Study on roadside greenery in Yogyakarta City towards development of productive urban landscape

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Abstract. Yogyakarta City has carried programs in developing green urban open spaces however those are still needed to be improved continuously. This paper aims to identify the type of trees in three roadside types. Field observations have been carried out in three types of road, i.e. secondary arterial road, secondary collector road, and local street. This paper also shows the identification of problems in developing a productive landscape of roadside greenery. Survey results were analyzed by descriptive statistics. 26 road samples were identified in relation to the tree species based on three road types. The survey results showed that secondary arterial roads consisted of 28.76% angsana trees (Pterocarpus indicus) and 17.20% tanjung trees (Mimusops elengi). Secondary collector roads were dominated by tanjung trees (58.31%), and local streets consisted of 23.44% tanjung trees and 18.86% glogogan trees (Polyalthia longifolia). The survey also recognized that edible plants at roadside greenery were only 14.7%. Some problems were related to the trees such as inappropriate trees, less roadside space, less planting media, and less maintenance. 160 urban community also were interviewed. The interview results showed a lot of people disagreed to plant fruit trees at roadside greenery because of the unsafe feeling of fruit falling for walking at pedestrian under the trees and problems of intensive maintenance.

Keywords: Productive urban landscape, roadside greenery, road type, urban tree, Yogyakarta City

1. Introduction

Improving the quality of urban greenery should be conducted continuously regarding the degradation of urban environment quality. Climate change has turned on the atmosphere in the condition of warmer and uncomfort. Urban trees in the urban landscape have a role in the amelioration of the urban environment, providing shading, controller of relative humidity, and any other functions. Urban trees have been in the design of roadside greenery that should be improved in conceptual greening. The productive urban landscape has taken for granted in improving functions of roadside greenery.

The function of plants, especially trees, in the urban landscape has a positive impact on increasing the quality of urban environment. Landscape planning is required to afford a high-quality residential environment and achieve esthetical, social, economic and ecological benefits (Shin et al., 2001;
Blaschke, 2006). With greening, environmental problems such as clean air problems, and air pollution can be minimized. Through urban landscape, we can understand natural-anthropogenic, ecosystem simultaneously as an environment for life and recreation as well as areas of economic activities of urban population (Matovnikov and Matovnikova, 2016).

Greening urban landscape can be conducted by planting trees in many areas such as social spaces, green open spaces, green corridor, settlements, and parks. In urban landscape, plants especially trees have functioned as visual control reducing the effects of sunlight reflection on water bodies, climate control contributing a cooler and comfortable local environment, erosion control, animal habitat, as well as aesthetics (Carpenter, 1990). The function of plants in urban landscape has also potential as food provisioning in community. Development of productive urban landscape as urban greenery has initialized in Europe in 2005 (Viljoen, et al, 2005). Recent research has demonstrated the social role of public green space for citizens stress release (Van den Berg et al., 2010); restorative and preventative functions in healthy (Velarde et al., 2007; Hartig, 2008; Ward Thompson, 2010); decreasing health inequality (Mitchell and Popham, 2008), new lifestyle (Ward Thompson, 2002); people’s life satisfaction (Sugiyama et al., 2009); human needs and sustainability of society (Chiesura, 2004), enhancing social contact and sense of community (Kuo et al., 1998b; Maas et al., 2006, 2009).

Yogyakarta City as a case of productive landscapes study was selected by considerations of the comfortable place as tourism and educational activities. The city has high population density and limited space for planting urban trees. In addition, Yogyakarta is also a cultural city that has a philosophy of the trees, so that social-cultural aspects should be considerations for the selection of trees. Previous study showed that the tree characteristics of Yogyakarta City have indicated less productive values for urban environment. The diversity indices of urban trees have to be improved to enrich the species (Irwan et al, 2019). The concepts of developing productive urban landscape in Yogyakarta should be formulated more specifics related to specific functions of the city.

2. Methods

The study was carried out with survey activities in Yogyakarta City. Data collection were conducted on April – June 2018 by stratified random sampling survey. The study was started by a grand tour of observation to determine the sample units. The samples were roadside greenery based on the function of the road type based on Yogyakarta Mayor Regulation No. 214/KEP/2013. The regulation contains totally 558 roads in Yogyakarta city, consist of 15 secondary arterial roads (SAR), 36 secondary collector roads (SCR) and 507 local streets (LS). The sample units of data collection were 26 road sections: 2 SAR, 3 SCR and 21 LS (Figure 1).
3. Results and discussion

3.1. Urban trees in three types of roadside greenery

In the previous studies, the urban landscape would have advantages to be developed as a productive urban landscape in urban greenery. Viljoen, et al. (2005) explained that urban open space could be planted and managed in such a way as to be environmentally and economically productive, for example, to provide food from urban agriculture, pollution absorption, the cooling effect of trees or increased biodiversity from wildlife corridors. Productive values of trees show intangibly and tangibly functions for human living. Tangible functions of tree cover fruit, flower, leaf for human needs such as food, herbal medicine, wood. Aesthetics, supplying oxygen, fresh air constitutes intangible functions that could be felt by human. Fruit trees in roadside greenery as the edible trees were the focus of this study. For advanced study it would be a revealing model of the productive urban landscape in Yogyakarta City. The steps of the study were begun in describing existing urban trees at roadside greenery of Yogyakarta city and identification of the problems.

Table 1 shows the number of trees and species in three types of roads/streets. The roads were classified into Secondary Arterial Road (SAR), Secondary Collector Road (SCR), and Local Streets (LS). Table 1 shows urban trees at 26 samples of roadside greenery. The roadside have been observed to recognize road length, roadside trees, and the surrounding area. The trees have been identified by species and count of trees. Regarding the development of productive landscape, edible plants also have been identified from the total trees. Table 1 shows data of road side planted by 2000 trees and 294 edible trees that had been observed in the three types of roadside greenery.
The highest number of trees were on SAR type, namely Kolonel Sugiono road with a total species were 23 and the total trees were 370. The highest number of edible plants were on the LS type. The Sidomukti street (road #22) covered 9 species of 47 edible trees that planted on road length of 539 m. The fruit trees were *Pometia pinnata* (matoa tree), *Tamarindus indicus* (tamarind tree), *Dimocarpus longan* (longan tree), *Averrhoa carambola* (star fruit tree), *Parkia speciosa* (petai tree), *Anacardium occidentale* (jambu mete tree), *Persea americana* (avocado tree), *Artocarpus heterophyllus* (jack fruit tree), *Gnetum gnemon* (melinjo tree), and *Mangifera indica* (mango tree).

The surrounding road areas of SAR and SCR were common as a commercial area such as any kind of shops. Figure 2 shows the situation of three types of roadside greenery. Kolonel Sugiono road (road...
#2, Table 1) is more length than HOS Cokroaminoto road (road #1, Table 1) as SAR. Nevertheless, the Kolonel Sugiono road were planted more trees in higher tree density and also more fruit trees than HOS Cokroaminoto road. The fruit trees on Kol. Sugiono road were tamarind tree, guava tree, mango tree, soursop tree, jack fruit tree, kersen tree, kepel tree, and kedondong tree. The average of trees planting distance was more and less 2 m. The road surrounding areas were commercial area and near to the residential area. The fruit trees have functions of aesthetics, providing food, shading, oxygen supplier, and biodiversity. The fruit trees were more dominant in LS which was covered by mostly residences. In SAR, we could see many tanjung trees (Mimusops elengi) in AM Sengaji road (road #4, Table 1) and tabebuia tree (Tabebuia aurea) on P. Mangkubumi road (road #5, Fig.1&Table 1). The roads were relatively near to the icon of Yogyakarta City of Malioboro area and the trees had more aesthetical functions. Table 2 explains the diversity of the most 20 species on the three types of roadside greenery.

![HOS Cokroaminoto Road (SAR)](image1)
![Patangpuluhan Street (LS)](image2)
![P. Mangkubumi Road (SCR)](image3)

**Figure 2.** SAR, SCR, and LS roadside greenery condition

Five streets of LS were not planted by trees, because the streets had limited planting space and less planting media. Those were Gedongkiwo St, Cokrodipuran St, Rukun Satria St, Noroyono St., and Mayang St. (Table 1). There were also one street, Serma Romli/Ungaran St, was unplanted by edible plant. The number of roadside trees consisted of 2000 urban trees and 73 species. Those trees were 34 species of fruit trees.

The highest percentage trees of roadside greenery on the secondary arterial road (SAR) were *Pterocarpus indicus* (angsana tree, as the local name), 28.76%, *Mimusops elengi* (tanjung tree) 17% and *Polyalthia longifolia* (glodogan tree) 8.06%. Tanjung trees were also dominant 58.31% planted in secondary collector road (SCR) and 23.44% on the local street (LS). Many trees of Glodogan trees (*Polyalthia longifolia*) were also 8.06% on SAR, 4.40% on SCR and 18.86% on LS (Figure 3). Table 2
shows 20 species of trees were dominantly planted on roadside greenery in Yogyakarta City which covered more than 80% of the total trees.

Table 2. Tree percentage on three road side types

| No | Local name     | Botanical name          | %  | Local name     | Botanical name          | %  | Local name     | Botanical name          | %  |
|----|----------------|-------------------------|----|----------------|-------------------------|----|----------------|-------------------------|----|
| 1  | Angsana        | Pterocarpus indicus     | 28.76 | Tanjung       | Mimusops elengi        | 58.31 | Tanjung       | Mimusops elengi        | 23.44 |
| 2  | Tanjung        | Mimusops elengi         | 17.20 | Tabebuya      | Polyalthia aurea       | 14.19 | Glodokan      | Polyalthia longifolia  | 18.86 |
| 3  | Glodokan       | Polyalthia longifolia   | 8.06 | Glodokan      | Angsana                 | 4.40 | Asam Jawa     | Pterocarpus indicus     | 6.52  |
| 4  | Asam Jawa      | Tamarindus indicus      | 7.53 | Palem Kuning  | Chrysalidocarpus lutescens | 3.85 | Palem Kuning  | Chrysalidocarpus lutescens | 5.27  |
| 5  | Palem Perti    | Veitschia merillii      | 6.45 | Beringin      | Ficus benjamina        | 1.98 | Melinjo       | Lagerstroemia speciosa | 4.85  |
| 6  | Waru           | Hibiscus tiliaceus      | 6.18 | Krei Payung   | Filicium decipiens     | 1.76 | Palem Ekor    | Mangifera indica       | 4.02  |
| 7  | Beringin       | Ficus benjamina         | 4.84 | Palem Perti   | Veitschia merillii     | 1.65 | Bungur        | Lagerstroemia speciosa | 2.91  |
| 8  | Palem Ekor     | Woodyetia bifurcata     | 3.76 | Palem Ekor    | Woodyetia bifurcata    | 1.65 | Mangga        | Mangifera indica       | 2.77  |
| 9  | Ketapang       | Terminalia catappa      | 3.49 | Angsana       | Pterocarpus indicus     | 1.65 | Pucuk merah   | Syzigium oleana        | 2.77  |
| 10 | Palem Kuning   | Chrysalidocarpus lutescens | 2.96 | Sawo Kecik    | Manikara kauhi         | 1.32 | Beringin      | Ficus benjamina         | 2.50  |
| 11 | Nangka         | Artocarpus heterophyllus | 2.15 | Waru          | Hibiscus tiliaceus      | 0.99 | Biola cantik  | Ficus lyrata           | 2.36  |
| 12 | Kamboja        | Plumeria sp.            | 1.61 | Ketapang      | Terminalia catappa     | 0.99 | Kersen        | Muntingia calabura     | 2.22  |
| 13 | Jambu Biji     | Psidium guajava         | 1.08 | Bungur        | Lagerstroemia speciosa | 0.99 | Ketapang      | Terminalia catappa     | 1.80  |
| 14 | Kersen         | Muntingia calabura      | 1.08 | Asam Jawa     | Tamarindus indicus      | 0.88 | Alpukat       | Persea americana       | 1.53  |
| 15 | Jeruk Kingkit  | Triphasias trifolia     | 0.81 | Kersen        | Muntingia calabura     | 0.77 | Pinang        | Areca catechu          | 1.39  |
| 16 | Manga          | Mangifera indica        | 0.81 | Asam Kranji   | Pitelelobium dulce     | 0.44 | Asam Jawa     | Tamarindus indicus      | 1.25  |
| 17 | Cemara Bundel  | Cupressus paphuanus     | 0.54 | Srikaya       | Anmona Squamosa         | 0.33 | Belimbing     | Averhoa carambola      | 0.97  |
| 18 | Cemara Kipas   | Thuja orientalis        | 0.54 | Mahoni        | Swietinia macrophylla  | 0.33 | Jambu air     | Syzigium aqueum        | 0.83  |
| 19 | Fachira        | Pachira sp.             | 0.54 | Kelapa        | Cocos nucifera          | 0.33 | Jambu Biji    | Psidium guajava        | 0.83  |
| 20 | Pucuk merah    | Syzigium oleana        | 0.54 | Keben         | Barringtonia asiatica  | 0.33 | Kelengkeng    | Dimocarpus longan      | 0.83  |

| Other Trees | 1.08 | Other Trees | 2.86 | Other Trees | 12.07 |

Among the dominant 20 species, the edible plants were only five species. Those edible plants were Tamarindus indicus (tamarind tree), Artocarpus heterophyllus (jackfruit tree), Muntingia calabura (kersen tree), Tiphasias trifolia (Lime Berry tree), and Mangifera indica (mango tree).
Figure 4 shows the distribution of edible trees in three types of road, 34 species of edible trees are planted on SAR, SCR, and LS. Only 14.6% edible trees were covered among 2000 trees on the roads. Most edible trees were on LS located in a residential area. These cases showed residential community preferred fruit trees for greening. It may be concerning of community-related to providing food and near distance to do daily maintenance. On local streets, there were many trees of melinjo trees (*Gnetum gnemon*), mango trees (*Mangifera indica*), kersen tree (*Muntingia calabura*).

In term of edible trees on secondary collector roads (SCR) has been planted by sawo kecik tree (*Manilkara kauki*), tamarind tree (*Tamarindus indicus*) and kersen tree (*Muntingia calabura*). While on the secondary arterial road, the highest number of trees were tamarind tree (*Tamarindus indicus*), jackfruit (*Artocarpus heterophyllus*) and guava trees (*Psidium guajava*), Figure 4. Fruit trees were preferred as greenery tree that prospected to gain more benefits for the city and people. The trees were categorized as the productive trees, not only providing food but also having other productive functions such as climate amelioration, pollution control, and biodiversity.

The tamarind trees are the big tree prospected in plant selection of urban greenery, Figure 5. The functions of tamarind trees cover not only small fruit of tamarind tasted sourly for candy, food, and drink, but also as the habitat of birds. The tree is a high tree and provides shading for cooling effects. In Yogyakarta City, tamarind tree has a philosophy as the urban trees. Figure 4 shows melinjo tree (*Gnetum gnemon*), mango trees (*Mangifera indica*) and kersen tree (*Muntingia calabura*) as medium trees scattered at residential areas in Yogyakarta City. The trees were planted by local government and by the urban community in local streets. *Manilkara kauki* or sawo kecik tree were also a fruit tree but the fruit is not familiar to be consumed. Sawo kecik is also famous as the philosophical trees of Yogyakarta City.

We found that fruits trees were planted in limited number in all roadside types. In the future, efforts for providing food in the urban area should be considered in urban greening. On the other hand fruit fall from the trees, bird dropping from the trees will be potential problems for unsafety and uncomfortable pedestrian activity. Maintenance program and management of trees is the important thing in developing a productive urban landscape. Limited space utilization in the city was also a concern in design. Because of the reasons, the model of the productive urban landscape in detail design should be a must thing to do.
Figure 4. Edible Trees on three types of roadside greenery
3.2 Community preferences

Interview to 160 urban community data seems in Figure 6. As an environmental function, 26% community stated disagree and very disagree that productive trees having an environmental function. Based on the complementary interview we knew that productive trees were recognized planted in the home garden or “pekarangan”, not planted in roadside greenery. They thought the fruit trees will be unsafety for activities of walking on the street and difficult to be maintained because fruit trees need more soil nutrition and more space for planting. They thought fruit trees will disturb the mobility of people moving activities because of fruit fall or fruit borer organism. The urban greening area should be prepared by more maintenance programs, regarding the development of the productive urban landscape. Despite the reasons, the community agrees (61%) productive tree in development productive urban landscape have an economical function (Figure 6, right).

Figure 5. Edible trees in roadside greenery

Figure 6. Community response on environmental function (left) and economical benefit (right) of productive trees in roadside greenery
Other responses of urban community, Figure 7 shows the community perception of roadside greenery in Yogyakarta through the development of the productive urban landscape. Based on the diagram, it can be seen that 76% community has the responses that roadside greenery will create a pleasant space and will add the beauty of the city. As many as 70% of community state, roadside greenery will improve their mood. The lowest percentage of 62% community show that roadside greenery provides good visual contrast. The four responses data of urban community explained the enthusiasm of greenery functions in improving better quality of living.

4. Conclusion

This study found that three types of roadside greenery were planted trees in consideration with aesthetics aspects which dominated by tanjung tree (*Mimusops elengi*). The other productive aspects of trees have not yet seen in existing trees. It found that fruit trees were still planted in limited count on all of the roadside types. This study also found that there were several some trees have philosophical and historical values i.e., sawo kecik (*Manilkara kauki*), tanjung (*Mimusops elengi*), beringin (*Ficus benjamina*) and kepel trees (*Stelechocarpus burahol*).

This study identified that there was still an urban community have not yet agreed about fruit trees for urban greenery. The urban community has opinion that planting fruit trees on roadside areas caused unsafe and uncomfortable for activities under the trees. People thought that planting fruits trees on roadside areas have difficulties related to the limitation of space and intensive maintenance. On the other side urban community have a positive response that the development of roadside greenery could improve the beauty of the city, creating pleasant places, providing good visual contrast and improving people mood.

Recommendations of this study for developing productive urban landscape in roadside greenery Yogyakarta City are as follows

1. Socialization programs of the productive urban landscape to the urban community. The benefit of the productive urban landscape for people and urban ecosystem should introduce to the urban community,
2. Characteristics of tree types in relation to roadside space or area conditions should be the main consideration of the design of the roadside greenery. Cultural and historical aspects of trees and location of tree planting on the roadside area also present very important aspects in designing roadside greenery especially for Yogyakarta as a cultural city.
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