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ASSESSMENT OF SPECIES DIVERSITY AND GERMPLASM CONSERVATION OF RARE FRUIT PLANTS IN THE TAMAN CANDRA WILWATIKTA COLLECTION GARDEN, PANDAAN, INDONESIA

Achmadi Susilo[1] Dwi Retna Suryaningsih[2], M. Thohiron[3], Faez M. Hassan[4], Achmad Wicaksono[5]
[1,2,3]Agrotechnology Department, College of Agriculture, Wijaya Kusuma University, Surabaya, Indonesia
[4]Physics Department, College of Education, Mustansyiriah University, Baghdad, Iraq
[5]Accounting Department, College of Economics, Nadlatul Ulama University, Sidoarjo, Indonesia
Corresponding Email : *surjaningsih@uwks.ac.id*[2]

Abstract
The conservation of rare fruit plant germplasm over the coming decade will continue to rely primarily on conventional approaches, namely *ex situ* and *in situ* conservation, to preserve seeds or entire plants. Fruit germplasm resources need to be collected and characterized for conservation purposes as well as for use in plant breeding programs. This study aimed to evaluate the existing condition of the Rare Fruit Plant Collection Garden, including fruit species diversity and population size, utilization levels, development status, management constraints, and potential solutions as part of an *ex situ* conservation effort. The study employed a reassessment approach by re-examining the results of previous species identification. The observed variables included the current diversity of fruit plant species, population size of all species, the level of collection garden utilization, and management constraints. Secondary data were also collected as necessary to complement the analysis. Field observations and assessments were conducted from November to December 2025. The results showed that, at the time of evaluation, the Collection Garden still contained 112 fruit species with a total population of 283 trees. Of the 128 fruit species recorded, 83 species (64.84%) had been cultivated, while the remaining 45 species (35.16%) had not yet been developed. Based on growth habit, 112 species (87.50%) were classified as trees, 8 species (6.25%) as herbaceous tree-like plants, and 3 species (2.34%) as shrubs. Currently, the Collection Garden is utilized for harvesting fruit products, as a practical learning facility for students of the Faculty of Agriculture, as a source of plant materials for research and scientific development, and as an agro-tourism destination for visitors staying at Taman Candra Wilwatikta. Several constraints were identified in the management of the Collection Garden, including vandalism and theft by local residents, inadequate supervision by garden personnel, difficulties in water distribution, the absence of greenhouse facilities, the lack of rejuvenation and characterization programs, and challenges related to routine plant maintenance.
Keywords: Fruit Plants, Germplasm, Conservation, Species Diversity, Rare Fruit Collection.

INTRODUCTION

Indonesia is recognized as one of the two countries with the greatest biological wealth in the world, alongside Brazil. When the biological resources found on land are combined with those in marine ecosystems, Indonesia stands out as one of the world's megabiodiversity countries, possessing exceptionally rich biological resources. According to the *Indonesian Biodiversity Strategy and Action Plan (IBSAP) 2025–2045*, by 2022 approximately 31,902 plant species, 81,260 terrestrial animal species, and 7,841 marine animal species had been identified. Furthermore, the *Status of Indonesia's Biodiversity 2024* report indicates that Indonesia harbors more than 31,000 plant species, hundreds of thousands of animal species, and over 14,000 documented microorganism species (Bappenas, 2024). This remarkable biodiversity places Indonesia among the world's major centers of biological diversity and highlights its important role in maintaining ecosystem balance, providing ecosystem services, and

supporting sustainable development (Kementerian PPN/Bappenas, 2025a; Kementerian PPN/ Bappenas, 2025b).

Indonesia is also recognized as one of the eight global centers of plant genetic diversity, particularly for tropical fruit crops such as durian, rambutan, and mango (Purnama et al., 2023; Mursyidin et al., 2022). Data from the BRIN Repository indicate that Southeast Asia possesses approximately 400 edible fruit species, of which about 329 species (±75%) are found in Indonesia, including 226 species that are native to the country (BRIN, 2024; Tata et al., 2024).

Despite its extraordinary biological richness, only a small proportion of Indonesia's plant biodiversity has been utilized for development purposes. Some species have been exploited, others have only recently had their potential identified, and many remain poorly documented or even unnamed. Although biodiversity inherently possesses a capacity for self-recovery, this capacity is not unlimited. Because humans depend on natural resources for survival and economic development, the continued existence of biodiversity largely depends on how these resources are managed. The direct utilization of biodiversity without considering its regenerative capacity can lead to a decline in both species richness and genetic diversity within species (BRIN, 2024).

The utilization of biological natural resources in Indonesia remains largely focused on their economic value. Consideration of other important values, including ecological, biological, technological, and social dimensions, is often limited to theoretical discussions. For example, when discussing forests, parrots, or fruit crops, public perception is frequently dominated by their market value. In reality, the ecological, technological, and biological functions of forests and wildlife generate benefits that far exceed their immediate commercial value. Public awareness of the broader importance of biodiversity conservation remains relatively low, resulting in resource use that is often uncontrolled and inefficient, thereby contributing to the depletion of biological natural resources.

The gradual decline of Indonesia's biological wealth has become increasingly evident in recent decades. One particularly important example is the disappearance of several plant species that were once commonly found in local environments, including both food crops and fruit plants, as a consequence of the widespread adoption of modern agricultural practices. In many fruit crops, the need to increase food production has encouraged the standardization of cultivars and varieties. This trend is potentially detrimental because the unique characteristics and advantages of local genetic resources are increasingly neglected. If such practices continue, many local varieties may become extinct within a relatively short period. Therefore, the conservation and sustainable utilization of plant genetic resources are essential to support food security and sustainable agriculture (FAO, 2025; Engels & Ebert, 2024). Conservation efforts targeting germplasm resources, particularly fruit crops, are urgently needed to prevent genetic erosion and species extinction. At the same time, numerous fruit species that represent important flagship commodities in specific regions of Indonesia remain underutilized and insufficiently developed.

Germplasm Conservation and Research Objectives

Plant germplasm refers to genetic resources that possess broad genetic diversity arising from differences in varieties, populations, strains, lines, clones, and mutants within the same species, originating from different agroclimatic regions or geographical sources. The rich diversity of fruit germplasm distributed throughout the Indonesian archipelago represents a valuable biological resource with significant economic potential, as many fruit species are highly favored by local communities. The existence of these unique and often region-specific fruit species should be promoted and utilized for economic development while ensuring their long-term conservation and sustainability.

To safeguard fruit germplasm resources from degradation and extinction, effective conservation strategies are required, including both *in situ* and *ex situ* approaches (Engels & Ebert, 2024; FAO, 2025). *Ex situ* germplasm conservation is considered a safe and efficient method for preserving genetic resources and ensuring their continuous availability for plant breeding programs (Raina et al., 2023; FAO, 2025). One of the most widely applied *ex situ* conservation methods is the establishment of germplasm collection gardens.

The development of rare fruit collection gardens as an *ex situ* conservation strategy can serve as an effective means of maintaining the existence of rare fruit species while simultaneously providing plant materials for research and development activities. Therefore, this study aimed to evaluate the existing condition of the Rare Fruit Collection Garden, including the diversity and population of fruit species, utilization level, development status, management constraints, and potential solutions as part of an *ex situ* conservation effort.

METHOD

Data and information concerning the diversity and germplasm resources of rare fruit species were collected through direct field observations. The study covered all fruit plant species growing within the 2.25-ha Rare Fruit Collection Garden. In this study, rare fruit plants are defined as perennial plant species that produce edible fruits.

The research was conducted from November to December 2025. The study site was selected purposively at the Rare Fruit Collection Garden located within Taman Candra Wilwatikta, Pandaan, Pasuruan, Indonesia. The selection was based on the need to assess the current condition of the collection garden after approximately 25 years of *ex situ* conservation activities.

The evaluation was carried out by directly recording and counting all fruit species and individual plants that remained in existence within the collection garden. In addition, information regarding the level of utilization, management constraints, and implemented management solutions was documented and analyzed.

RESULTS AND DISCUSSION

Characteristics of Fruit Plants in the Collection Garden

The term *characteristics of fruit plants* in the collection garden refers to the actual physical condition of the fruit plant collection, including species diversity and population size at the time the study was conducted. A detailed description of the existing condition of fruit plants within the Collection Garden is presented in Table 1.

Table 1. Existing Diversity and Population of Rare Fruit Species Conserved in the Taman Candra Wilwatikta Rare Fruit Collection Garden

No	Family and Species Name	Scientific Name	Utilization	Growth Habit	Population size
	Anacardiaceae:				
1.	Mangga golek	*Mangifera indica L.*	1,4	P	4
2	Mangga kidang	*M. indica*	1,4	P	4
3	Mangga aromanis	*M. indica*	1	P	4
4	Mangga daging	*M. indica*	1,4	P	4
5	Mangga Endok	*M. indica*	1,4	P	4
6	Mangga bapang	*M. indica*	1,4	P	2
7	Mangga madu	*M. indica*	1,4	P	4
8	Mangga sengir	*M. indica*	4	P	4
9	Mangga kuweni	*M. indica*	2,4	P	4
10	Mangga madu	*M. indica*	1,4	P	4
11	Mangga lali jiwo	*M. indica*	1,4	P	4
12	Mangga gadung	*M. indica*	1,4	P	3
	Rutaceae				
13	Jeruk sambal	*Citrus sp*	2,4	P	3
14	Jeruk keprok sia	*C. nobilis*	2,4	P	3
15	Jeruk pecel	*C. aurantifolia*	2,4	P	3
16	Jeruk purut	*C. kystrik*	2,4	P	3
17	Jeruk bali	*C. grandis*	2,4	P	3
18	Jeruk manis	*C. aurantianum*	2,4	P	3
19	Jeruk sitrun	*C. nobilis*	2,4	P	3
	Musaceae				
20	Pisang Kelu	*M. blibisiana*	3,4	Tp	2
21	Pisang kidang	*M. acuminata*	1	Tp	2
22	Pisang ambon	*M. balbisiana*	1	Tp	7
23	Pisang santen	*M. acuminata*	1	Tp	6
24	Pisang rojo	*M. balbisiana*	1	Tp	1
	Bombacaceae				
25	Durian bangkok	*D. zibethinus*	1,2,3	P	2
26	Durian sitokong	*D. zibethinus*	1,3	P	2
27	Durian petruk	*D. zibethinus*	1,3	P	1
28	Durian lay	*D. zibethinus*	1,2,3	P	1
29	Durian sukar	*D. zibethih*	1,3	P	2
	Meliaceae				
303	Duku	*L.domecticum*	1,4	P	2
1	Langsep	*L.domecticum*	1,4	P	2
32	Kecapi	*S. kaecapi*	4	P	1
33	Buah kepel	*C. ramiflora*	1,4	P	2

34	**Euphorbiaceae**	*C. inophylum*	4	P	4
35	Nyamplung	*A. melucana*	4	P	2
36	Kemiri	*C. indica*	4	P	4
	Kenari				
37	**Flacourtiaceae**	*F. rukam*	1,4	P	1
38	Rukem	*P. javamicum*	1,2,4	P	4
	Trenggulun				
	Myrtaceae				
39	Jambu camplong	*P. guazava*	1,4	P	2
40	Jambu darsono	*S. jambos*	1,4	P	2
41	Jambu krikil	*P. guazava*	1,4	P	2
42	Jambu klutuk	*E. officianlis*	1,4	P	2
43	Jambu mente	*A. muricana*	1,3,4	P	2
44	**Apocinaceae**	*A. muricana*	1,4	P	1
45	Manuo besar	*A. Squamosa*	1,4	P	1
46	Manuo kecil	*A.muricata*	1,4	P	4
47	Srikaya	*C. guinenesis*	1,2,4	P	4
48	Buah Sirsat	*C.cauliflora*	1	P	3
49	**Lauraceae**	*D. discolor*	1	P	2
50	Apokat	*P. acidus*	1,2,4	P	2
51	Nam-nam	*E. uniflora*	4	P	2
52	Bisbol	*E. cumini*	4	P	3
53	Cerme	*M. cauki*	1,2,3,4	P	5
54	Dewandaru	*M. cauki*	1,4	P	2
55	Sawo manila	*G. dulcis*	4	P	2
56	Sawo mentega	*S. dulcis*	1,4	P	2
57	Sawo Kecik	*E. longana*	1,3,4	P	4
58	**Cluciaceae**	*Antidesma bunius*	1,2,4	P	2
59	Mundu	*G. mangustama*	1,3,4	P	2
60	Kedondong	*A. integra*	1,4	p	2
61	Klengkeng	*A. communis*	1	P	2
62	Manggis	*A. altilis*	1,4	P	2
		A. campeden	2,4	P	3
63	**Moraceae**	*I. edulis*	3,4	P	2
64	Nangka celeng	*I. edulis*	4	P	2
65	Nangka mini		1,4	P	2
66	Nangka Brasil	*D. aurens*	1,4	P	2
67	Sukun	*L. glaucia*		P	2
68	Keluwih	*T. indica*	4	P	3
69	Cempedak	*T. indica*	3,4	P	2
70	Gayam batok	*T. indica*	3,4	P	1
	Gayam emprit	*F. elephantum*	3,4	P	2
71	**Sapotaceae**	*F. lucida*	3,4	P	2
72	Buah sempur	*M. pajang*	1,4	P	2
73	Petai Jawa		1,4		2
74	Asam jawa	*A. carambola*	4	P	
75	Asem china	*A. carambola*		P	2
76	Asam manis	*Averhoa Sp*	1,2,4	P	2
77	Kawisti batu	*Averhoa Sp*	1,4	P	2
78	Kawisto krikil	*A. bilimbi*	1,4	P	1
	Asam Selong		1,4		2
79	**Scrophulaceae**	*N. lappseum*	3,4	P	
80	Blimbing manis	*N. lappaceum*		P	3

81	Blimbing smb	*N. lappaceum*	1,4	P	1
82	Blimbing penang	*N. lappaceum*	1,4	P	2
83	Blimbing taiwan	*P. pinnata*	1,4	P	2
	Blimbing wuluh		1,4		2
84	**Sapindaceae**	*G. genemun*	1,2,4	P	
85	Rambutan binjai	-		P	4
86	Rambutan aceh	*P. globosa*	2,4	P	2
87	Rambutan rafiah	-	2,4	P	2
88	R. lebak bulus		1,4		2
	Matoa	*B. racemosa*	4	P	
89	**Fabaceae**	*L. eugonifploia*		P	4
90	Mlinjo	*Sterculea foetida*	4	P	2
91	Buah slobin	*M. trifolia*	4	P	2
92	Kedawung		2,4		2
	Makutodewa	*C. nucifera*	2,4	P	
93	Menteng	*C. nucifera*		P	2
94	Pule	*C. nucifera*	2,4	P	2
95	Kacang kepuh	*C. nucifera*	2,4	P	2
96	Asam selong		2,4		2
	Arecaceae	*H. vadatus*	2,4	Pd	
97	Kelapa hijau	*R. comunis*		Pd	15
98	Kelapa jawa	*R. cummunis*	1,4	Pd	2
99	Kelapa Kuning	*Rocaceae*	4	P	2
100	Kelapa kopyor	*M. caesia*	4	P	4
			1,4	P	2
101	Buah naga	*B. sapida*	1,4	P	3
102	Jarak merah	*D. kaki*	1,4	P	2
103	Jarak kepyar	*F. inermis*	1,4	P	3
104	Kersen	*B. macropylla*	1,4	P	2
105	Leguat	*P. edule*	4	P	2
106	Buah kemang	-	1,4	P	2
107	Kesemek	-	1,3,4		2
108	Lobi-lobi	-	1,4		
109	Gandaria				
110	Kluwek				
111	Murbei Bintaro				
112					
					283

Source : Primary Data Analysis (2025)

Notes: Utilization:

1 = fruits consumed fresh;

2 = ripe fruits processed into food or beverage products;

3 = immature fruits consumed fresh or used as food ingredients; and

4 = plant materials used for breeding purposes (e.g., grafting, hybridization, and other breeding activities).

Growth Habit:

P = tree;

Pd = shrub; and

Tp = tree-like herbaceous plant (*herbaceous tree*).

Changes in Species Diversity and Population of Fruit Plants in the Collection Garden

The evaluation results indicate that the existing condition of fruit plants in the collection garden has declined in terms of both species diversity and population size. At the time the collection was first established, a total of 175 fruit species comprising 482 individual trees were planted. However, after 25 years of operation, a reassessment revealed that the collection had decreased to 112 species with a total population of 283 trees (Table 1). Of the 112 fruit species currently present, only 83 species have been utilized or cultivated intensively to meet human needs. The remaining 29 species have not yet been utilized for practical purposes, and some are still largely unknown to the general public. Among the 17 plant families recorded, four families exhibited relatively high species richness but experienced noticeable declines over time. These included the Anacardiaceae family, which decreased from 16 to 12 species; Rutaceae, from 9 to 7 species; Musaceae, from 8 to 5 species; and Bombacaceae, from 8 to 5 species. The remaining species have not yet been completely classified into family groups.

Utilization and Management Constraints of the Collection Garden

The Rare Fruit Collection Garden at Taman Candra Wilwatikta serves as an important germplasm conservation site and provides multiple benefits. Initially, the collection was utilized directly in several ways. **(a) Physical utilization.** This includes harvesting fruits for consumption and, in some cases, for seed production. Species commonly utilized for this purpose include *Dewa Daru*, *Matoa* (*Pometia pinnata*), rambutan, *Jambu Kelampok*, *Jambu Dersono*, red fruit (*Pandanus conoideus*), green coconut, yellow king coconut, mini jackfruit, kawista (*Limonia acidissima*), menoa, mango, java plum (*Syzygium cumini*), and soursop.**(b) Academic utilization.** The collection has been used as a practical learning facility for anatomy and morphology courses offered to students of the Faculty of Agriculture at the University of Wijaya Kusuma Surabaya (UWKS). All fruit species within the collection garden have contributed to educational activities. The use of collection materials for plant breeding research remains limited and has primarily involved the utilization of selected species as rootstocks in cutting propagation studies. **(c) Aesthetic and agro-tourism utilization.** The collection garden contributes significantly to the landscape value of Taman Candra Wilwatikta. The presence of large, mature, and densely shaded fruit trees creates an attractive, cool, and comfortable environment, particularly for guests staying in accommodation facilities located south of and adjacent to the collection garden. **(d) Ecological and environmental functions.** The hundreds of fruit trees conserved within the collection garden, together with the surrounding shade trees, play an important ecological role as oxygen (O_2) producers and as biological filters capable of absorbing air pollutants emitted by motor vehicles traveling along the Pandaan–Tretes roadway located directly in front of the

collection garden. **Management Constraints** Several challenges have been encountered in managing the collection. garden.

(a) Technical constraints. These include limitations in routine maintenance due to the small number of field staff. Only three workers are responsible for maintaining more than 345 trees distributed across a 2.25-ha area. Additional challenges include fruit damage caused by civets (*Paradoxurus* spp.), which feed on matoa, kesambi, jackfruit, and banana fruits, as well as infestations of nettle caterpillars and other insect pests affecting several plant species

Management Constraints (continued)

Additional technical constraints include pest infestations affecting several fruit species, including mango, matoa, canistel (*Pouteria campechiana*), white java plum (*Syzygium* sp.), and tamanu (*Calophyllum inophyllum*). **(b) Non-technical constraints.** These primarily involve theft committed by individuals from nearby communities, occasionally accompanied by vandalism and damage to plants and facilities. Another major challenge is the limited financial support available for the management and maintenance of the collection garden.

Discussion

Characteristics and Potential of Fruit Plants in the Collection Garden

The assessment of the current condition of the collection garden revealed that it presently contains 112 rare fruit species with a total population of 283 trees (Table 1). In comparison, when the collection garden was first established in 2000–2001, it contained 175 fruit species and 482 individual trees. These figures indicate a decline of approximately 36% in species diversity and 41.28% in plant population over the past 25 years.

Several factors have contributed to this degradation in species richness and population size. First, inadequate irrigation, particularly during the dry season, has adversely affected plant survival. The collection garden is located at an elevation of approximately 600 m above sea level and is characterized by heavy grumosol soils that become extremely dry under water-limited conditions. Second, maintenance activities have been constrained by an insufficient number of field workers. Only three personnel are responsible for maintaining the entire 2.25-ha collection garden. Third, the supervision system is relatively weak because field workers do not reside on-site and leave the area after 4:00 p.m. each day. This situation increases the risk of theft and occasional vandalism when the garden is left unattended. Finally, reduced attention and institutional support from the management of Taman Candra Wilwatikta following administrative changes have also contributed to the decline of the collection.

Of the 112 fruit species currently conserved, only 72 species (64.54%) have been cultivated and utilized by local communities, whereas the remaining 40 species (35.46%) remain largely underutilized and have not yet contributed significantly to local economic development. Among these

underutilized species, several possess considerable potential for future development due to their economic, medicinal, or pesticidal value.

Species with high economic potential include kopyor coconut, matoa (*Pometia pinnata*), and gayam (*Inocarpus fagifer*). Several species are recognized for their medicinal properties, including kepel (*Stelechocarpus burahol*), buni (*Antidesma bunius*), mundu (*Garcinia dulcis*), *Jambu Dersono*, *Jambu Klutuk*, dewa ndaru, white java plum, bilimbi (*Averrhoa bilimbi*), asam seong, and green coconut. Other species show promise as sources of botanical pesticides, including klerek, duku (*Lansium domesticum*), langsat, canistel, sugar apple (*Annona squamosa*), large menoa, small menoa, breadnut (*Artocarpus camansi*), and soursop (*Annona muricata*).

To realize the full potential of these germplasm resources, comprehensive characterization, evaluation, and documentation programs should be implemented as soon as possible. In addition, a rejuvenation program is needed to replace aging trees and maintain the long-term viability of the collection.

Characterization is the process of identifying important traits that have economic value or serve as distinguishing characteristics of a particular variety. Germplasm characterization may be conducted through the assessment of morphological, agronomic, physiological, biochemical (e.g., isozyme), and molecular marker traits to reveal the genetic diversity present within an accession (FAO, 2023; Bioversity International, 2023).

Evaluation activities focus on identifying nutritional components, such as protein, fat, and vitamin contents, as well as assessing varietal responses to biotic stresses (resistance to pests and diseases) and abiotic stresses, including drought, iron (Fe) toxicity, aluminum (Al) toxicity, salinity, and other environmental constraints. Although the collection garden currently maintains a substantial stock of fruit germplasm resources, evaluation activities remain limited because of logistical constraints and insufficient funding. Consequently, most efforts to date have focused primarily on morphological characterization of a limited number of species.

Documentation activities are essential for recording and preserving valuable information generated from exploration, conservation, characterization, evaluation, and rejuvenation programs (Akbar, 2025; Indonesian Ornamental Plant Research Institute, 2026). In fruit germplasm management, documentation data are generally categorized into several types, including passport data, characterization data, evaluation data, and germplasm management records. Documentation and information management within the collection garden remain relatively limited and are largely restricted to records associated with routine garden management activities, such as morphological descriptions, utilization for student field practical courses, and a limited number of research projects.

Growth Habit Classification of Fruit Species in the Collection Garden

The classification of fruit plants based on growth habit showed that, of the 112 species recorded, 101 species (90.17%) were trees, 8 species (6.25%) were classified as tree-like herbaceous plants, and 3 species (2.34%) were shrubs. Thus, the vast majority of fruit plants conserved in the collection garden are perennial tree species. This condition is particularly advantageous for germplasm characterization, evaluation, and rejuvenation programs.

Although these activities have been planned, only limited characterization efforts have been conducted to date, primarily involving several mango cultivars. It is expected that, in the future, comprehensive characterization, evaluation, and rejuvenation programs can be implemented for all species in the collection to support both the utilization and conservation of fruit germplasm resources.

The presence of tree-like herbaceous species also provides opportunities for rejuvenation through vegetative propagation techniques. During the initial phase of the rejuvenation program, propagation activities were undertaken not within the collection garden itself but at the Nursery Garden of the Faculty of Agriculture, University of Wijaya Kusuma Surabaya (UWKS). The resulting seedlings were subsequently distributed to local communities surrounding the university campus, while approximately 30 seedlings including mango, kepel, rambutan, jackfruit, and other fruit species were entrusted to the Environmental Education Center (PPLH) Seloliman for planting and conservation purposes.

Utilization and Management Constraints of the Germplasm Collection Garden

Germplasm collection gardens can be utilized directly to support human needs for food, clothing, housing materials, and medicinal resources (Akbar, 2024). Utilization may occur through cultivation or direct harvesting from natural populations. Various cultivars and wild relatives of fruit and vegetable crops contribute significantly to meeting nutritional requirements. Such utilization generally occurs at the individual level, involving plant materials that have been selected based on desirable phenotypic and agronomic characteristics.

However, in the case of the Rare Fruit Collection Garden, utilization at both individual and institutional levels remains relatively limited.

Direct Utilization

From a practical perspective, fruit harvesting is generally limited to the fruiting season of each species. Since different fruit species produce harvestable fruits at different times of the year, the collection garden theoretically has the potential to provide fruit resources almost continuously throughout the year. However, this potential has not been fully realized because of inadequate security and supervision.

Although three garden guards are assigned to the site, they typically leave the premises at approximately 3:30 p.m. Consequently, periods without supervision are frequently exploited by unauthorized individuals who harvest fruits illegally. Theft is not limited to fruit harvesting; valuable

replacement seedlings and young plants with high economic value, such as durian, *Jambu Dersono*, dragon fruit, and other species, have also been removed from the collection garden.

Academic Utilization

Academic utilization of the collection garden remains relatively limited. Current uses include student practical courses, undergraduate research projects, and a small number of research activities conducted by academic staff of the Faculty of Agriculture, UWKS.

At the genetic level, germplasm resources may serve as valuable biological materials for plant breeding programs (Andarini & Nugroho, 2023; Salgotra & Chauhan, 2023). Nevertheless, the utilization of the collection garden for plant breeding research has so far been restricted primarily to the use of selected species as rootstocks in propagation and cutting experiments involving fruit crops.

Biotechnological applications remain limited as well. Research activities have focused mainly on the propagation of selected rare fruit species through tissue culture techniques utilizing axillary buds and shoot meristems. Such activities have been conducted in the Plant Tissue Culture Laboratory of the Agrotechnology Study Program, Faculty of Agriculture, University of Wijaya Kusuma Surabaya.

Aesthetic and Agro-tourism Functions

From the outset, the collection garden was designed to support the broader functions of Taman Candra Wilwatikta as a cultural heritage site, particularly for traditional performing arts, as well as a venue for recreation, accommodation, meetings, training programs, and other social activities.

Between 1999 and 2004, Ramayana ballet performances were regularly organized every three months during full moon periods by the East Java Provincial Tourism Office. However, these cultural events have not been held during the past four years.

The presence of a collection garden characterized by large, mature trees and a cool, aesthetically pleasing environment enhances the attractiveness of Taman Candra Wilwatikta as a destination for visitors seeking accommodation and recreation. Guests staying within the complex can enjoy the shade and scenic beauty provided by the collection garden while also participating in agro-tourism activities, including the harvesting and consumption of ripe fruits directly from the garden.

Ecological Benefits and Environmental Functions of the Collection Garden

Another important benefit of the collection garden is its contribution to ecological sustainability and environmental balance. The presence of hundreds of fruit plant species within the collection garden, together with the shade trees growing in the surrounding area, serves as a major source of oxygen (O_2) production and as a sink for air pollutants emitted by motor vehicles traveling along the Pandaan–Tretes roadway located directly in front of the collection garden.

Plant species that contribute to pollutant absorption within and around the collection garden include *sono* trees (shade trees located outside the collection area), mango, matoa, kepel, kecapi, kreco, nogosari, canistel, duku, langsat, *sawo kecik*, sapodilla (*sawo manila*), gayam, breadnut (*kluwih*), and several other species. Covering an area of 2.25 ha, the collection garden constitutes an important Green Open Space (*Ruang Terbuka Hijau*, RTH) and functions similarly to an urban forest.

Urban forests provide substantial benefits for environmental quality and human well-being, including aesthetic, ecological, climatological, hydrological, protective, hygienic, and educational functions (Bappenas, 2025b). The principal challenge in managing the collection garden is the lack of a clear and stable management structure, which complicates both routine management and future development efforts. In addition, a long-standing constraint is the limited financial support available for garden management, particularly for research and development activities.

CONCLUSION

The Rare Fruit Germplasm Collection Garden at Taman Candra Wilwatikta continues to play an important role as an ex situ conservation site for fruit genetic resources. The evaluation revealed that the collection currently contains 112 fruit species with a total population of 283 trees. Compared with the initial collection established in 2000–2001, consisting of 175 species and 482 trees, the garden has experienced a decline of approximately 36% in species diversity and 41.28% in plant population.

Of the species currently conserved, approximately 64.54% have been utilized or cultivated by local communities, while the remaining species remain underutilized despite their potential economic, medicinal, ecological, and plant-breeding value. In addition to conserving germplasm resources, the collection garden serves educational, research, agro-tourism, aesthetic, and environmental functions.

The main constraints affecting the sustainability of the collection include limited irrigation, insufficient maintenance personnel, weak security and supervision, theft and vandalism, inadequate funding, and the absence of comprehensive characterization, evaluation, documentation, and rejuvenation programs. Therefore, strengthening garden management through improved conservation practices, systematic characterization and documentation, rejuvenation of aging plants, and enhanced institutional support is essential to ensure the long-term conservation and sustainable utilization of rare fruit germplasm resources

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