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Identification of Suitable Trees for Urban Parks and Roadsides in Iskandar Malaysia

Rohayu Abdullah[a,c], Kasturi Devi Kanniah[b,d,*], Chin Siong Ho[a,c]

[a]Department of Urban and Regional Planning, Faculty of Built Environment, Universiti Teknologi Malaysia, 81310 Skudai, Johor Darul Takzim, Malaysia
[b]Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia, 81310 Skudai, Johor Darul Takzim, Malaysia
[c]UTM-Low Carbon Asia Research Centre (UTM-LCARC), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor
[d]Centre for Environmental Sustainability and Water Security (IPASA), Research Institute for Sustainable Environment (RISE), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor
kasturi@utm.my

Urban trees provide a number of benefits, mainly for environment, community, and economy, but can also be harmful to property and human lives. Urban trees planted at roadsides with low endurance rate and unhealthiness increase the risk of tree fracture and fall which is hazardous to motorists and pedestrians. Overhanging limbs, on the other hand, can obscure streetlights, signs and traffic signals and affect road users' vision in vicinity. These situations contribute to the cumulative maintenance burden to the local authority. This makes the study of maintenance level and suitable location for urban tree planting important. An appropriate maintenance and location can be suggested for assuring a healthy, safe, resilient and long-term survival of urban trees. Urban tree field data from two local authorities in Iskandar Malaysia region (located in the southern part of Peninsular Malaysia), Johor Bahru City Council, and Pasir Gudang Municipal Council, were obtained to achieve the objective of this study. Survey based on questionnaire was conducted to gain detailed information about the maintenance level of existing trees and their suitable locations in the cities from the professionals including urban planners, landscape architects, and certified arborists. By applying a simple scoring method to the data obtained from professionals, suitable locations for existing trees in the two cities were determined. The scores range between 0 and 300 and the highest value means less maintenance is required by the trees. Results show that Mimosup elengi tree species (Sapotaceae family) has the highest score of 300 followed by Cinnamomum verum (297) and Hopea odorata (283). Khaya senegalensis, on the other hand, with 245 score value was found to require high levels of maintenance. The results also indicate that maintenance level and suitable location for planting vary and depending on the features of the tree species. Strongest trees or limbs tend to cause less problems thus require less maintenance. Trees found in the nature (forest) including Mimosup elengi and Cinnamomum verum are usually more resilient and can tolerate a wide range of conditions and locations. This study can help reducing the risk of tree fracture and fall, prolong the life of trees, and reduce the burden of maintenance for local authorities and decision makers by providing insights to the maintenance level and suitable locations for planting and to make better management plans for urban forestry in Malaysia in the future.

1. Introduction

Urban trees provide a number of benefits, mainly for environment, community and economy, including climate modification (i.e. providing shade, sequestrating carbon dioxide), air quality enhancement, aesthetics, habitat for urban wildlife (Karuppannan et al., 2014) food production, moderate storm water runoff (Saraswat et al., 2016), and others (Kanniah and Ho, 2017). Tree species vary in their abilities to provide these different benefits. Trees can also threaten public safety and affect the road user's visibility. Urban trees planted at roadsides with low endurance rate and unhealthiness can increase the risk of tree fracture and direct falling creating a hazard to motorists and pedestrians as well as causing damage to property (ISA, 2011). Although

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there are no reports of accidents involving the damage of tree structures in Iskandar Malaysia, it does happen in other cities like Kuala Lumpur. Overhanging limbs can obscure streetlights, signs, and traffic signals and affect the appearance of vicinity. Other pressing problems include shorter-survival, cumulative maintenance burden as well as production of secondary air pollutants (Churkina et al., 2015). Any official documents or guidelines informing about tree maintenance is still unavailable in Malaysia. Selection of site or location to plant trees also should be appropriate according to tree species (City of London Urban Forestry Strategy, 2014). This helps to assure trees become healthy, resilient, and can survive for long-term, thereby reducing maintenance burden. The study of maintenance level and suitable location for urban trees planting is therefore important to suggest appropriate maintenance and location to assure a healthy, safe, resilient, and long-term surviving urban trees. The objective of this study is to investigate the maintenance level and suitable locations of various roadside tree species in one of the fast-developing economic region in Malaysia.

2. Study area

The study area comprises of two districts, which are Johor Bahru and Pasir Gudang (Figure 1). Both districts are located in Iskandar Malaysia (IM), the main southern development corridor in Johor, Malaysia. Johor Bahru is administrated by Johor Bahru City Council (MBJB), which covers 18,217 ha. Johor Bahru includes 3 sub-districts which are Johor Bahru City Centre, Plentong and Tebrau (Ho et al., 2015a). Being conferred City Status in 1994, Johor Bahru (JB) has developed rapidly since then. It is now the centre of Malaysia's second largest conurbation, with a population of over 1 million. Johor Bahru has high residential, commercial, and leisure values to locals and non-locals. Pasir Gudang is administrated by Pasir Gudang Municipal Council (MPPG), and it covers 33,937 ha. MPPG consists of 2 sub districts; Sungai Tiram and part of Plentong (Ho et al., 2015b). The population of Pasir Gudang is 152,564 (2005 census). Industrial area is one of the main land use in Pasir Gudang and it comprises of 2 main ports; Johor port (which currently has more than 300 manufacturing companies with the largest edible oil tankage facility) and Tanjung Langsat Port (handles bulk cargo such as liquefied petroleum gas (LPG) and dangerous chemical). At the same time, Johor Bahru has more open space and recreational areas compared to Pasir Gudang. Both MBJB and MPPG have a tropical climate with warm weather all year round and consistent rainfall, more towards the year-end. It has temperature ranging from 21 °C to 32 °C while annual rainfall varies from 2,000 mm to 2,500 mm. The main land use in MBJB and MPPG includes residential, commercial, industry, forests, mangrove and agriculture (oil palm and rubber).

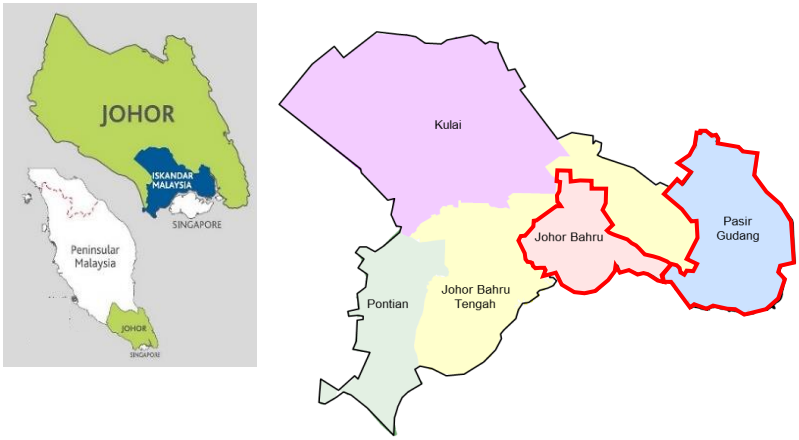

Figure 1: Location of Johor Bahru and Pasir Gudang within Iskandar Malaysia region

3. Methods

3.1 Data collection

In order to collect data and gain detailed information on maintenance level and suitable location for urban tree planting, a questionnaire survey was conducted. A total of 18 respondents or experts including arborist, landscape architects, landscape lecturers, landscape organiser/plant nursery, and technical landscape assistant from various local authorities, agencies and universities participated in this questionnaire survey.

The questionnaire was designed for respondents to give appropriate scale for maintenance levels for each type of tree currently found in the cities. Scale of 0, 1, 2, 3, 4 and 5 were used for the following levels of maintenance: never, very rarely (once a year), rarely (2 - 3 times a year), occasionally (once a month), frequently (2 - 3 times a month) and very frequently (2 - 3 times a week). According to the Tree Maintenance Guidelines by the Department of Recreation and Parks, City of Los Angeles (2003), maintenance works are categorised into 2 types; regular work and tree emergencies. Regular work is for all tree maintenance that does not fall under the tree emergencies category, not posing an immediate hazard to human life or property and performed consistently. Tree emergencies are by demand only (if an emergency occurs) at all times. Regular work consists of (i) pruning or removal of leaves or dead parts of plants especially branches, (ii) fertilising and mycorrhizae treatments, (iii) watering practices and (iv) insect and disease control. Tree emergencies consist of (i) trees or limbs that have fallen and caused accidents or personal injury, (ii) trees or limbs that have fallen and caused damage to vehicles or structures, (iii) trees or limbs which are in immediate danger of falling or breaking, (iv) broken hanging limbs adjacent to structures, roads, or in picnic or play areas, (v) trees or limbs that are blocking streets or roads, and lastly (vi) sudden dead or severely declining trees.

3.2 Data analysis

A simple scoring method known as “weighting and scoring” that is based on a multi criterion analysis was used in this study to investigate the maintenance level of each tree species. A scale ranging from 1 to 5 was given by respondents or experts in terms of frequency of maintenance work involved and the frequency of tree emergencies for each tree species. Four types of maintenance works were taken into account, namely pruning (removal of leaves or dead parts of plants especially branches), fertilising and Mycorrhizae treatments, watering practices, and insects and disease control (City of Los Angeles, 2003). Six intended tree emergencies are trees or limbs that have fallen and caused accidents or personal injury, trees or limbs that have fallen and caused damage to vehicles or structures, trees or limbs which are in immediate danger of falling or breaking, broken hanging limbs adjacent to structures, roads, or in picnic or play areas, trees or limbs blocking streets or sudden roads, and dead or severely declining trees (City of Los Angeles, 2003). A scale ranging from 0 to 5 regarded as “never”, “very rarely (once a year)”, “rarely (2 - 3 times a year)”, “occasionally (once a month)”, “frequently (2 - 3 times a month)” and “very frequently (2 - 3 times a week)” was used. The scale for each tree species was allocated score accordingly, such as 5, 4, 3, 2, 1 and 0, then adjusted by knowledge level of respondent (9, 6 and 3 were used for good, fair and poor) before summing up and averaging the resulting set of scores.

4. Results

4.1 Respondents profile

A total of 18 respondents were participated in the questionnaire survey and majority of them are from local authority with 56 % followed by university with 44 % (Figure 2). Local authorities that participated in the survey include MBJB, MPPG, Pontian Local Council (MDP), and Kuala Lumpur City Hall (DBKL). Universities included Universiti Teknologi Malaysia (UTM), Universiti Putra Malaysia (UPM), and Universiti Teknologi Mara (UiTM) Shah Alam. Most of the respondents or experts have experience working as landscape architects (29 %) and landscape lecturers (29 %), followed by landscape technical assistant, arborist, and landscape or nursery organisers (Figure 2). Landscape architects are from local authorities and work at both large and small-scale developments with trees as common element in their designs apart from other plants like shrubs and grass. Landscape architects not only create plan or design but are also involved in the implementation including tree planting (Conway and Vander Vecht, 2015). Technical assistants (TA) have the same scope of work as landscape architect, but they are more technically skilled and are involved in assessment, design and supervision of works related to landscape. Landscape lecturers work in collaboration with other staff such as research assistant, contributing to the teaching and research in the discipline of landscape architecture. Some of them are also certified arborist. Arborist is a professional who specialises in the care of individual trees. They are knowledgeable about the needs of trees and are trained and equipped to provide proper care including pruning, tree removal, emergency tree care, planting and other services (ISA, 2011). Landscape organisers or plant nursery organisers participated in the survey included those who plant, prune, control weeds, fertilise and control pests as well as harvest trees. Most of them work in the landscape field particularly in maintenance for more than 10 y.

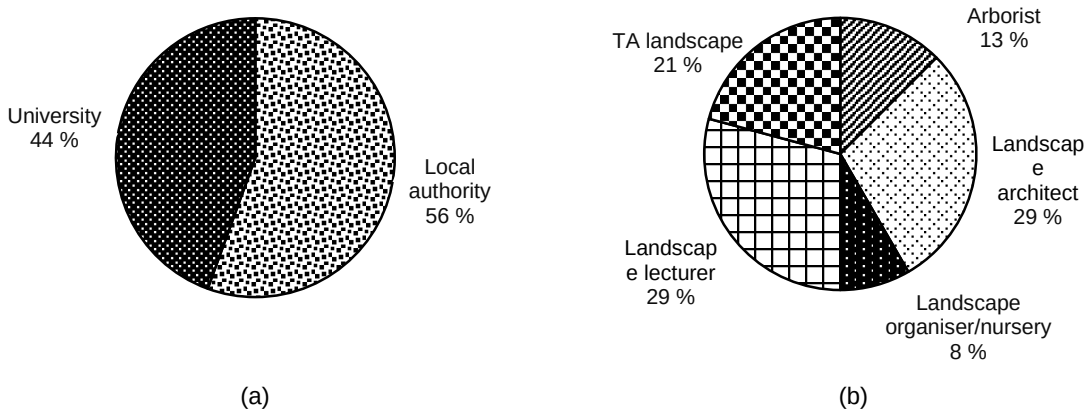

Figure 2: Respondent's profiles with (a) place of work and (b) respondent's position

4.2 Tree maintenance

The results demonstrate that urban trees such as *Mimosup elengi* from the family of Sapotaceae obtained the highest score of 300 (Table 1). High score indicates less maintenance is required by the tree species, thus *Mimosup elengi* is considered as urban tree species requiring least maintenance followed by *Cinnamomum verum* (297) and *Hopea odorata* (283). *Saraca thaipingensis*, *Khaya grandifolia* and *Fagraea fragrans* recorded the same total score of 262. *Alstonia angustifolia, Sweitenia macrophylla* and *Khaya senegalensis* scored low values, indicating their requirement for high maintenance.

Table 1: Total score of maintenance for every trees species

No.	Family	Specific name	Local name	Total score
1.	*Sapotaceae*	*Mimosup elengi*	*Bunga tanjung*	300
2.	*Lauraceae*	*Cinnamomum verum*	*Kayu manis*	297
3.	*Dipterocarpaceae*	*Hopea odorata*	*Merawan siput jantan*	283
4.	*Myrtaceae*	*Melaleuca cajaputi*	*Gelam*	277
5.	*Fabaceae*	*Dalbergia oliverii*	*Tamalan*	273
6.	*Fabaceae*	*Spondias pinnata*	*Mempari*	269
7.	*Fabaceae*	*Cassia fistula*	*Rajah kayu*	268
8.	*Fabaceae*	*Delonix regia*	*Semarak api*	265
9.	*Fabaceae*	*Saraca thaipingensis*	*Yellow saraca*	262
10.	*Meliaceae*	*Khaya grandifolia*	*African mahogany*	262
11.	*Gentianaceae*	*Fagraea fragrans*	*Tembusu*	262
12.	*Myrtaceae*	*Syzgium polyanthum*	*Salam*	259
13.	*Apocynaceae*	*Dyera costulata*	*Jelutong*	257
14.	*Annonaceae*	*Polyalthia longifolia*	*Asoka*	256
15.	*Fabaceae*	*Acacia auriculiformis*	*Aksia*	253
16.	*Fabaceae*	*Peltrophorum pterocorpum*	*Yellow flame*	252
17	*Fabaceae*	*Samanea saman*	*Hujan-hujan*	251
18.	*Apocynaceae*	*Alstonia angustifolia*	*Pulai*	249
19.	*Meliaceae*	*Sweitenia macrophylla*	*Mahogany*	247
20.	*Meliaceae*	*Khaya senegalensis*	*Khaya*	245

4.2 Suitable location for tree planting

Table 2 shows the existing tree species in parks and roadsides in Johor Bahru and Pasir Gudang, their current location, and proposed new location. Proposed locations are obtained from survey conducted in this study. One section in the questionnaire asked the respondent to choose a suitable location for planting each tree species. Analysis of the questionnaire shows that currently only 10 tree species are located at the right or suitable locations. From the ten species 7 trees are correctly located/planted in parks, 1 on roadsides and 2 in both parks and roadsides. The rest of the tree species are found to be located at inappropriate locations and

are suggested to be planted at a new location. The notable reason why the remaining tree species are suggested to be planted at a new location is because of the feature of the trees. *Khaya senegalensis* for instance, a deciduous tree with big leaves, tends to clog the drains and is dangerous to vehicles and other development due to fallen limbs and insufficiency to support its wide spreading crown (Sinar Harian, 2014). Broad tree with large spreading crown and taproot such as *Fagraea fragrans* and *Sweitenia macrophylla* cause problems to roadsides including vehicles, pavement, signage, utility lines, as well as buildings, thus it is suggested to be planted in a park.

Table 2: Comparison between existing location and suitable location for tree planting

No.	Family	Specific name	Local name	Total score
1.	*Sapotaceae*	*Mimosup elengi*	*Bunga tanjung*	300
2.	*Lauraceae*	*Cinnamomum verum*	*Kayu manis*	297
3.	*Dipterocarpaceae*	*Hopea odorata*	*Merawan siput jantan*	283
4.	*Myrtaceae*	*Melaleuca cajaputi*	*Gelam*	277
5.	*Fabaceae*	*Dalbergia oliverii*	*Tamalan*	273
6.	*Fabaceae*	*Spondias pinnata*	*Mempari*	269
7.	*Fabaceae*	*Cassia fistula*	*Rajah kayu*	268
8.	*Fabaceae*	*Delonix regia*	*Semarak api*	265
9.	*Fabaceae*	*Saraca thaipingensis*	*Yellow saraca*	262
10.	*Meliaceae*	*Khaya grandifolia*	*African mahogany*	262
11.	*Gentianaceae*	*Fagraea fragrans*	*Tembusu*	262
12.	*Myrtaceae*	*Syzgium polyanthum*	*Salam*	259
13.	*Apocynaceae*	*Dyera costulata*	*Jelutong*	257
14.	*Annonaceae*	*Polyalthia longifolia*	*Asoka*	256
15.	*Fabaceae*	*Acacia auriculiformis*	*Aksia*	253
16.	*Fabaceae*	*Peltrophorum pterocorpum*	*Yellow flame*	252
17	*Fabaceae*	*Samanea saman*	*Hujan-hujan*	251
18.	*Apocynaceae*	*Alstonia angustifolia*	*Pulai*	249
19.	*Meliaceae*	*Sweitenia macrophylla*	*Mahogany*	247
20.	*Meliaceae*	*Khaya senegalensis*	*Khaya*	245

5. Discussion

The results indicate that maintenance level vary depending on the features of the tree species. Strongest trees or limbs tend to cause less problems thus require less maintenance. Tree species found in the nature (forest) such as *Mimosup elengi, Cinnamomum verum* and *Hopea odorata* are usually more resilient and can tolerate a wide range of conditions including poor soils and climate (World Agroforestry Centre, 2016). They require less regular maintenance including watering and pest control compared to cultivated tree species in order to survive and grow. *Mimosup elengi* is one of the popular wayside trees because of its attractive shape and fragrant flowers. The wood is reputed to be the strongest of Indian timbers and is sometimes called bullet wood. Due to this, tree emergencies like trees or limbs fallen is reduced. *Cinnamomum verum* is also a hardy wayside tree and its timber is usually used for house building and cabinet work. *Hopea odorata* is widely planted along the roadside in Kulaijaya, one of the districts in Iskandar Malaysia, due to its low maintenance burden to the local authority. In contrast, *Khaya senegalensis* requires high maintenance. It is a foreign species to Malaysia, a deciduous tree that sheds leaves, which prevents it from producing functions of shade and evapotranspiration cooling. It also clogs drains and triggers flash flood. *Khaya senegalensis* has beautiful flowers that attract birds which create a nuisance from noise in the evening and their droppings on cars parked below the trees (Chin, 2003). The feature and maintenance of trees affect the location for tree planting. Based on the findings in Table 2, most of the tree species are presently planted at suitable areas. Several tree species are pressed to be planted at different areas, mostly in parks. The feature of tree species such as deciduous, large spreading crown, broad and big leaves, and shallow surface roots cause problem to roadsides including vehicles, pavement, signage, utilities lines, as well as building. Planting trees in parks can reduce this problem due to sufficient space. Trees planted in parks require less maintenance and have more space. Some landscape architects declared most of the fallen trees at roadsides in Johor Bahru are caused by narrow space planting especially median strip. They also commented that town planners who are responsible to plan and provide space for development including roads often overlooked this space problem.

6. Conclusions

This study was conducted to list the types of urban tree species that are suitable for urban parks and roadsides based on their maintenance in Iskandar Malaysia. This study can also help to reduce the risk of tree fracture and fallings thus, reducing the maintenance burden for local authorities. In this way, it can also prolong the lifetime of trees which will enable us to get the maximum benefits from the trees. For urban planners and decision makers, this study can assist them by providing insights of maintenance level and suitable location for tree planting. They can understand the actual and potential role of urban trees and make better management plans for urban forestry in Malaysia in future. Nevertheless, it should be noted that this conclusion was based on the analysis of limited number of tree species and the respondents or samples) used in this study from only two local authorities in Iskandar Malaysia. Future studies should explore more factors such as the carbon storage potential, cooling effects and pollutant removal capacity of urban trees that can contribute to tree selection for parks and roadsides in Malaysia.

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