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Green Infrastructure and its Roles in Enhancing Quality of Life

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Abstract

This study undertaken to evaluate the respondents' level of awareness towards green infrastructure (GI) component in Labuan housing area with objectives; (i) to analyze the existence of GI attributes in the study area and (ii) to examine the public perspectives on these attributes. The questionnaire was distributed to the 386 respondents in housing area (1800 meter radius from the Botanical Garden). The findings implicate that Labuan Botanical Garden which the most prominent GI in the vicinity, not only contributes to the enhancement of visual quality to the housing area but also provides recreational and social interaction to the house residents.

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Keywords : Green Infrastructure; environmental attributes; visual quality attributes; Botanical Garden

1. Introduction

According to Mell (2008), GI is a vital indicator for environmental consideration that existed since 19th Century in United States. GI serves 4 major benefits to the community in term of social, health, environment and economic (Benedict and McMahon 2002; Mansor et al., 2010). All the benefits are mitigating the potential impacts of existing and future development and growth as well as to offer valuables services to the surrounding community. Recently, most of the developments projects have

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promote the trend of eco-friendly lifestyle to preserve their environment. It comprises varieties of goods and services, which engaged the surrounding area with minimum or no harm to the environment (Morgan, 2009). In the other words, eco-friendly are activities that provide a positive impact to our environment and future generation. Nowadays, people are engaged with this eco-friendly term because they are very concerned about their health from time to time (Defra, 2011). This has been proven by Islam (2008), where public are more aware about their environment as they always find out the best way to improve the condition of their environment. In relation to that concept, GI acts as one of the eco-friendly function towards sustainable development. Identically, Benedict and McMahon (2002) stressed that GI networks consist of hubs and links. Hubs in this study refer to the main place for the human and ecosystem. While, link refers to the connection from one hub to another. The hub and the link have their own functions based on the needs, place and situation. The hubs in this study will be the housing area and Botanical Garden. All GI elements are the link to the hubs.

In the housing sector, GI becomes an attraction for the house buyers to buy or invest in the housing property because nowadays public are aware of their environment on deciding to buy a new house. As a proof, Jim (2004) explained that GI or green spaces contributes to the sustainability of the cities that preferred by the community. At the same time, green space has presented the characteristics of public local goods and also generates externalities on economic analysis point of view (Chourmet et al., 2008). The aim of this paper is to find out the awareness of public towards their GI elements in their surrounding environment. Based on the aim, two main objectives have been determined for this study; to analyze the existence of GI in the study area and to examine the public perspectives on GI attributes.

2. Green infrastructure in Malaysia

Kuala Lumpur has enhances the GI components in its planning and enforcement to maintain the environment, as well as visual quality of the city. In order to possess the world-class living environment, the metropolitan city of Kuala Lumpur offers an adequate quality of housing with first class accessibility and facilities surrounded by healthy and safe environment (CHKL, 2003; Ghani and Izwar, 2009). Since 1984, The Kuala Lumpur Structure Plan formulated general policies related to landscape, townscape and conservation, which were generally appropriate (CHKL, 2003) for future development. Kuala Lumpur is aiming towards being a sustainable city, which creates a balance between physical, economic, social and environmental development. On top of that, Putrajaya, which is another new city in Malaysia that is also known as a new township in Malaysia, has emphasized on the green city concept in their previous, current and future legislation and policies. Generally, the housing area in Putrajaya provides pocket parks for visual and environmental purposes. Besides, buffer zone like shrubs can be found in most of the housing area in Putrajaya to enhance neighborhood concept. To make it livable, the housing area offers an adequate open space, well-planned, well-maintained, well-serviced and well-connected facilities (Qureshi and Ho, 2011). It creates nice view and at the same time preserving the environment. Indirectly, it might seek to strike a balance between the well-planned city and community lifestyle.

3. The main green infrastructure element in this study (Botanical Garden)

A Botanical Garden serves general functions such as a recreational area for the community, research center and plant arboretums for the researchers. The main function is providing a variety of information, which concern on the form, habitat, quality of life and general biological as well as, ecological relationship of the vegetation in the area. Plants and man has a special relation and prominent by concentration to the horticultural and economic growth of the subject (Macdougal, 1990). A Botanical Garden should be located within the reasonable walking distance, easy and safe accessible. It might be a

focal point for the residents in the dwelling area. Hence, Botanical Garden should be pleasing with the natural landscape and ecology. It is to create a balance on the nature with a variety of human activities. Besides that, a Botanical Garden should be attractive resources to attract the community and establish a network of natural areas (Kithiia and Lyth, 2011). At the same time, a garden may become one of attraction for tourist, visitor or investor to work and live in the area (Shukur et al., 2010). It happens because the spill over of this Botanical Garden offers welcoming externalities for the surrounding residents (Jim and Wendy, 2010). By right, the residents can enjoy and appreciate the scenery view and desirable living environment surrounding their housing area.

In Malaysia, there are many Botanical Garden located in Kuala Lumpur, Labuan, Melaka, Putrajaya, Penang and Kepong. All these Botanical Garden serve almost the same benefits towards community. It is part of green lung of the city with variety collection of plants from various countries. The garden not only serves a botanic collection, but it also gives a visitor to feel fresh ambience in the green area despite being anxious in the metropolitan city. In example, Kepong Botanical Gardens is developed to become one of the centers for Malaysian plant collections. This garden has created variety research opportunities in horticulture, landscape and other related fields. All the plants from various sources were collected and planted in the garden for display purposes and ex-situ conservation. Besides, Penang Botanical Garden was one of the main tourist spot in Penang because it is existed since 1884. The main attraction at the Penang Botanical garden is monkeys. Besides, visitors might enjoyed the beautiful scenery of the garden and learn about unique trees collected and planted there. Melaka Botanical Garden also one of the tourist destination that promising peace from the busy city. It is calming and peaceful located near the town of Melaka. The garden serves a variety of activities for recreational and exercise purposes surrounded by almost 300 species of flora and fauna. It has become one of the unique gardens in Malaysia because it has the element of a show garden with the tropical rainforest and the serenity of getaway place.

4. Case study of Labuan

The study was conducted in Labuan, Malaysia as it is the only offshore financial centre in Malaysia and one out of three federal territories besides Putrajaya and Kuala Lumpur. Labuan is located at the east of Malaysia. Total area of Labuan is 75 square feet and facing the South China Sea. In year 2010, total population of Labuan is 86,908 people (Department of Statistic, 2011). Labuan is offering business services, international financial activities, deep-water oil and gas activities. 65.68 percent of Labuan area covered by vegetation with a total area of 6, 245.94 hectares (Labuan Local Plan, 2013) and indirectly, it is considered as GI component. Despite numerous studies were done in Labuan Island, many of these studies were related to tourism, social and political economic but none were done on the GI components especially in relation to the Botanical Garden.

In this study, Labuan Botanical Garden has been chosen as the main GI component as it is located near the housing area. Actually, Labuan has a variety of GI component such as a playing field, golf course, Labuan Square, Sea Sport Complex and other recreational places for futsal, pocket bike and skateboard activities. However, the Botanical Garden has been chosen as the main GI element because it is the nearest GI component that located near to the housing area and it has attracted the community from different age, gender and race. It serves a recreational area, plant arboretum area and research center. Most of the people in the community use the facilities provided frequently. A study done by Ballantyne et al., (2008), suggested that if the Botanical Garden can offers an educational programme which emphasize on the environmental consideration. At the same time, it might attract the visitors to learn and experience the conservation learning.

The Labuan Botanical Garden was developed in 1852 with total area of 50 acres. It is one of a recreational park consists of varieties of trees and beautiful scenery in Labuan. The park possesses amazing landscape and beautiful old trees. It offers huge perimeter houses, a hibiscus garden of different species, herbal garden with a variety of herbs and spices, a reading corner, a man made lake with an arched bridge, a reflexology pathway, a tai-chi ground and other community activities. It provides a pedestrian walkways, bike path and road for easy access. This park becomes one of tourist attraction in Labuan.

Figures below show the view of the Labuan Botanical Garden. Figure 1(a) shows the main entrance of Labuan Botanical Garden. The garden provides a beautiful landscape with a variety of trees planted outside the entrance gate such as bougainvillea, hibiscus, lilies, and roses. It gives welcoming sign to the visitors to visit the garden. The car park was provided outside the entrance gate. It can cater almost 70 cars at one time. Besides, a small kiosk has situated near the car park and it serves drinks and snacks for the visitors. Figure 1(b) shows the right wing of the Labuan Botanical Garden where the 'tree house' is located. The tree house becomes one of the unique features at the garden that attract tourist from local and outsiders. Visitor might observe the surrounding garden from the tree house. Besides, at the area also has been provided with pergola and benches for recreational purposes. Figure 1(c) shows the left wing of the Labuan Botanical Garden. At this wing, visitors can feel the ambience of fresh and beautiful flora and fauna while jogging and cycling. This area serves with well-maintained jogging track. Figure 1(d) is the ponds area. The ponds have connected by a bridge. It serves fishing and water activity. Variety of tropical trees was planted surrounding the ponds and it created calm and peace ambience. Figure 1(e) is a playground area. The playground provides slides, seesaw, swing and gazebo. Figure 1(f) shows the jogging and bicycle path. The path as well surrounded by a variety of trees and covered by lighting. Many users were used these facilities for jogging, walking and cycling with their friend and family. This area is consisting a variety of plants and ornamental trees and it creates colorful scenery during daytime. It has been one of the attraction spot of the visitor to see and feel the nice view at the area with the colorful and fragrant botanic plant. During the weekend, the total visitor was increased compared to weekdays.

Fig. 1. (a) Main entrance of Labuan Botanical Garden

Fig. 1. (b) The right wing of Labuan Botanical Garden

Fig. 1. (c) Left Wing of Labuan Botanical Garden

Fig. 1. (d) Ponds Area

Fig. 1. (e) Playground area

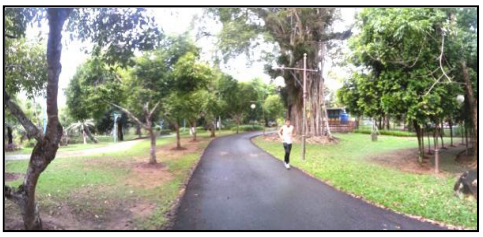

Fig. 1. (f) Jogging and bicycle path

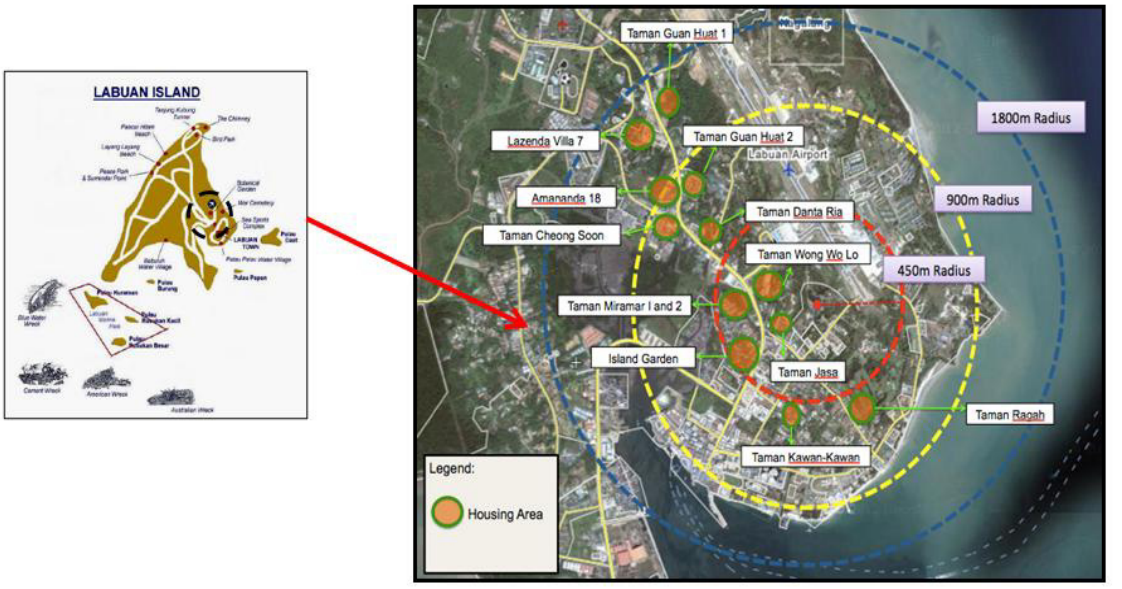

Fig. 2. Location Plan and Radius of Study Area (400m, 900m, 1800m)

The map above (Figure 2) shows the housing area that was involved in this study. It has been highlighted in 1800 meter radius from the Labuan Botanical Garden. The housing areas are Taman Guan Huat 1 (18 units), Lazenda Villa 7 (26 units), Amananda 18 (18 units), Taman Danta Ria (21 units), Taman Cheong Soon (24 units), Taman Wong Wo Lo (39 units), Taman Miramar (60 units), Taman Guan Huat 2 (44 units), Taman Island (42 units), Taman Jasa (24 units), Taman Kawan-Kawan (40 units), Taman Ragah (30 units). Basically, total numbers of the housing units are 386 units. Total area for this study area is 908.02 hectares with population of 1,158 people.

5. Methodology

The first step of this study is to do selection of attributes and variables related to GI. There are many GI attributes from various scholars but, based on the current situation in Labuan area, the researchers have decided to choose only two main attributes due to cost and time constraints. They are the environmental and the visual quality attributes. Secondly, site inventory on existing GI characteristics was conducted. During site inventory, checklist was used to record every elements and structures that exist at the housing area and botanical garden. This helps the researchers to determine and to understand the physical characteristics of existing GI attributes and network formation in the study area. Then, an interview with the local authority, developer and community were conducted. Next step, a pilot study was conducted for 3 weeks in the study area from 1st January 2013 to 21st January 2013. It involved various parties such as the local authority, developer, house owners, and botanical garden users. During the pilot study, questionnaire forms were distributed to the respondents. Respondents were asked to answer all the question in the time frame given and returned to the researchers once completed. Besides that, the researchers also used social network (Facebook) to interview the community. From the output and comments, the researchers make necessary amendments and then a new set of questionnaire form were distributed to the respondents. 386 respondents (radius 1800 meters) were involved, which were determined by Geographical Information System (GIS). The GIS is covered the unit of housing involved and total area of the study area (908.02 hectares) with the population of 1,158 people (33.3% from total respondents in the study area). It took about 3 months from 1st February 2013 to 1st April 2013 to complete the task. Finally, after all form and data was collected, the process of data key in was conducted using the software of Social Packages on Statistical System (SPSS version 20.0). The data key in process,

took about two weeks within 5th of April 2013 to 20th April 2013. After the process of data key in, analysis of data was conducted using the same software; descriptive statistic, ranking of mean result, t-test and correlation were produced.

6. Results and discussion

6.1. Frequency of respondents

Total respondents were 386 people from 12 selected housing areas. From the outputs, only 63% (237) of them willing to answer all questions in the questionnaire form. While the other 37% (149) declined. From the respondents, 62% are male and 38% are female living between radiuses 1800 meters in the study area. The Malays represented the majority of ethnicity of the respondents with 39% and the Indian was the lowest ethnicity with 1%. The largest percentage of the respondents (72%) was adults between ages of 21 to 45 years old. Majority of the respondents resided in the study area between 1 to 5 years. The respondents of this study were from the 4 to 6 family size. Most of the respondents (74%) were married. From the total respondents of 237, 85% of them were aware on GI components. Only 15% of them were not aware of the GI components in their housing area. From the results, the frequency of awareness on GI among respondents from Malaysia was 89% equal to 180 people while 11% were non Malaysian that aware of the GI elements in their housing area. The non-Malaysian in this study consist of respondents from America, Saudi Arabia, Philippine and Indonesia.

6.2. The existing green infrastructure component in study area

Figure 3 below shows the existing GI elements that the researchers found in the study area. It is divided into 3 components which are in the housing area (hub 1) and botanical garden (hub 2) and the linkages (link) between these two areas. It shows a variety of GI component in the study area that may attract community to stay in the area.

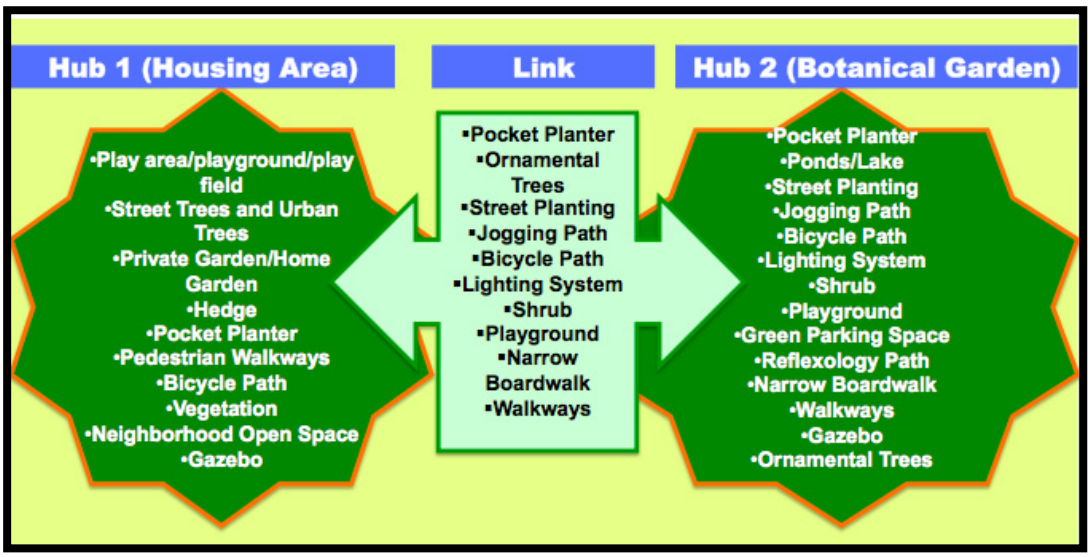

Fig . 3. Existing green infrastructure components in study area

6.3. Mean result for environmental attributes

Table 1 below presents the ranking of the mean result for environmental attributes (priority rating scale is 1=not important at all, 2=low important, 3=neutral, 4=important, 5=extremely important).It is reported

that maintenance of the road and surrounding environment were highly preferred. The lowest mean was calculated for the solar system usage (3.82). Maintenance of the road and surrounding environment are ranked highest in the housing area because it provides accessibility to the community.

Table 1. Ranking of mean results of environmental attribute variables

Environmental Attribute	Mean	Rank
Maintenance of the road and surrounding environment	4.85	1
Free from pollution, hazard and soil erosion	4.59	2
Cleanliness of air quality	4.51	3
Shady environment	4.50	4
Green parking space	4.35	5
Street cleaning services	4.30	6
Ability to adapt nature impact	4.19	7
Garbage disposal service	4.18	8
Usage of the solar system	3.82	9

6.4. Mean result for the visual quality attributes in housing area and Botanical Garden

Table 2 below presents the ranking of the mean result for visual quality attributes in the housing area and botanical garden (priority rating scale is 1=very dissatisfied, 2=dissatisfied, 3=neither dissatisfied nor satisfied, 4=satisfied, 5=very satisfied). It can be seen that view of the park was rated highest due to the view offers calm feeling to the residents. While, the view of vegetative form recorded the lowest mean because the housing area were located far from the vegetative form in the study area. For botanical garden, it can be seen that view of jogging and bicycle path were rated highest. It is because, most of the botanical garden users use this area for jogging and cycling. It has a beauty scenic, covered by trees. While, the view from the tree house were the lowest because the tree house is located high on the tree and most of the visitors has not experience the views from there.

Table 2. Ranking of mean result of visual quality in housing area and Botanical Garden

Visual Quality Attribute (Housing Area)	Mean	Rank
View of the park	4.51	1
Scenic beauty of the housing area	4.05	2
Sloping land	3.99	3
Topography	3.92	4
View of the vegetative form	3.84	5

Visual Quality Attribute (Botanical Garden)	Mean	Rank
View of jogging and bicycle path	4.31	1
View of ponds/fishing area	4.11	2
View of ornamental trees	4.06	3
View of playground	3.84	4
View from the tree house	3.46	5

6.5. Mean result for the Botanical Garden facilities

Traditionally, botanical garden serves varieties of recreational activities, educational and preservation of trees. Table 3 presents the ranking of the mean result for botanical garden facilities (priority rating scale is 1=very dissatisfied, 2=dissatisfied, 3=neither dissatisfied nor satisfied, 4=satisfied, 5=very satisfied. It can be seen that jogging, bicycle and reflexology path were highly preferred. By right, those activities are

part of leisure activities. With easy access, whether by walking or cycling, public can still can go to park without the need to drive. At the same time, it can reduce the cost and time. The kiosk was recorded the lowest because the park has provided only one kiosk at the main entrance.

Table 3. Mean Result for Botanical Garden Variables

Botanical Garden Facilities	Mean	Rank
Jogging, bicycle and reflexology path	4.23	1
Ornamental Trees	4.13	2
Guard House	4.09	3
Children's Playground	3.95	4
Herbal Trees	3.91	5
Lighting, Pergola, Facilities	3.90	6
Ponds, Fishing area and Dustbins	3.89	7
Tree House and Landscape	3.86	8
Entrance, Signage and Parking Area	3.52	9
Instruction Signage and Water Feature	3.48	10
Exercise Station and Public Toilet	3.21	11
Kiosk	3.02	12

6.6. Comparison of mean between visual quality attributes and citizenship using t-test

This test involved comparison of means of two groups, which is recorded as 'Malaysian' and 'Non-Malaysian' with the visual quality attributes at housing area. It can be concluded that there is no statistically significant difference between these two groups in their satisfaction levels towards the visual quality attributes although generally the non Malaysian rated higher for all visual quality attributes except for sloping land.

Table 4. Mean result for Botanical Garden variables

Variables	Malaysian	Non-Malaysian	F	Sig.
View of the park	4.43	4.46	1.816	0.179
Scenic beauty at housing area	4.27	4.46	1.212	0.272
Topography	3.81	3.89	1.030	0.312
Sloping Land	3.93	3.65	1.666	0.198
View of vegetative form	3.69	3.73	0.489	0.485

6.7. Correlation analysis

Correlation analysis is used to describe the direction and strength of the linear relationship between two variables. Results in Table 5 showed significant correlation between some of the visual quality attributes and Botanical Garden (BG) variables. Highly significant and positive correlation ($p<0.01$) is seen between view towards jogging and bicycle path with herbal trees (0.545**); lighting, pergola and facilities (0.498**); ponds and fishing area (0.440**); jogging, bicycle and reflexology path (0.848**); children playground (0.427**); tree house (0.463**); ornamental trees and landscape (0.727**); and guard house (0.561**). Second attribute is view towards ornamental trees and landscape. The results showed the majority of the variables were significant between each other's except for the kiosk variable. There were positive and negative correlations co-efficient in this result.

At the same time, view towards playground was recorded most significant between each variable except for instruction signage, water feature and kiosk. There rest shows highly significant with correlation $p<0.01$. Next is view toward ponds. The results recorded that there were significant difference

at $p<0.01$ with herbal tree (0.638**); lighting, pergola (0.575**); ponds, fishing area (0.565**); jogging, bicycle, reflexology path (0.861**); children playground (0.457**); ornamental trees (0.966**); tree house (0.500**); public toilet (0.169**); exercise station (0.169**); dustbin (0.523**); guard house (0.033**).

Finally, look at the correlation between views of the tree house with Botanical Garden variables. The results showed only few significant correlations between these two variables. At $p<0.01$, the highly significant correlation was seen in instruction signage (0.982**); water feature (0.982**); dustbin (0.195**) and guard house (0.159**). It can be concluded that view of ornamental trees and landscape has attracted the visitors to come and feel the fresh scenery at the botanical garden. Based on the interview with the respondents, researcher found that the visitors loved the variety of ornamental trees and landscape provided in the garden thus evoke the feelings of calmness and welcoming the tourist to come to the garden.

Table 5. Mean result for Botanical Garden variables

Visual Quality Attributes / BG Variable	View of Jogging and Bicycle Path	View of Ornamental Trees	View Towards Playground	View of Ponds	View from Tree House
Entrance, Signage and Parking Area	-0.049	-0.531*	-0.295**	0.028	0.016
Herbal Trees	0.545**	0.452**	0.490**	0.638**	0.085
Lighting, Pergola, Facilities	0.498**	0.604**	0.630**	0.575**	0.136*
Ponds, Fishing area	0.440**	0.545**	0.823**	0.565**	0.062
Jogging, bicycle and reflexology path	0.848**	0.349**	0.577**	0.861**	0.022
Children's Playground	0.427**	0.841**	0.761**	0.457**	0.089
Tree House	0.463**	0.611**	0.994**	0.500**	0.125
Ornamental Trees and Landscape	0.727**	0.308**	0.502**	0.966**	0.985**
Instruction Signage	0.043	0.128*	0.116	-0.063	0.982**
Public Toilet	-0.031	0.258**	0.260**	0.169**	0.075
Water Feature	0.043	0.128*	0.116	0.116	0.982**
Exercise Station	-0.031	0.258**	0.260**	0.169**	0.075
Kiosk	-0.076	0.068	0.107	-0.012	0.069
Dustbins	0.451*	0.541**	0.735**	0.523**	0.195**
Guard House	0.561**	0.361**	0.326**	0.033**	0.159**

7. Major findings

The major findings from this research were:

- Public awareness among respondents reported 85 percent from total respondents. It shows that the majority of the respondents in the study area are aware of their green infrastructure components
- 89 percent of them were Malaysian and the rest were Non Malaysian. From the interviews, most of the respondents were aware of their environmental consideration and sustainable development but they might not aware or not understand the GI terminology. They think the term sounds new whereas it already exists since 19th Century in United States. Perhaps, in order to encourage public more aware and understand the GI term, local authority or NGO's should play their roles in conducting an awareness campaign or give talks to the public from time to time.
- There is a variety of GI components in the study area (in the housing area, Botanical Garden and the link between housing and Botanical Garden) which provides a lot of benefits towards community in the area. All the GI components were link between one to another to create a connection from one hub to another hub.
- The most important environmental attribute is the road and surrounding maintenance. Perhaps in future local authority or developer will maintain the facilities from time to time to enhance community satisfaction.
- The most important Botanical Garden variables are jogging, bicycle and reflexology path, which is shown in the mean results. It means that, most community preferred to use jogging, bicycle and reflexology path in the botanical garden. So, the local authority should realize this output in order to preserve or to maintain the cleanliness and safety of those facilities to attract more tourists in future.
- Views of ornamental trees and landscape showed high significant level at $p<0.01$. It means that the Botanical Garden users mostly satisfied with the attributes. Besides, the view of the park created different living experience to the visitors.
- Hence, the visual qualities of the Botanical Garden need to be improve from time to time so that the visitors will feel comfortable and satisfied. In addition to that, social interaction will be enhanced.

8. Conclusion

From the research findings, it can be summarized that GI provides many benefits towards community and might overcome the negative effects on the environment. Environmental attributes combined with visual quality attributes with proper care and maintenance will contribute to the higher satisfaction among the housing residents and visitors thus enhanced the quality of life in the urban area. For future research, other GI attributes were suggested to be cover by other researchers such as on the accessibility, diversity, amenities and location attributes for better understanding on GI components itself.

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