	*Syzigium boerlagei mer govaerse*	*Myrt*	1	Rare tree
47	*S. Eraghi (riedl) Merr*	*Myrt*	1	Rare tree
48	*S. aleinium wall*	*Myrt*	2	Decorative plant
49	*S. polynthum (wight) walp "Salam"*	*Myrt*	2	Herbal plant

The university is an actual environment where lecturers and students are frequently in contact. University serves as a place for both academic study and professional work for faculty members and students. Therefore, there is a strong anticipation for a comfortable and organized environment. Green open spaces on campus serves as a place for the academic community to relax, and it also provides a venue for lecturers to facilitate outdoor learning and for students to engage in activities. Environmental management is implemented through the creation and maintenance of green open spaces. Green open spaces encompass various types, including rare trees. The following graph highlights the types of rare trees that the academic community would prefer to have planted at the Universitas Negeri Malang, as shown in *Fig. 6*.

Fig. 6 illustrates that the most preferred tree species among the academic community for enhancing the current green open space on campus are *matoa* (*Pometia pinnata*), *kepel* (*Stelechocarpus burahol*), and *kalpataru* (*Ficus benghalensis*). The *Kalpataru* tree serves as both the symbol for the trophy for the Environmental Conservation Championship in Indonesia and the logo of Universitas Negeri Malang. The Kalpataru tree is conserved in the green open area around the mosque area. The campus area is mostly populated by trees with expansive leaf canopies, which serve to shield the soil, flowering plants, parked vehicles, and even buildings from direct sunshine.

Improving the ranking of UI GreenMetric by conserving rare trees and local food genetic resources to optimize the green open space on campus

The UI GreenMetric is a ranking institution focused on environmental sustainability (Atici et al., 2021). This ranking system aims to motivate colleges globally to improve sustainability initiatives and support environmental conservation (Lukman et al., 2009). The UI GreenMetric consistently tries to encourage universities in Indonesia as well as globally to adopt sustainability principles and aid in resolving global environmental issues (Sharp, 2002). This year, the number of higher education institutions in Indonesia participating in UI GreenMetric has increased to 183. The UI GreenMetric comprises 1477 universities from 95 countries (UI GreenMetric, 2024). Universitas Negeri Malang has participated in UI GreenMetric ranking from 2016. The UI GreenMetric ranking provides a framework that presents the findings of an online poll about the present status and policies associated with sustainability efforts and institutional advancements at universities globally. The criteria for this rating encompass global climate change, clean energy, water conservation, waste recycling, green transportation, and sustainability education and research (Ragazzi and Ghidini, 2017). This ranking is anticipated to influence increased

Fig. 6. *Preferred rare tree by the academic Community at Universitas Negeri Malang*
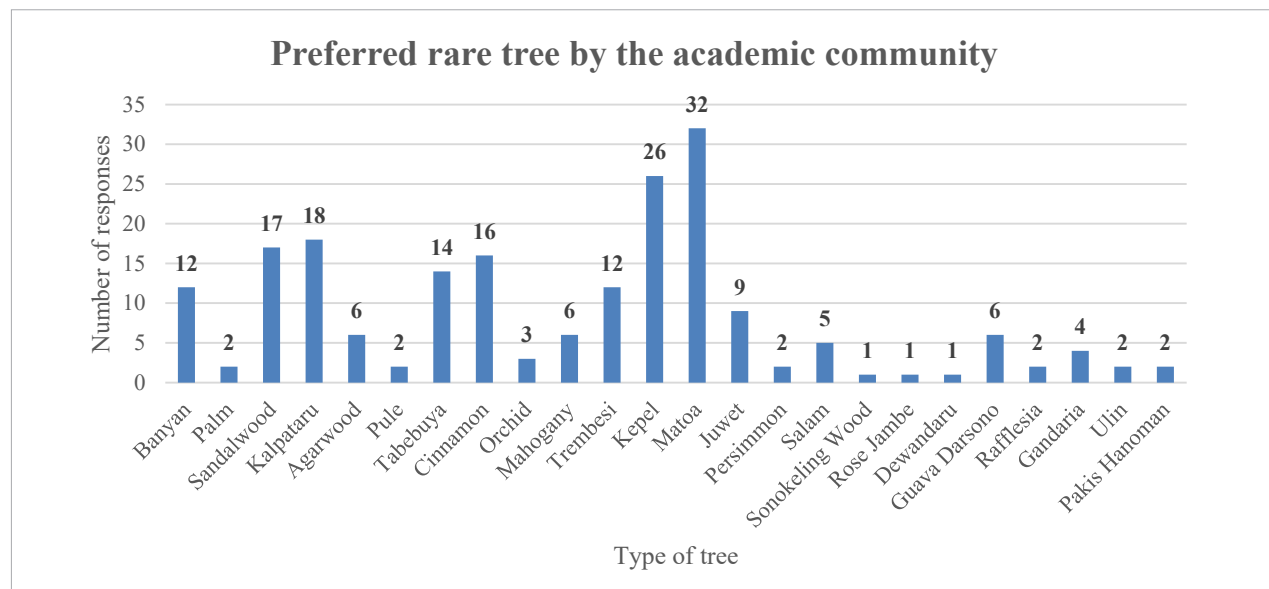
awareness and behavioural changes among university community members. Numerous metrics in this ranking are closely associated with the responsibilities of policymakers in delivering green open spaces.

Green open spaces play a crucial role in the environment by mitigating the effects of climate change (Kingsley, 2019), reducing the emissions of carbon dioxide from vehicle exhaust and also generating oxygen (Xu et al., 2023). The green campus initiative can be supported by making use of green open spaces on campus (Kanelli et al., 2024). Green campus refers to an environmentally friendly campus that prioritizes sustainable development. Green campus concept encompasses an understanding of environmental challenges and the ability to effectively manage the environment (Yanthi et al., 2019).

The green campus implements the concept of sustainable development through environmental actualization activities that prioritize policies based on environmental concern values and creative approaches that support environmentally friendly sustainable development (Selanon and Chuangchai, 2023). The environmental actions conducted involve conservation efforts aimed at maximizing the utilization of green open spaces. The green campus engages in conservation efforts that encompass all stakeholders, including internal parties such as the dean, lecturers, students, and campus staff, as well as external parties like the local community and campus partners. Green campus has established a specialized team to implement environmental conservation programs, integrating lecturers and students as environmental volunteers in the working group. The green campus special team created an initial environmental update schedule.

The lecturers and student volunteers who are part of the green campus team play a crucial role in carrying out environmental conservation efforts (Sumarmi et al., 2024). Furthermore, support from cleaning staff, the local community, and university academic community plays a vital part as well. It facilitates the formation of partnerships to support sustainable development through environmental conservation efforts. Collaborative conservation efforts are conducted to ensure mutual benefits for all parties involved in order to meet the common goals established by the special green campus team (Sima et al., 2019).

The rare tree planting project engages environmental volunteers, both lecturers and students. Conserving rare trees can effectively maintain a balance in carbon storage (Ameray et al., 2021), promote human wellness (Turner-Skoff and Cavender, 2019), and contribute to the overall environmental balance on campus (Nunes et al., 2020). Furthermore, earlier research discovers that rare trees possess attributes that make them suitable for use as traditional solutions (Hemmami et al., 2023). It is speculated that rare trees possess medicinal benefits; for example, *kepel* fruit can be used to reduce cholesterol levels in the body (Yuanisyak et al., 2022), *wuni* fruit can be used to treat diabetes (Mauldina et al., 2017), and *mundu* fruit can be used to treat malaria (Khamthong and Hutadilok-Towatana, 2017).

The optimization of green open spaces involves engaging in environmental conservation efforts, which include not only planting rare trees but also cultivating local food genetic resources. The conservation of local food genetic resources is implemented to enhance food security. Furthermore, conservation efforts will directly influence the allocation of green open spaces within the campus environment. This aligns with the conclusions drawn from prior research, which indicate that the campus has a significant role in enhancing knowledge about natural phenomena (Reimers, 2021). Thus, by implementing education focused on natural changes, it becomes possible to address environmental issues and promote sustainable education. The campus environmental volunteer project in planting of sweet potato seeds is shown in *Fig. 7*.

Fig. 7 shows the process of growing local food genetic resources. Lecturers and student volunteers collaborate to carry out planting activities in the campus environment. Green campus starts environmental initiatives as a conservation effort to generate green open spaces in the campus environment. Local food genetic resources serve not only as oxygen suppliers, but also as a fundamental biological foundation for ensuring food and nutritional security (Sthapit et al., 2008). Furthermore, it has been discovered that the improvement of food security is achieved through local food genetic resources (Rozaki, 2021). Other research has found that tubers, which are genetic resources, can be utilized as a replacement for rice in regular meals (Chandrasekara and Josheph Kumar, 2016). Tuber plants possess the characteristic of having a low sugar content, making them advantageous for human health, particularly for individuals with diabetes (Ludvik et al., 2002).

The food security initiative at Universitas Negeri Malang has generated local food genetic resources, which received several processing methods for both food and

Fig. 7. *A) Students harvesting sweet potatoes; B) Harvesting sweet potatoes with university leaders; C) Employees planting taro; and D) Planting taro seeds*
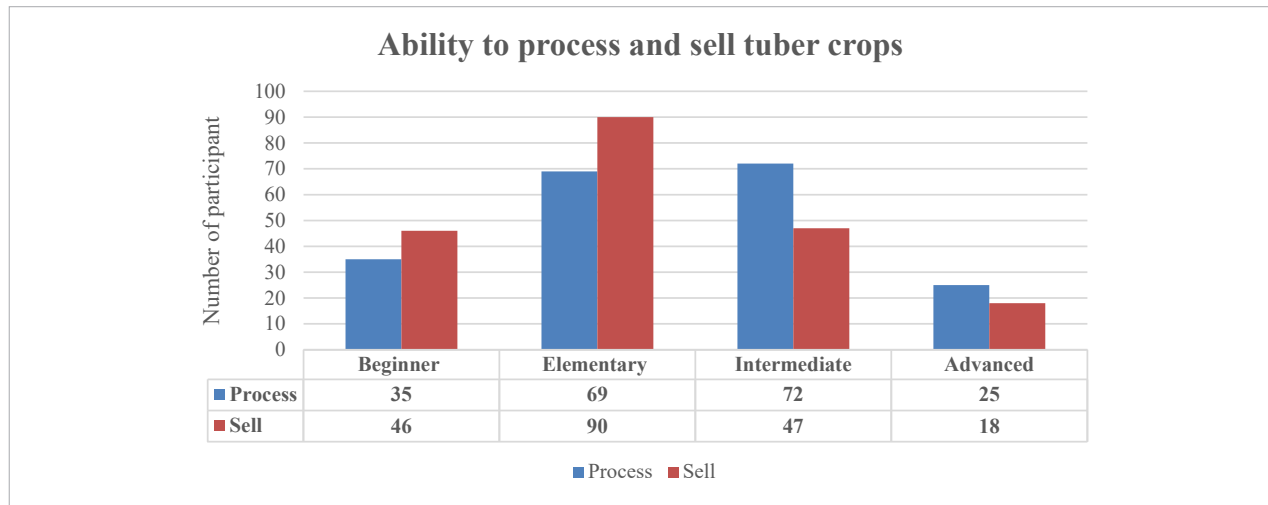

beverage production. Existing forms of tuber processing include traditional rice, cassava flour as a component in the production of various cakes, cassava juice, ice cream, and other products. Furthermore, there are also processed taro products, like as fried or boiled foods, that are used in processed food preparations. Typically, when there is an event on campus, the food served can consist of steamed tubers, also known as *polo pendhem* in Javanese. Various types of processed tubers are shown in the following *Fig. 8*.

Fig. 8. *A) Processed cassava products such as sweet potato latte and cassava ice cream; B) Processed cassava goods such as fried and boiled cassava flour*

Fig. 9. *The ability of the academic community to process and sell tuber crops*

Ability to process and sell tuber crops

	Beginner	Elementary	Intermediate	Advanced
■ Process	35	69	72	25
■ Sell	46	90	47	18

Moreover, *Fig. 9* illustrates that the academic community of Universitas Negeri Malang have a moderate level of ability to process and sell items from local food genetic resources. The variety of processed products derived from sweet potatoes includes traditional rice, flour for cake ingredient, ice cream, juice, and various other products. Therefore, one of the initiatives to enhance the ability to utilize processed local food genetic resources on Universitas Negeri Malang is to organize entrepreneurial activities. This activity aligns with one of the campus' missions, which is to produce graduates who possess entrepreneurial abilities and can effectively compete on a global level. As this skill progresses, the demand for processed food will correspondingly rise, as will the requirement to supply food supplies. At last, it is imperative for the broader community, and particularly for the academic community at Universitas Negeri Malang, to make collective efforts to preserve local food genetic resources.

Moreover, this research also brings up further questions regarding the recommended plants to be added to be planted at Universitas Negeri Malang. The recommended selection of plants and trees is determined by the frequency of mentions given. The responses are shown in the following *Fig. 10*.
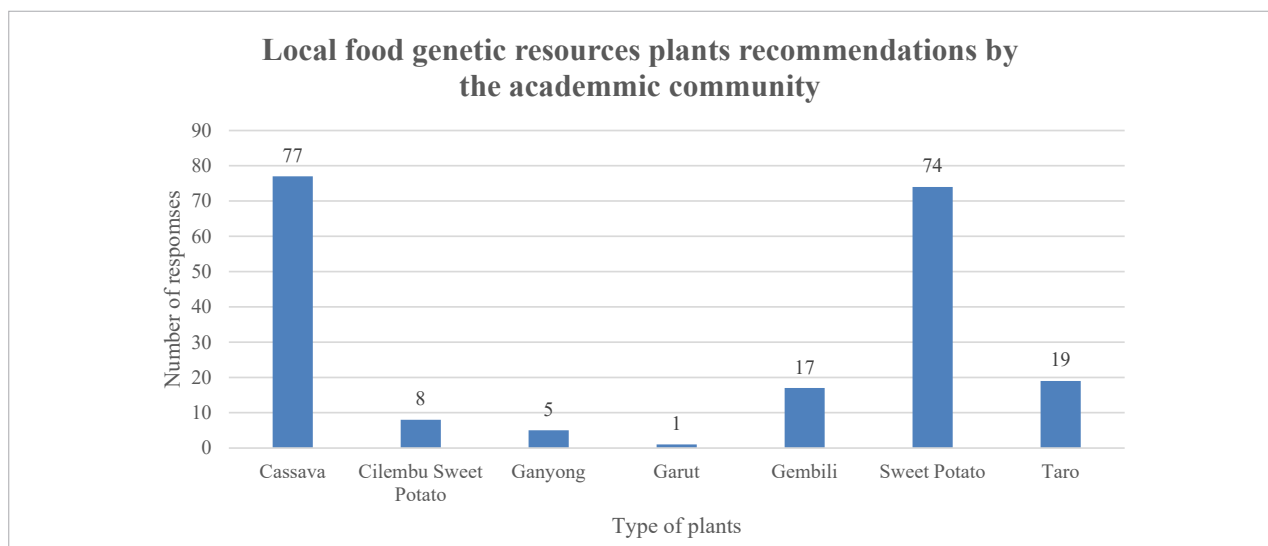
Fig. 10. *Local food genetic resources plants recommendations by the academic community*

Local food genetic resources plants recommendations by the academmic community

Fig. 10 indicates that the local food genetic resources that more attract the attention of residents are cassava, sweet potatoes, and taro. The increasing number of local culinary varieties has become a popular trend among students and the academic community in Universitas Negeri Malang. This presents an excellent opportunity to assess the demand for processed food. This material is valuable for the advancement of the business sector and entrepreneurship, particularly for students from the Universitas Negeri Malang who are involved in student creativity programs.

Increasing campus community participation in developing campus green open space through conservation of rare trees and local food genetic resources to improve UI GreenMetric rankings

Environmental actualization operations involve the conservation of rare trees through planting. Planting rare trees require the participation of lecturers and students who volunteer in environmental projects. Preserving rare trees can help maintain a balance between carbon storage and human health. Various rare fruit trees such as *kepel* (*Stelechocarpus burahol*), *kreco* (*Diospyros malabarica kostel*), *wuni* (*Antidesma bunius*), *mundu* (*Garcinia dulesi*), *namnam* (*Cynometra cauliflora*), *menteng* (*Baccaurea racemose*), *bisbul* (*Diospyros balncoi*), *matoa* (*Pometia Pinanta*), gowok (*Syzygium polycephalum*), black plum (*Syzygium cumini*), rose apple (*Syzygium jambos*), darsono plum (*Syzygium malaccense*), *sempur* (*Dillenia indica*), *sawo kecik* (*Manilkara kauki*), *gayam* (*Inoocaarpus Fogiferus*), star

apple (*Chrysophyllum caimito*), *nona* (*Annona reticulata*), *gandaria* (*Bouea macrophylla griff*.), *cempedak* (*Artocarpus integer*), and sandalwood (*Santalum album*) are planted. Producing local food genetic resources contributes to ensuring food security, encompassing crops such as sweet potatoes, cassava, taro, *gembili* (*Dioscorea esculenta*), various tubers, *sukun* (*Artocarpus altilis*), *kluweh* (*Artocarpus camansi*), and jackfruit (*Artocarpus heterophyllus*).

Based on *Fig. 11*, it is evident that the fruit trees found in the campus area are rare varieties. This plays a crucial role in the conservation of rare vegetation varieties. Certain rare fruit trees provide numerous advantages, including their medicinal properties and their potential as raw materials for food processing (Ameray et al., 2021; Chandrasekara and Josheph Kumar, 2016). This effort also aligns with one of the UI GreenMetric evaluation criteria, specifically the Energy and Climate Change criterion and the Education and Research indicator.

The academic community plays a crucial role in actively engaging in the management, maintenance, and protection of the many elements of the campus green open space. The findings of a survey that examined the level of involvement of the academic community in utilizing the green open space on campus are shown in *Fig. 12*.

According to the *Fig. 12*, the involvement of the academic community at Universitas Negeri Malang in enhancing open spaces is insufficient, as most of them

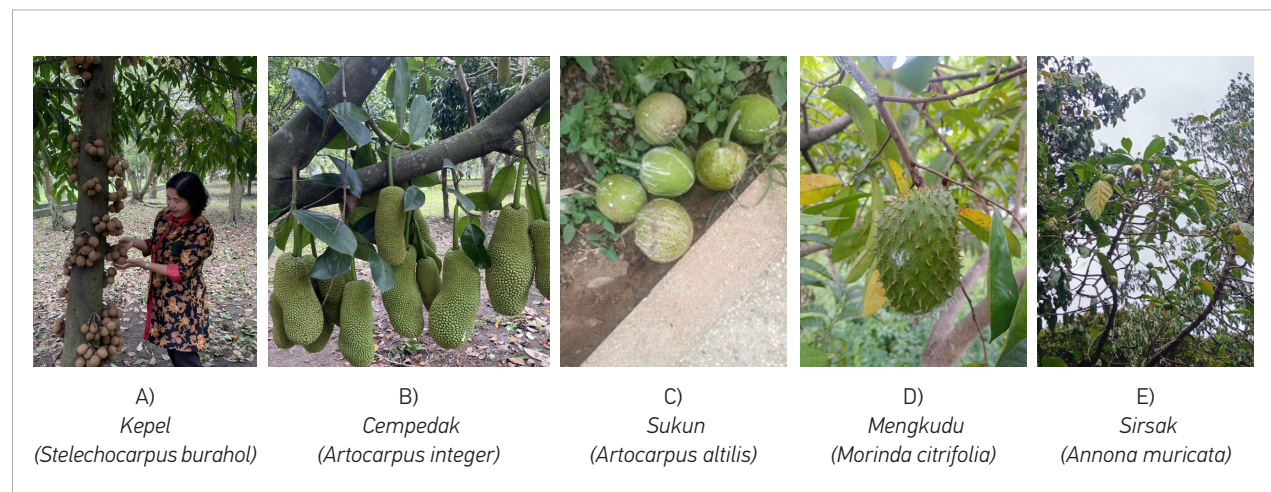**Fig. 11.** *Conservation of planting rare fruit trees*

A)	B)	C)	D)	E)
Kepel (*Stelechocarpus burahol*)	*Cempedak* (*Artocarpus integer*)	*Sukun* (*Artocarpus altilis*)	*Mengkudu* (*Morinda citrifolia*)	*Sirsak* (*Annona muricata*)

Fig. 12. *Participation of the academic community in optimizing green open spaces*

Participation of the academic community in optimizing green open spaces

	Never	Sometimes	Often	Very Often
■ Participation	72	75	46	8

Number of participant (y-axis)
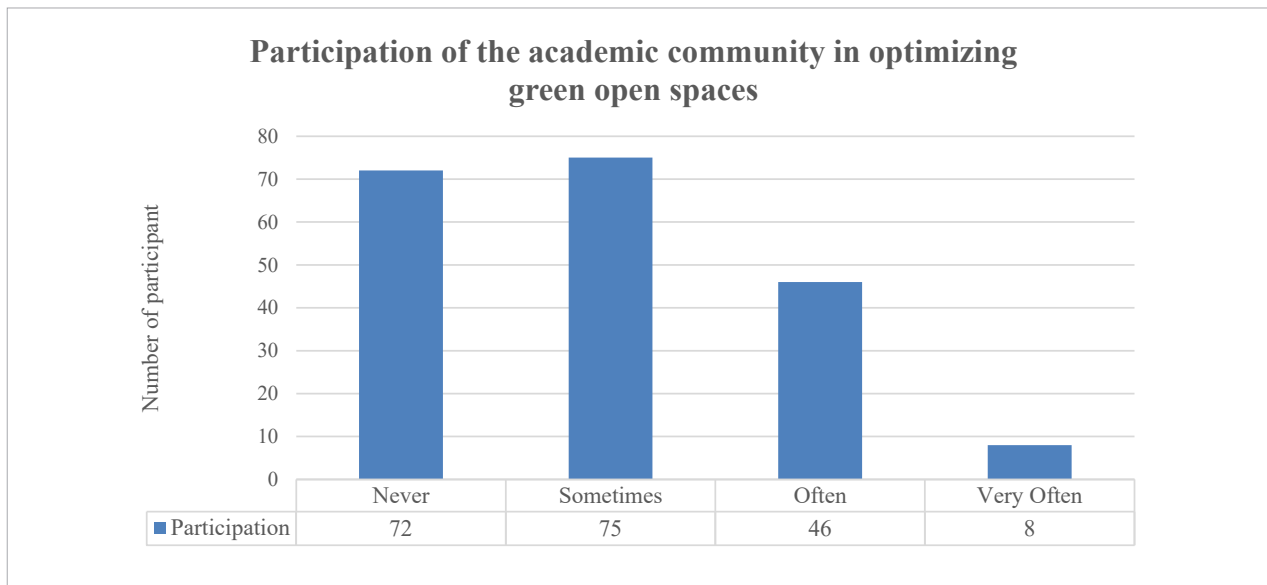
only participate occasionally. Therefore, a collaborative tree planting event is consistently conducted each year on April 22nd to honour Earth Day. In addition, a collaborative event is organized every year on June 5th to celebrate Environment Day, which includes a tree planting activity of 1000 plants, including 500 rare fruit trees, were planted on 22 April 2024 (*Fig. 13*), in celebration of Earth Day. The event was attended by university leaders, staff members, lectures and students, under the direct of the Dean of the Universitas Negeri Malang. Furthermore, it extended invitations to other community organizations such as Perum Jasa Tirta I (PJT I), Jaring-Jaring Kelompok Peduli Air (JKP-KA), Kaliku Nusantara, which focuses on river border

conservation, and the Department of Agriculture. Based on the figure provided, the academic community have worked together with other organizations to contribute to the improvement of recreational and transportation facilities on campus.

The process of planting seeds and seedlings to maintain the green campus aims to foster unity among the academic community at Universitas Negeri Malang in achieving a healthy and smart campus. Polybags are utilized as planting material for nursery activities in the open spaces surrounding the university (Sumarmi et al., 2024). The planting substrate utilizes campus plant leaves to make compost fertilizer. Currently, Universitas Negeri Malang has transformed organic waste into

Fig. 13. *A) Earth day commemoration ceremony on 22 April 2024, B) Tree planting and plant nursery program*

Table 3. *Results of the assessment and ranking of Universitas Negeri Malang in the UI GreenMetric World University Ranking 2017–2024*

Year	Setting and Infrastructure	Energy and Climate Change	Waste	Water	Transportation	Education and Research	Total Score	Indonesia Ranking	Global Ranking
2017	559	683	447	330	411	288	2718	43	565
2018	275	825	600	200	325	900	3125	48	617
2019	275	825	600	300	325	300	2525	57	717
2020	500	1600	825	450	1250	1275	5900	26	345
2021	775	1675	825	700	1150	1250	6375	37	346
2022	900	1725	825	700	1400	1475	7025	32	288
2023	1150	1600	1125	800	1400	1675	7750	28	210
2024	1175	1650	1050	900	1575	1675	8025	27	196

Source: (UI GreenMetric World Univeristy Ranking 2024)

compost, thus reducing the amount of waste deposited to the landfill. In the future, it will increase compost production to better support campus greening efforts. This will involve selecting specific types of plants that offer various benefits, such as absorbing high levels of CO_2 to combat global warming, retaining rainwater, providing shade, producing fruit for food security, and adding aesthetic value through flowers (Selanon and Chuangchai, 2023; Sonetti et al., 2016; Suciyani, 2018; Xu et al., 2023). All of these plants contribute to the sustainable development of the Universitas Negeri Malang. Over time, the environmental conditions at Universitas Negeri Malang have been improving, as indicated by the UI GreenMetric rating that Universitas Negeri Malang has been consistently maintaining. The specific outcomes of this ranking are presented in the following *Table 3*.

Additionally, UI GreenMetric includes setting and infrastructure as one of its indicators. Over the past three years, from 2022 to 2024, Universitas Negeri Malang has experienced significant development in its setting and infrastructure achievements. This development can be observed from the assessment results presented in *Table 4*.

Table 4. *Setting and infrastructure achievements 2022–2024*

	Indicators	Point 2022	Point 2023	Point 2024
SI 1	The ratio of open space area towards total area	50	150	150
SI 2	Area on campus covered in forest	25	75	100
SI 3	Area on campus covered in planted vegetation	100	100	100
SI 4	Area on campus for water absorbance	50	75	50
SI 5	The ratio of open space area divided campus population	150	200	200
SI 6	University budget for sustainability effort	200	200	200
SI 7	Percentage of operation and maintenance activities of building in one year period	75	75	75
SI 8	Campus facilities for disabled, special needs and or maternity care	75	100	100
SI 9	Security and safety facilities	75	75	75
SI 10	Health infrastructure facilities for students, academics, and administrative staff's wellbeing	50	50	50
SI 11	Conservation: plant, animal and wildlife, genetic resources for food and agriculture secured in either medium or long-term conservation facilities	50	50	75

Moreover, the progress in this indicator of setting and infrastructure has influenced the Universitas Negeri Malang ranking development both nationally and globally, which can be seen in *Table 5*.

Table 5. *Improvement of Universitas Negeri Malang ranking in the UI GreenMetric ranking from 2022–2024*

Year	National Ranking	Global Ranking
2022	32	288
2023	28	210
2024	27	196

The leaders of Universitas Negeri Malang are becoming more dedicated to enhancing hygiene and promoting greenery. A number of students participating to the environmental volunteer group, small and medium enterprises, and student organizations involved in environment actively contribute to the further greening of Universitas Negeri Malang. In addition, not only it provide students with the chance to engage in actual environmental activities, but it also serves as a significant experience that helps foster sustainable environmental consciousness (Ruiz-Mallén and Heras, 2020).

The academic community of Universitas Negeri Malang is actively expanding the number of plants in the Universitas Negeri Malang forest area. Planting seedlings is an environmental actualization activity. Environmental education is integrated with environmental awareness programs. Research shows that environmental education influences human behavior with the aim of developing environmental consciousness (Van De Wetering et al., 2022). Environmental education can affect students' level of environmental awareness (Phan Hoang and Kato, 2016). Environmental actualization activities are integrated with environmental education to support students' environmental awareness (Sukma et al., 2020). Furthermore, environmental actualization provides environmental knowledge as students gain direct learning experiences about the environment (Žalėnienė and Pereira, 2021). These actualization activities not only offer students practical experience in environmental conservation but also help develop sustainable environmental awareness (Sumarmi et al., 2024). This aligns with behaviorism theory, which suggests that knowledge can be acquired through direct interaction with the environment (Staddon, 2016). Previous research has demonstrated that environmental actualization activities incorporate behaviorism theory effectively to enhance environmental awareness (Grilli and Curtis, 2021).

Involvement in real environmental activities not only provides opportunities for students to participate directly in environmental activities but also serves as a crucial experience in fostering sustainable environmental awareness (Sukma et al., 2020). Universitas Negeri Malang demonstrated how an educational institution may actively contribute to environmental protection, promote sustainable principles, and cultivate future leaders who prioritize sustainability issues (Sumarmi et al., 2024). It also enhances the accomplishment of the goal to become a "Healthy and Smart Campus" in order to significantly improve the UI GreenMetric ranking.

Similarly, the promotion of food security at Universitas Negeri Malang continues active. The activity reached its highest point with the gathering of sweet potatoes that had been cultivated in all Faculties, as well as empty property owned by Universitas Negeri Malang. Lecturers, students, and staff get together to actively collaborate across different fields in order to attain the same goals. The participation of green campus as a leader in establishing food security demonstrates that food security is not solely the obligation of the government or the commercial sector, but also a collaborative effort. An active and problem-solving campus is crucial for achieving sustainable food security (Hubanks, 2021; Muluneh, 2021).

Universitas Negeri Malang demonstrates its commitment to food security through continuous practical initiatives, highlighting that it is not merely a topic of discussion but a matter that demands dedicated action. The community around the campus were familiar with processed food derived from local food genetic resource. The culinary team uses traditional rice and flour as ingredients for processed bread and other sweet potato advancements in food processing. Each of these activities serves to promote the objectives of a sustainable and environmentally friendly campus while also contribute to the Universitas Negeri Malang efforts to prevent food loss and waste.

The economy, the environment, and food security are all significantly threatened by food loss and waste. They are a critical issue in nutritional insecurity because they decrease the availability of food for human consumption (Ishangulyyev et al., 2019). The environment, economy, poverty, and natural resources are also significantly influenced by food loss and waste (Lipinski, 2020). As a result of these significant impacts, green campus initiatives have included green space optimization and rare

tree conservation to protect local genetic resources. Furthermore, the Indonesian government program in 2024 is aimed at improving local agricultural productivity through food self-sufficiency that corresponds with initiatives to minimize food loss and waste.

Conclusions

Based on the studies and discussion above, it can be inferred that conserving rare trees and local food genetic resources in green open spaces would enhance the UI GreenMetric ranking. Green open spaces incorporate the concept of forests planted with various rare fruit trees that have the ability to produce oxygen, reduce pollution, and yield fruits beneficial for health. The green open spaces at Universitas Negeri Malang are dominated by rare tree species such as *matoa* (*Pometia pinnata*), *kepel* (*Stelechocarpus burahol*), and *kalpataru* (*Ficus benghalensis*). The optimization of green open spaces occurs through environmental actualization activities including conservation and planting of rare trees and local food genetic resources, involving lecturers, students, and environmental volunteers. Plant seedling activities serve as a sustainability effort for the green campus program at Universitas Negeri Malang, engaging lecturers, administrative staff, students, and environmental volunteers as participants. The development of campus green open spaces through the conservation of rare trees and local food genetic resources to improve the UI GreenMetric ranking has been successfully implemented, with increasingly better management of green open spaces and Universitas Negeri Malang ranking continuously improving from 2017 to 2023. Conservation efforts for rare trees are primarily directed toward rare fruit trees. The UI GreenMetric ranking has achieved success, as seen by the improved management of green open spaces factors, as well as the consistent growth in rankings from 2017 to 2024. The conservation efforts mostly focus on preserving rare fruit trees. The selection of rare fruit trees is based on their capacity to generate oxygen, assimilate CO_2, retain water, and provide fruit to ensure food security. Universitas Negeri Malang is committed to becoming a leader in the field of food security, particularly in the conservation and utilization of rare fruit trees and local food genetic resources. The plant species that have been cultivated on the campus as part of the local food genetic resources initiative include sweet potatoes, cassava, *waluh*, *bentul*, *uwi*, *ganyong*, and *suweg*. The green open spaces management program implemented on the Universitas Negeri Malang campus serves as a role model for enhancing the campus's contribution to mitigating climate change. This research has implications for green space management at the Universitas Negeri Malang, serving as a role model for enhancing university participation in climate change prevention. The green space management, which includes conservation of rare fruit trees and local food genetic resources, has demonstrably improved the UI GreenMetric ranking in Universitas Negeri Malang. The research's limitation lies in its focused scope at the Universitas Negeri Malang. Future research could explore similar themes across different locations and variables.

Acknowledgements

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