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Research Article
Productive Urban Landscape through Urban Trees on Roadside Greenery of Yogyakarta City

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Abstract

Background and Objective: Previous studies explained specifically about urban plant diversity and productive urban landscape. This study evaluated urban trees through the implementation of productive urban landscape concept in the tropical city of Yogyakarta. **Materials and Methods:** Field observation and investigation were conducted by survey method. Data collection was conducted at 27 locations of roadside greenery, i.e., 2 secondary arterial roads (SAR), 3 secondary collector roads (SCR) and 22 local streets (LS). Data were analyzed through tree diversity and evenness calculated by Shannon-Wiener (H) and Evenness (E) Indices. Urban trees were classified by tree size and productive values. Spatial distribution of trees was interpreted by detrended correspondence analysis (DCA). **Results:** The roadside greenery was identified by 1884 trees belong to 62 species. The tropical *Mimusops elengi* is overwhelmingly dominant (38,15%) followed by *Polyalthia longifolia* (10,3%) and *Pterocarpus indicus* (8,45%). The tree diversity index (H') and Evenness index (E) showed a medium score of 2.48 and 0.59. The edible trees covered only 14.38% of the total trees dominated by fruit trees of *Tamarindus indica*, *Gnetum gnemon*, *Mangifera indica*, *Muntingia calabura* and *Manilkara kauki*. Most of them were in the local street of the settlement area. **Conclusion:** The greenery should be improved by increasing the number of trees, number of species, intensive maintenance and enhancing productive values of trees. Applying productive urban landscape at roadside greenery of Yogyakarta City has not been optimal yet at all types of roadside.

Key words: Edible tree, productive urban landscape, roadside greenery, urban trees, Yogyakarta

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The role of urban trees optimally controls the profound pressure of the urban environment. Previous studies explained that the exerted quality of urban environment, such as air pollution, high humidity, high temperature in the urban atmosphere has been ameliorated by the trees through developing productive urban landscape[1-5]. Studies on providing food in the urban area showed productive landscape can help to meet the food demand in a household. Continuous productive urban landscape increases the availability of fresh, healthy and affordable food for the other urban consumers as much of the food produced by urban farmers bartered or sold locally[2,6]. As part of productive urban landscape, growing urban agriculture is generally defined as the providing food in a city. Planting edible trees in urban landscape have an opportunity in improving fruits harvest, ameliorating urban climate and aesthetics. The concept of urban farming system was developed in the basic study of rural agriculture analysis. The system was followed by agronomic studies approached to the adaptation of agriculture to environmental, soil, site specific and was later used to build typologies of urban agriculture[7-9].

This study proposed Yogyakarta City in context of a tropical city in Indonesia. The city has been recognized as a destination of tourism and an education activity center. Yogyakarta should be a comfortable, healthy and ecological city[1]. In the last decade, Yogyakarta has developed as an urbanized city. The urbanization has exerted profound pressure on the urban environment[10]. Roadside greenery of Yogyakarta City has looked lack conceptual plan in supporting a conducive environment.

This study was starting from identifying problems of trees in urban area, i.e., lack of species, low count of trees, planted edible tree or fruit tree, productive values of existing trees and spread of species in types of roadside. The problems were analyzed to be an input of integrating function process in developing productive urban landscape. The concept can be optimally improved in design of urban greenery in types of roadside. These ideas were growing by few previous studies that specifically stating on urban plant diversity[4,5,11,12], concept of productive urban landcape[1-3], functions of urban plant[6-9,13-20] and urban landscape development[10,21-25], which conducted separately in own focus of objectives.

In Yogyakarta City, the protocol roads of secondary arterial road (SAR) and secondary collector road (SCR) were not covered fruit trees. It might be an issue on safety and low maintenance of trees[26]. The urban greenery guidance has not preferred fruit trees planted as roadside greenery. However, studies on fruit trees have shown more benefit for urban greenery[4,5,15,26]. This initial study aimed to describe the existing condition of roadside greenery, to identify potencies and problems in Yogyakarta City. The publications are arranged to be submitted and published in proceedings and journals by the research team. A study was disseminated in International Conference of Human Security 2018, proceeding in submission[26]. This study evaluated the urban trees of roadside greenery in Yogyakarta City of Indonesia, with reference to (a) Tree species characteristics, (b) Species diversity and evenness and (c) Species distribution at types of roads. However, this study is focused on analysis of urban trees in roadside greenery of Yogyakarta City as an input of evaluation for development of productive urban landscape.

MATERIALS AND METHODS

Study site: The study was conducted by survey method in Yogyakarta City, Indonesia. Yogyakarta is a capital city of Special Region of Yogyakarta Province located at 7°S, 110°E in Java Island (Fig. 1). The Province contains 5 districts including Yogyakarta City, Sleman District in the north, Kulon Progro District in the west, Bantul District in the south and Gunung Kidul District in the east. Yogyakarta climate has been tropical warm humid, position at 50 km north of Bantul coastal area. Central Bureau of Statistics of Yogyakarta provided the latest data of Yogyakarta City. The mean daily maximum air temperature often exceeds 22.6-32.5°C in 12 months precipitation covered 94.5-425 mm per month. Total population of Yogyakarta City was 417,744 lived in area of 32.5 km^2. The population of Yogyakarta City as much as 11.2% lived in area of 1.02% the province of Yogyakarta. Yogyakarta City is the most densely populated about 13 people km^{-2} compared to other districts of Yogyakarta Province[27].

Sample units: Data collection was conducted on April-August, 2018 in 27 roadside greenery of Yogyakarta City, Special Region of Yogyakarta Province (Fig. 1). Sample units of this study were roadside greenery based on Yogyakarta Mayor Decree Number 214/KEP/2013. Figure 1 shows location of study. The regulation contains totally 558 roads in Yogyakarta City with three types of road functions, consist of 15 secondary arterial roads (SAR), 36 secondary collector roads (SCR) and 507 local streets (LS).

The sample units were calculated by statulator. com in 558 population of roads, 95% level of confidence, 80% expected proportion and 15% margin of error. Urban trees

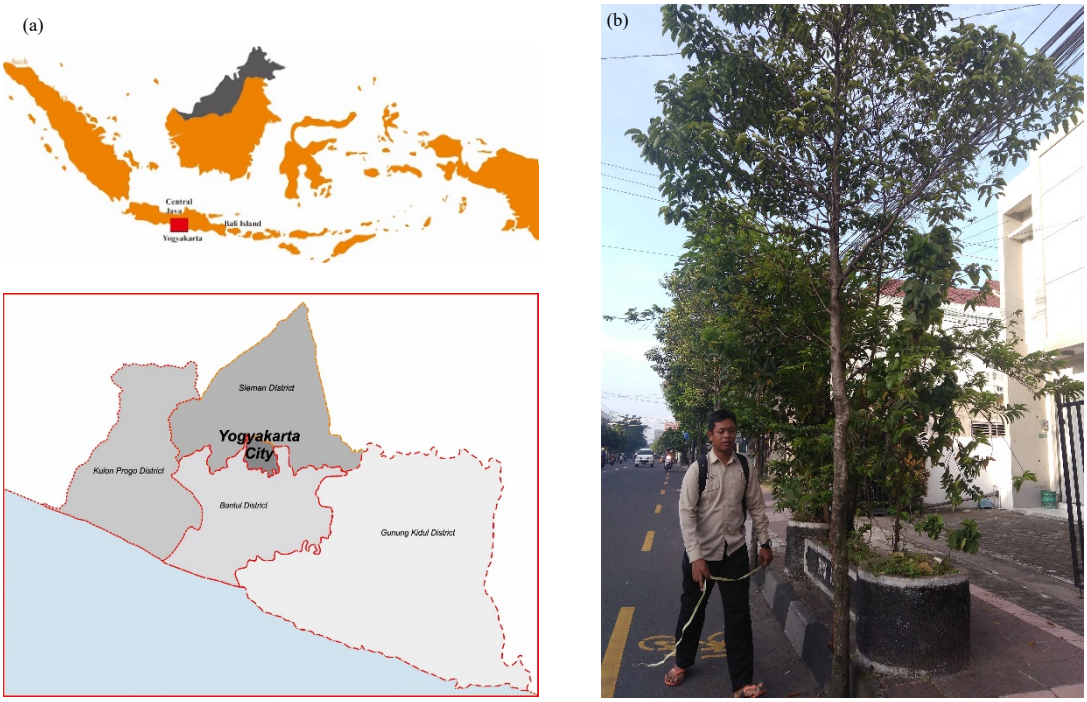

Fig. 1(a-b): Location of study, (a) Yogyakarta Province (above), Yogyakarta City (below) and (b) Urban trees at road side greenery of AM Sengaji Rd. (SCR)
Source: Redrawing from google map

were identified at 27 samples along the roadside greenery[26]. The classification of tree sizes was created by combination of tree height and tree crown diameter[28]. In this study, urban trees were classified by tree size based on combination of tree height, tree crown diameter and trunk diameter. The sample of this study consisted of 2 SAR, 3 SCR and 22 LS regarding to the proportion of the three road functions.

Data analysis: Urban tree species, size, distribution and function were analyzed descriptively to recognize the existing condition. The productive values were identified through functions of productive landscapes is between food providers, polluters, climate control and for biodiversity[2]. Detrended correspondence analysis (DCA) of the species were performed to better understand the species among different three roadside greenery[11]. The DCA was processed by R Statistics 3.5.1 version in "Vegan" packages[29]. The analysis can interpret tree distribution at three types of roads.

Measuring tree height, crown diameter (average west-east and north-south) and tree trunk diameter were conducted to classify trees as size of small (S), medium (M), big (L) and very big (XL). Tree characteristics were classified in four sizes which in combination of tree height, crown and trunk[30]. Tree height was measured on ground trunk or upper root to approximately upper crown. The height was categorized by three, i.e., less than 5 m (A), 5-10 m (B) and more than 10 m (C). The tree crown was divided by the average crown diameter, i.e., Ø $\leq$2 m (a), Ø 2-5 m (b) and Ø >5 m (c). Than, tree trunk diameter was measured at 1.2 m upper ground grouped into Ø $\leq$0.05 m (1), Ø 0.05-0.12 m (2) and Ø >0.12 m (3). These three indices combination determines three sizes of small tree (Aa1, Aa2, Ab1, Ba1, Bb1), medium tree (Aa1, Aa2, Ab1, Ba1, Bb1), big tree (Ca3, Cb2, Cb3, Cc2) and very big tree (Cc3).

Some numerical indices developed in vegetation ecology and commonly applied in urban-landscape studies have been adopted in this study. The studies indicated the tree composition in species diversity (H) and evenness (E). Two indices were calculated in this study for comparison amongst the three types of roadside greenery. Species diversity was represented by Shannon-Wiener index (H) calculated by:

$$H' = -\Sigma\, pi \ln pi$$

where, pi was the proportion of individuals of i-th species. Evenness index (E) was calculated by:

$$E = \frac{H'}{\ln (S)}$$

The criteria of H' are categorized into H ' <1 (low diversity), 1 <H' ≤3 (medium diversity) and H' >3 (high diversity)[28]. Ecosystem stability is also determined by evenness index, which ranges from 0 to 1. Close to 0 indicates the more uneven distribution of organisms dominated by certain species. The species community more stable in ecosystem indicated near to 1. Then, E < 0.2 means that the spread of species is unstable and more stable induced 0.2 ≤E ≤1[31].

RESULTS

The study revealed that the dominant trees in roadside greenery of Yogyakarta City were *Mimusops elengi* 40.48%, *Polyalthia longifolia* 10.93%, *Pterocarpus indicus* 8.97% and *Tabebuia aurea* 7%. The urban trees covered abundantly 85.62% non-edible plants and 14.38% edible plants[26]. The edible trees planted were *Tamarindus indicus* covered 2.39%, others were 1.86% *Gnetum gnemon*, 1.49% *Muntingia calabura* and 1.33% *Mangifera indica*. The tamarind tress have been mostly planted at the secondary arterial road since long ago in the colonial period. Nevertheless, fruit trees were plentiful in settlement area grew at local street (LS).

The urban trees and species were unevenly distributed by roadside greenery in Yogyakarta City. Each roads of SAR, SCR and LS could have a few to more than a 100 trees. Figure 1 shows an urban tree, *Mimusops elengi* at AM Sengaji Road one of the secondary collector roads. The over all Shannon-Wiener diversity index (H') and Evenness index (E) of the urban trees in Yogyakarta scored H' 2.48 and E 0.59. The diversity indices on urban trees in roadside greenery of Yogyakarta City performed in medium diversity (H') and medium structured species community (E). The tree canopy coverage length were 4059.2 m (0.4 km) that calculated by tree crown diameter and the road length was 16,209 m (1.6 km). The tree canopy covered 25.4% road length that performed the lack of shading and not optimal for improving cooling effect along roads.

Table 1 shows the tree size of 62 species of total 1884 urban trees in roadside greenery. The edible trees species were 32 species. The Spanish cherry trees (*Mimusops elengi*) were the most count of trees (763), even though the small size were more than half of total count. Angsana trees

Table 1: Urban trees in Yogyakarta City

No.	Species	Common name	Family	Tree count	**Tree count based on tree size				Productive values: Providing					
					S	M	L	XL	Food	Shading	Flower	Fruit	Seed	Pollution absorption
1	**Anacardium occidentale*	Cashew nut	Anacardiaceae	1	1	0	0	0	●	●	●	●	●	●
2	**Annona muricata*	Soursop	Annonaceae	6	3	3	0	0	●	●	●	●	-	●
3	**Annona squamosa*	Sugar apple	Annonaceae	7	5	2	0	0	●	●	●	●	-	●
4	*Araucaria heterophylla*	Norfolk Island pine	Araucariaceae	2	0	1	1	0	-	-	●	-	●	●
5	**Areca catechu*	Areca palm	Arecaceae	11	1	10	0	0	●	-	●	●	●	●
6	**Artocarpus altilis*	Breadfruit	Moraceae	3	0	3	0	0	●	-	●	●	-	●
7	**Artocarpus heterophyllus*	Jackfruit	Moraceae	15	2	13	0	0	●	●	●	●	-	●
8	**Averrhoa carambola*	Star fruit	Oxalidaceae	7	6	1	0	0	●	-	●	●	-	●
9	*Barringtonia asiatica*	Poison fish	Lecythidaceae	5	1	4	0	0	-	●	●	●	●	●
10	**Carica papaya*	Papaya	Caricaceae	1	1	0	0	0	●	-	●	●	-	●
11	**Citrus aurantifolia*	Key lime	Rutaceae	1	1	0	0	0	●	-	●	●	-	●
12	**Citrus* sp.	Citrus	Rutaceae	1	1	0	0	0	●	-	●	●	-	●
13	**Cocos nucifera*	Coconut	Arecaceae	5	1	4	0	0	●	-	●	●	-	●
14	*Cupressus papuana*	Cupressus	Cupressaceae	5	1	4	0	0	-	-	●	-	●	●
15	*Delonix regia*	Flame	Fabaceae	2	0	1	0	1	-	●	●	-	●	●
16	*Dimocarpus longan*	Longan	Sapindaceae	6	5	1	0	0	●	●	●	●	-	●
17	*Ficus benjamina*	Weeping fig	Moraceae	54	15	37	2	0	-	●	●	●	-	●
18	*Ficus elastica*	Rubber plant	Moraceae	1	1	0	0	0	-	●	●	●	-	●
19	*Ficus lyrata*	Fiddle-leaf fig	Moraceae	18	0	18	0	0	-	●	●	●	-	●
20	*Ficus septica*	Septic fig	Moraceae	1	0	1	0	0	-	●	●	●	-	●
21	*Filicium decipiens*	Fern	Sapindaceae	16	1	15	0	0	-	●	●	●	-	●
22	*Gigantochloa apus*	Watho	Gramineae	1	1	0	0	0	-	-	●	-	-	●
23	*Gmelina arborea*	Gmelina	Lamiaceae	1	1	0	0	0	-	●	●	●	-	●
24	**Gnetum gnemon*	Melinjo	Gnetaceae	35	4	31	0	0	●	-	●	●	-	●
25	*Hibiscus tiliaceus*	Cottonwood	Malvaceae	37	10	27	0	0	-	●	●	●	●	●
26	*Lagerstroemia speciosa*	Pride of India	Lythraceae	30	1	28	1	0	-	●	●	●	●	●

Table 1: Continue

No.	Species	Common name	Family	Tree count	**Tree count based on tree size				Productive values: Providing					Pollution absortion
					S	M	L	XL	Food	Shading	Flower	Fruit	Seed	
27	*Leucaena leucocephala	Lead tree	Fabaceae	1	1	0	0	0	●	-	●	●	-	●
28	*Litsea glutinosa*	Indian Laurel	Lauraceae	2	1	1	0	0	-	●	●	●	-	●
29	*Mangifera indica	Mango	Anacardiaceae	25	6	19	0	0	●	●	●	●	-	●
30	*Manilkara kauki	Caqui	Sapotaceae	17	1	16	0	0	●	●	●	●	-	●
31	*Melochia umbellata*	Melochia	Sterculiaceae	1	0	1	0	0	-	●	●	-	-	●
32	*Mimusops elengi*	Spanish cherry	Sapotaceae	763	478	284	1	0	-	●	●	●	-	●
33	*Morinda citrifolia	Indian mulberry	Rubiaceae	6	0	6	0	0	●	-	●	●	-	●
34	*Moringa oleifera	Horseradish	Moringaceae	1	1	0	0	0	●	-	●	-	-	●
35	*Muntingia calabura	Calabur	Tiliaceae	28	8	20	0	0	●	●	●	●	-	●
36	*Murraya paniculata	Orange jessamine	Rutaceae	2	2	0	0	0	-	-	●	-	-	●
37	*Nephelium lappaceum	Rambutan	Sapindaceae	2	1	1	0	0	●	●	●	●	-	●
38	*Pachira* sp.	Pachira	Bombaceae	3	3	0	0	0	-	-	●	-	-	●
39	*Parkia speciosa	Bitter bean	Fabaceae	1	0	1	0	0	●	●	●	●	-	●
40	*Persea americana	Avocado	Lauraceae	11	1	10	0	0	●	●	●	●	-	●
41	*Phoenix dactylifera	Date palm	Arecaceae	4	1	3	0	0	●	-	●	●	-	●
42	*Pithecellobium dulce*	Madras thorn	Fabaceae	7	0	7	0	0	-	●	●	●	-	●
43	*Plumeria alba*	Champa	Apocynaceae	10	5	3	2	0	-	●	●	●	-	●
44	*Polyalthia longifolia*	Mast	Annonaceae	206	52	144	10	0	-	●	●	●	-	●
45	*Pometia pinnata*	Fijian longan	Sapindaceae	2	1	1	0	0	●	●	●	●	-	●
46	*Psidium guajava	Guava	Myrtaceae	12	10	2	0	0	●	●	●	●	-	●
47	*Pterocarpus indicus*	Angsana	Fabaceae	169	28	135	5	1	-	●	●	-	-	●
48	*Spathodea campanulata*	African tulip	Bignoniaceae	2	0	2	0	0	-	●	●	-	-	●
49	*Spondias dulcis	Golden apple	Anacardiaceae	1	0	1	0	0	●	●	●	●	-	●
50	*Stelechocarpus burahol	Keppel apple	Annonaceae	4	0	4	0	0	●	●	●	●	-	●
51	*Swietenia macrophylla*	Honduras mahogany	Meliaceae	5	0	5	0	0	-	●	●	●	-	●
52	*Syzygium aqueum	Water apple	Myrtaceae	6	2	4	0	0	●	●	●	●	-	●
53	*Syzygium cumini	Java plum	Myrtaceae	2	0	2	0	0	●	●	●	●	-	●
54	*Syzygium malaccense	Malay apple	Myrtaceae	3	3	0	0	0	●	●	●	●	-	●
55	*Tabebuia aurea*	Caribbean trumpet	Bignoniaceae	132	25	107	0	0	-	●	●	-	-	●
56	*Tamarindus indicus	Tamarind	Fabaceae	45	4	33	5	3	●	●	●	●	-	●
57	*Terminalia catappa*	Indian almond	Combretaceae	35	2	32	0	1	-	●	●	●	-	●
58	*Terminalia mantaly*	Madagascar almond	Combretaceae	1	0	1	0	0	●	●	●	-	●	●
59	*Thuja orientalis*	Biota	Cupressaceae	3	0	3	0	0	-	●	●	-	●	●
60	*Triphasia trifollia	Lime berry	Rutaceae	1	1	0	0	0	●	-	●	●	●	●
61	*Veitchia merrilii*	Manila palm	Arecaceae	41	13	26	2	0	-	-	●	●	-	●
62	*Wodyetia bifurcata*	Foxtail palm	Arecaceae	58	4	53	1	0	-	-	●	●	-	●
	Total			1884	717	1131	30	6						

*Edible tree, **Modified tree size[30], Tree size: Small (S), Medium (M), Big (L), Very big (XL)

(*Pterocarpus indicus*) were 163 trees found in four various size. As well, the fruit tamarind trees (*Tamarindus indicus*) were existed in four various size of 3 very big trees, 5 big trees, 33 medium trees and 4 small trees.

Both of *Mimusops elengi* and *Tamarindus indicus* have been the uniqueness and philosophical story of Yogyakarta City. Other tree of *Ficus benyamina*, an icon of Javanese culture, is a very big tree but because of limited space of planting on roadside, the small and medium trees were not available on the roads (Table 1). Small count of *Stelechorcarpus burahol* also strengthens the image of Java in Yogyakarta City. The beautiful yellow flower of tabebuia trees have been more existing for aesthetics. Few palm trees were available on roadside as accent in regular tree crown. Both of trees give visual contrasts but a little shading, so as roadside greenery should be combined planting by shading trees.

The most tree sizes at roadside greenery of Yogyakarta City were medium tree (M) 60% and small tree (S) 38% (Table 1). The big (L) and very big (XL) trees were very limited available. Six productive values of trees were identified by doing field observation and citing literature for the performance indicator in developing productive landscape, i.e., providing food, shading, flower, fruit, seed and pollution absorption. The productive values of trees covered providing food (272 trees belong to 33 species), shading (1695 trees belong to 42 species), flower (1884 trees belong to 62 species), fruit (1500 trees belong to 49 species), seed

Fig. 2(a-c): Roadside greenery, plants and problems, (a) Kol. Sugiono Rd. (SAR), (b) HOS Cokroaminoto Rd. (SCR) and (c) Patangpuluhan St. (LS)

(98 trees belong to 11 species) and pollution absorption (1884 trees belong to 62 species). A tree can serve more than one values for urban greenery. Some of tree characteristics provided shading that people feel comfortable in activity because of the cooling effect.

Planting at the roadside greenery had problems of the limited space and the low quality of maintenance (Fig. 2). Planting methods, therefore have to be redesigned regarding to the growing process of trees at the protocol roads (SAR, SCR) and at the settlement area (LS). The tree maintenance seemed to be conducted with unwell management in term of watering, pruning, fertilizing, etc., so that tree growth was looked not optimal.

Trees planting distribution at three types of roads were analyzed by detrended correspondence analysis (DCA) (Fig. 3). The DCA showed that the urban trees were scattered at the three types of roads in Yogyakarta City, i.e., secondary arterial road (SAR), secondary collector road (SCR) and local streets (LS). The three types of roads were drawn as circle and the urban trees as cross. The number (#) means that the urban trees species were showed in Table 1 and the star (*) marked edible trees that have production of fruits. Based on the results of the DCA, it can be seen that 15 species were found at the three types of roads in which five species were edible. The urban trees that were available at all road types of SAR, SCR, LS were *Artocarpus heterophyllus** (#7), *Barringtonia asiatica* (#9), *Ficus benjamina* (#17), *Hibiscus tillaceus* (#25), *Mangifera indica** (#29), *Mimusops elengi* (#32), *Muntingia calabura** (#35), *Plumeria* sp. (#43), *Polyalthia longifolia* (#44), *Psidium guajaya** (#46), *Pterocarpus indicus* (#47), *Tamarindus indicus** (#56), *Terminalia catappa* (#57), *Veitchia merillii* (#61) and *Woodyetia bifurcate* (#62).

There were 17 tree species which grown up at the local streets (LS) only, not available at SAR and SCR were *Anacardium occidentale** (#1), *Averrhoa carambola** (#8), *Carica papaya**(#10), *Citrus* sp.* (#12), *Dimocarpus longan** (#16), *Gigantochloa apus* (#22), *Gnetum gnemon**(#24), *Litsea glutinosa* (#28), *Moringa oleifera** (#34), *Murraya paniculata** (#36), *Nephelium lappaceum** (#37), *Parkia speciosa** (#39), *Persea americana** (#40), *Phoenix dactylifera** (#41), *Pometia pinnata** (#45), *Syzygium aqueum** (#52), *Syzygium malaccense** (#54). The most edible fruit plants (*mark) were covered at the local street (LS) in the settlement area. The urban trees were scattered irregularly not based on the types of roadside. The plant species commonly be planted with unwell plan by the local government or the local community.

The total species planted on three types of roadside greenery was 97 consisted of 62 species of trees, 35 other species of tropical shrubs. The shrubs spread on the ground of roads were *Chrysalidocarpus lutescens, Sansiviera trifasciata, Clerodenrum speciosum, Excoecaria cochincinensis, NeproLepis biserrata, Euphorbia* sp., *HymenocaLis speciose, Bougenvilea spectabilis, Arachis pintoi, Cordy line* sp., *Cymbopogon citratus, Hymenocalis speciose, Adenium obesum, Ixora indica, Livistona saribus, Pachira* sp., *Rhombusa* sp., *Cyperus alternifolius, Dracaena fragrans, Musa* sp., *Notophanax scutelaria, Salacca zalacca, Vernonia arborea, Spinifex littoreus, Caryota* sp., *Cordyline fruticose, Euphorbia milii, Hibiscus rosa sinensis, Ixora indica, NeproLepis biserrata, Podocarpus neriifolius, Pseuderanthemum carruthersii* and

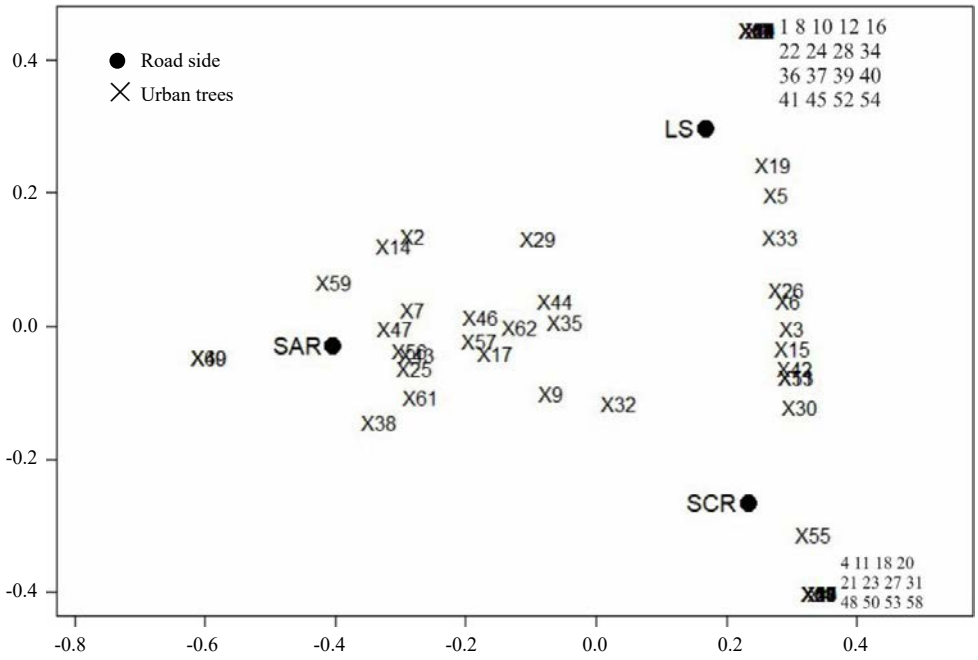

Fig. 3: Detrended correspondence analysis (DCA) of spatial distribution of trees at three roadside greenery
SAR: Secondary arterial road, SCR: Secondary collector road, LS: Local street, Tree species #, see Table 1

Ptychosperma macarthurii. Most of the shrubs were planted by the local government and community, regardless of the unwell maintenance and disorderly growth. The five species of *Chrysalidocarpus lutescens*, *Sansiviera trifasciata*, *Clerodenrum speciosum*, *Excoecaria cochincinensis* and *Neprolepis biserrata* grew dominantly at the roadsides. The mentioned shrubs are often seemed and cultivated in the tropics, nevertheless they could grow wild.

DISCUSSION

The observation results showed many problems of planting trees at roadside greenery in Yogyakarta City. For that reason, one effort can be urged is that the urban trees of the roadside greenery in Yogyakarta City have to be improved by increasing species, more planted trees, proposed edible trees and planting spread evenly on each type of roads. Planning activities have to be focused on decreasing the effects of the contemporary issues[10]. The increasing of using motorized vehicles causes air pollution and noise. Climate change and any other environmental problems globally have occurred causing city warmer and not comfort. Urban planning for a sustainable development is a necessary measure.

Urban trees have functions to ameliorate urban environment and provide food. Urban landscapes can be managed to give many benefits to people, urban living, increasing productivity and well-being. Limited green space for planting and high population in a city have caused the lower ratio of green space per capita. Productive landscape grows the land quality through productive values of plants[1,13,21].

Yogyakarta City is a tropical city that needs comfortable living and good quality of environment. The functions of urban trees are expected to play the roles, then it can achieve sustainable city for living. Productive urban landscape concerned on urban agriculture and urban landscape[2]. Urban agricultural landscapes are claimed to contribute to climate change mitigation and adaptation, biodiversity[22], provide contact with nature, promote physical and mental well-being[32], foster social cohesion, cultural integration, intergenerational interactions and cooperation and community enterprise[14,23,33] with associated opportunities for leisure and recreation[24], artistic/creative expressions and place-making[25]. In the management of urban landscape, users participations are needed toward ecologically and socially sustainable landscapes and processes[21]. The urban agriculture produces high-valued products, such as vegetables, aromatic and medicinal herbs and fruit crops as well[34]. Fruit trees and shrubs contribute to the beautiful landscapes. Fruit trees could showcase the beautiful blooms, attract birds and pollinators[15]. Local government can get benefits from urban agriculture, when fruit trees are used in appropriate landscapes in cities.

The organization can gain an extra income sources by selling the products of fruits to market[15,16]. All of these studies are supporting the integrated implementation for urban landscape and urban agriculture, specifically implementation of productive urban landscape in which this study was conducted in Yogyakarta City.

In many countries, the agricultural landscapes have developed over centuries, being influenced by long-term management of species in the city[1,15,35]. Urban agriculture as a practice that is gaining attention in many cities worldwide. In Tanzania, urbanization of agriculture has resulted in changes of people interest in urban agriculture and in constructing urban green space[36]. Mexico city produces some 20% of its own food from the urban agriculture. This is an important thing in economic terms in which the employment and income is still limited in the country[17]. Trees in cities of Mediteranian need to be recognized and maintained because of the important role for health and quality of life for the urban community[12].

Choosing appropriate plants for urban landscapes is vital to avoid potential financial and environmental losses that may occur if all selection parameters are not taken into account[18]. Soil resources, fertility status, water conservation practices might be specified in agricultural landscape features[9]. Planting and maintenance of plants in the urban landscapes is very expensive. Therefore, having a policy to use appropriate plants that are cheaper to grow and more adaptable to local conditions is vital to significantly decrease the expenses of large-scale practices. In Turkey, unplanned urbanization and any other urbanized activities have exhorted pressure on the natural resources. Region with their ecological needs, size/shape and sensibility to environmental factors were in studies[19]. Plants can be a source of human disturbance in urban areas if they are not well selected. More than 1.8 million cedar trees were planted on the periphery of Tokyo, Japan, decades ago and today, during their pollination in spring, they have turned this mega-city into the allergy capital of the world with three million allergic residents in Tokyo[20].

Plant selection on planting fruit trees in settlement and office areas was begun by observing the existing condition, land sustainability, aesthetics and user activities[4,5]. Nevertheless, people perception in Yogyakarta City showed that they feel more comfortable to plant fruit trees planted on the local streets (LS) or the settlement area than planting them on the protocol roads (SAR, SCR), because of fruit trees have high maintenance[26].

Planting space, maintenance, method of planting, insufficient species, vandalism were problems that have become an home work. Plant selection has not executed well, that the greenery plan is a must. Nevertheless, productive values of the urban trees have to be upgraded as well as for the urban greenery. The planting space should be designed to provide larger space for bigger trees and for showing aesthetics. The tree performance generally should be in intensive maintenance. Connected to the edible plants in the roadsides greenery in Yogyakarta City, however, it could be seen that the planting of the edible plants had not been seriously planned and managed.

All of productive values not only directly for human benefits but also for biodiversity, i.e., birds, butterfly, etc. that support the ecosystem quality, even though the values might be improved by people appreciation and by further research. For example, *Hibiscus tilaceus* (#25) is not indicated as providing food. Nevertheless, the root can be natural medicine for fever but not classified as an edible plant. Urban landscape planning is crucial for Yogyakarta City to optimize their functions to benefits for the urban environment. Tree functions can increase the productive values in the development on productive urban landscape.

The road map of this multi year-study concerns to apply the method of plant selection in the development of productive urban landscape for urban greenery of Yogyakarta City. The whole study has been comprehensively carried out in interdisciplinary of physical and social aspects. The whole results will achieve the urban tree planting model and plant selection method of productive urban landscapes. As a result from the first year of the study, this study recommends the local government proceed to conduct a productive urban landscape plan and to stimulate an active movement in the local community to plant more trees, specifically the edible plants, i.e., fruit trees at all types of the roadside greenery. Improving plan concept through development of productive urban landscape should proceed to the study series, i.e., biodiversity, public perception, schematic planting design and aesthetics.

CONCLUSION

This study revealed that tree species characteristics of roadside greenery of Yogyakarta City indicated less productive values for urban environment. The diversity and evenness indices of the greenery trees showed medium score that should be improved by more planted species evenly on all types of road. Productive urban landscape plan is a must conducted by concerning trees count, more species, planting edible trees and maintenance guidance fon roadside greenery of Yogyakarta City.

SIGNIFICANCE STATEMENT

This study discovered the problems of urban trees in roadside greenery of Yogyakarta City regarding to increasing productive values. It was a beneficial input to the productive urban landscape plan. This study will help the researchers to uncover the critical areas of initiating execution of productive urban landscape plant through fundamental and integrated aspects of urban trees that many researchers were not able to explore. Thus a new theory on integrating productive values of urban trees to implement urban greenery plan may be arrived at.

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