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REAPPROPRIATION OF ELEVATED HIGHWAY RESIDUAL SPACE THROUGH GREEN INFRASTRUCTURE PLANNING

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Abstract

Kuala Lumpur City's demand for a better connectivity has led to the vast development of elevated highways. This has caused the formation of residual spaces underneath megastructures. Previous studies indicated that these residual spaces triggered issues from dumping of debris to crimes. Aimed at exploring the typologies and reappropriation of these spaces through green infrastructure planning, three methods were utilised in this study: site observation, document analysis and expert interview. Results from the study showed that there were two main typologies of residual spaces, namely: (1) easily accessible and (2) hard to access spaces. The interview sessions with the experts suggested that suitable green infrastructure elements, such as play lots, recreational lots and community gardens were regarded as suitable for Typology 1. However, semi-natural areas and functional landscapes were viewed as suitable for Typology 2. It is hoped that the understanding of the typologies of residual spaces underneath elevated highways and its appropriation through green infrastructure planning could lead to a more sustainable use and management of urban space thus viewing it as an important urban resource.

***Keywords**:* Residual space, urban landscape planning, green infrastructure, infrastructural landscape

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INTRODUCTION

The number of private vehicles rises and urban areas expand, causing an increase in demands for better transportation infrastructures. Transportation infrastructures, including elevated highways are one of the major drivers to cause landscape fragmentation in urban areas (Bürgi et al., 2004; Forman et al., 2003). Landscape fragmentation may affect almost all components of urban landscapes, such as aesthetic, ecological, historical, and recreational qualities (Forman et al., 2003; Weisbrod, 2011). In Malaysia, Kuala Lumpur City is not exceptional from the situation as the ratio of highways is considerably high (Barter, 2004) as compared to the number of population (68 metres per 1,000 urban population). The development of elevated highways has resulted in the formation of empty and residual spaces (Franck, 2011; Sanches & Pellegrino, 2016). Kuala Lumpur City is also experiencing the same scenario (Qamaruz-Zaman et al., 2013). Nevertheless, there have been a few studies carried out in Kuala Lumpur City. The studies in the local context include Barter 's (2004) study which highlighted the extreme scale of number of people to the number of highway areas. On the other hand, Qamaruz-Zaman et al. (2013) delved deeper into the situation by studying some of the spaces underneath elevated roadways and noted that these spaces were informally utilised and had a potential to be planned and designed as a space that could serve the public better if permitted by local bylaws. Concern about issues regarding residual space is also highlighted in Kuala Lumpur Structure Plan 2040, in which it states that the available residual spaces are often neglected and should be better planned for.

In order to address the issues at hand, there is a need to review the current situation primarily in understanding the types of typologies of the residual spaces underneath elevated highways. The understanding of the typologies may facilitate planners, designers and policy makers to engage in more effective planning for residual spaces. Therefore, the objectives of this study are to identify the typologies of spaces underneath elevated highways and to explore the possibilities of usage for the residual spaces through green infrastructure (GI) planning approach. Prior to achieve the objectives, there is a need to understand the current situation of the elevated highways and the formation of residual spaces, as well as the concept of green infrastructure which are pertinent to provide a stance towards the whole issue. Thus, this paper begins with a brief discussion about the topic of formation of residual urban spaces caused by the elevated highways followed by the discussion on green infrastructure planning as an approach in addressing residual spaces. Then, the methods used in this study are described, followed by results, discussion and finally the conclusions.

GREEN INFRASTRUCTURE PLANNING AS AN APPROACH TOWARDS ADRESSING RESIDUAL URBAN SPACES

Considered as the most generally used and economical means of transportation, elevated highways are one of the most significant connections in landscape between urban areas and their outskirts. Elevated highways have often been built in the subsequent urban areas: urban fringe, river bank, industrial areas, as well as crossing low-income housing areas (Bisecker, 2015). The development of the elevated highways would increase the accessibility and mobility of urban dwellers. Nonetheless, the development of the elevated highways, at the same time, become obstructions that separate district or neighbourhood and create vast amount of residual spaces that affect the city as a whole. Territorial vagueness of the spaces can also lead to issues of land misuses, such as dumping of debris, abandoning of cars or illegal activities (Hamersma et al., 2017; Mohamad & Kiggundu, 2007; Rahim, 2001; Shoaib & Ghendy, 2013). The unsuitable use of the residual spaces eventually lead to social and economic problems, in which can affect the value of adjacent properties. Branas et al. (2011) relate the residual spaces to the "incivilities" theory, in which the abandoned residual spaces promote weak social ties among nearby residents and encourage crimes, ranging from harassment to homicide. Harnack and Cohler (2011) describe elevated highways as pieces of infrastructure which seldom attract people's affection and pose a constant provocation. Following this, Jalian (2015) states that the resulting interstice in an example of "a space that intervenes between one thing and another" often generates seemingly uninhabitable zones and problematic discontinuities in the physical and social fabric. Issues relating to formation and unclear function of these residual spaces have mostly been discussed in the Western world but still limited in South East Asian region (Clements, 2013; Hormingo & Morita, 2004; Qamaruz-Zaman et. al., 2013; Sanches & Pellegrino, 2016).

Scholars, designers and planners, ranging from multiple fields of practice, have noted that the issue of residual spaces in relation to transport infrastructure is a result of a lack of integration during the early stages of development, primarily during the planning and design process. Thus, the problem of residual spaces is indeed a gap that needs to be addressed (Akinci et al., 2016; Jalian, 2015; Mossop, 2006; Prasetyo & Iverson, 2015). One of the recent approaches in addressing residual spaces in the city is through green infrastructure planning. The greening of residual, derelict and vacant land approach becomes a suitable opportunity to reduce crime and social tensions, as well as to enhance the quality of life, leisure, recreation, and social cohesion in the city (Sanches & Pellegrino, 2016). The greening approach can be considered as an opportunistic strategy, acknowledging the potential of the residual landscape to be managed or structured in a different manner to provide specific functions, such as pedestrian and cycle paths or as greenways (Ahern, 2007).

The term green infrastructure is defined in various ways by different scholars in vast literatures. For example, European Commission defined green infrastructure as a network of green spaces, habitats and ecosystems within a defined geographic area, which can range in scale and varies in functions from providing ecosystem service to enhancing the human quality of life (Maes et al., 2015). In contrast, prior to that, Beer (2010) states that green infrastructure is purposeful, intentional, designed, and intended primarily for widespread public use and benefit. Following this, Mell (2016) remarks that green infrastructure has been broadly defined in literature to mean either investment in green space or as an infrastructure with sustainable objectives. On the contrary, Vandermulen et al. (2011) have associated green infrastructure with green spaces in general. Roe and Mell (2016) describe green infrastructure as highly modified, man-made or engineered “intentional landscapes” and not covered by spontaneous vegetation. In a latter study by Matthews et al. (2015), green infrastructure is seen as an approach that highlights human modification and ecosystem services within green infrastructure (water purification and heat reduction), which are purposefully- designed spaces.

In differentiating green infrastructure (GI) planning with traditional planning approach, Benedict and McMahon (2012) elucidate that the main contrast between traditional planning and GI-based planning approach is that traditional planning is mono-functional, while GI-based planning approach is multi-functional. Adding to this, Lennon and Scott (2014) state that GI concept reverses traditional planning practice and provides an array of benefits, such as economic benefits in terms of increasing land and property value, inward investment, visitor spending, environmental cost saving, health improvement, market sales, and employment generation (Donovan & Butry, 2010; Gore et al., 2013; Kim 2016). Social and cultural benefits are also associated to GI planning, such as increasing spiritual attachments, recreation experiences and aesthetic values. This, in turn, may catalyse greater community engagement within a space (Nemeth & Langhorst, 2014). Through GI, the exposure to nature and real or perceived biodiversity may provide many benefits to people, such as improved psychological well-being, physical health and cognitive function (Anderson & Minor, 2017; Kim, 2016; Nemeth & Langhorst, 2014; Sanches & Pellegrino, 2016). Adding to this, environmental benefits are related to GI being introduced in the residual spaces in providing climatic and microclimatic modifications in terms of mitigating urban heat island (Armson et al., 2012), as well as enhancing ecosystem service (Gore et al., 2013; Hensen & Pauleit, 2014; Kim, 2016; Pauleit et al., 2017; Sanches & Pellegrino, 2016). The benefits range from potential to increased urban biodiversity (Harrison & Davies, 2002; Muratet et al., 2007). It is in this sense that GI is foreseen as a suitable planning approach to address the issue of residual urban spaces, particularly underneath elevated highways in the city.

METHODOLOGY

This research was done through two phases; a case study and through expert interview which allowed the authors to investigate current phenomenon using qualitative methods. Data collection for the case study which mainly involved site observations were guided by a systematic framework established by Malterre-Barthes (2011) and was carried out within a period of several months. This data collection consisted of observations and documentation of sites that were based on a set of checklists describing the typology of the site, namely: (1) public space, (2) public space with service function (3) transit space hub (4) transit space circulation, and (5) inaccessible space. Through this set of checklists, the typologies of the site were recorded, documented and categorised. The categories and characteristic observed in relation to the typologies were presented in Table 1. The specific framework was chosen as the main data gathering tool that was supported by Biesecker (2015) who indicated that it allowed the documentation of the typologies of the studies site to be systematic. Bisecker (2015) also explained that the specific framework was chosen to provide a general understanding of people who used the space and the types of activities that may happen or happened at the site, specifically in residual spaces. In this study, Duta Ulu Kelang Expressway (DUKE - E33), Ampang Kuala Lumpur Elevated Highway (AKLEH - E12) and the Maju Expressway (MEX - E20) were selected as the case studies (see Figure 1). These sites were purposively selected as they represented the highest available residual space underneath elevated highways in Kuala Lumpur City with a combined total area of 582,793 m^2. These three elevated highways have parts that run across dense urban communities and neighbourhood, as well as green areas resulting in the presence of multiple typologies of interstitial spaces.

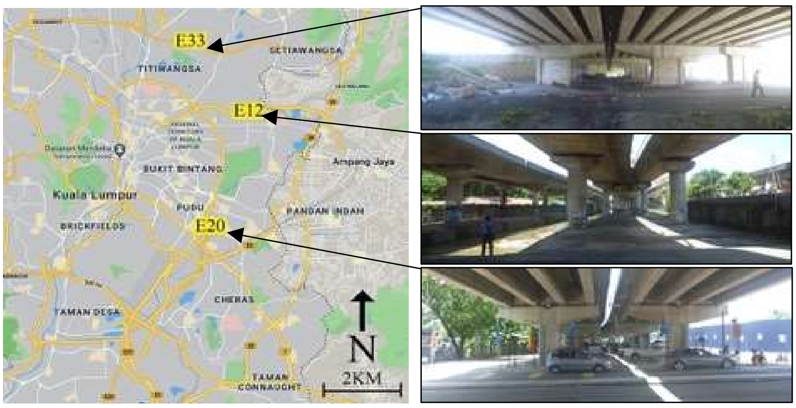

Figure 1: The location of DUKE (E33), AKLEH (E12) and MEX (E20) in relation to its location in the city of Kuala Lumpur
Source: Author and map adapted from Google Maps

Table 1: Categories and General Related Characteristic to the Typologies of Spaces Underneath Elevated Highways

Typology	Characteristics	Category
Public Space	Public space is accessible to pedestrians only. Activities and function are determined by surrounding businesses and people. It is designed and maintained by the city's authorities	**Typology 1** Easy to Access
Public Space with Service Function	Most of the space is accessible by cars and motorised vehicles. It is crammed in between two to four traffic lanes adjoining the main road axis, as well as it is dominated by parking zones and partly-furnished with some form of urban furniture. It has a presence of service space with limited public access.	
Transit Space Hub	Transit space hub is a commuter-friendly transit space and provides shelter in times of adverse weather. It is used as a hub for transportations (bus or taxi stops)	
Transit Space Circulation	Transit space circulation is solely dedicated to vehicular and pedestrian circulation. It has a presence of traffic lanes with minimal sidewalks and crossings.	**Typology 2** Hard to Access
Inaccessible Space	Inaccessible space does not give access to public as it is only accessible to private business. It is mainly used for storage and transportation depot and is oftentimes fenced or gated.	

(*Source: Adapted from Malterre-Barthes, 2011*)

First phase: Site Documentation and Observations

Duta Ulu Kelang Expressway (DUKE E33)

The site of the first case study is located underneath the DUKE highway near the Jalan Pahang ramp and Sentul Pasar Interchange. At present, the surrounding major site context, included religious institutions - Jamiul Ehsan Mosque, commercial lots, as well as a newly built mix residential tower – The Reach @ Titiwangsa. The 103,090 m^2 space was predominantly used as an informal parking space, a shelter for motorcyclist taking refuge from rain and an informal space for selling of food items by the roadside (see Figure 2). Moving further into the space underneath DUKE, it was revealed that the space was used as an informal dumping site for construction waste (see Figure 3). However, some parts of the site are enclosed by a structure of the highway, while some other parts of the site offer a more open area which supports informal passive activities, such as jogging and fishing in the nearby flood retention pond (Gombak River Retention Pond). At night, the space was poorly lit with no activities to be seen and recorded. The accessibility to the space was somewhat easy because of multiple entry points into the residual space underneath the structure, as well as no barriers found at the site during the time of field work.

Figures 2&3: The spaces underneath DUKE being utilised informally as a place to sell food and dumping debris
Source: Author

Figure 4: The residual space underneath DUKE is easily accessible from the surrounding existing and future residential area
Source: Author

Ampang Kuala Lumpur Elevated Highway (AKLEH E12)

The site underneath AKLEH runs from Datuk Keramat Light Rail Transit (LRT) Station to Jalan Gurney. The surrounding site context encompasses a light rail transportation hub, residential dwellings, as well as some institutional buildings. Although the site can be accessed rather easily, accessibility into the site is limited due to some parts of the site not being at the similar level with the surrounding road sides and streets. The discontinuation between the interstitial spaces is furthermore accentuated by the contrast in scale between the structure and the adjacent neighbourhood. Moreover, the massive form and high-paced nature of the AKLEH intensifies the juxtaposition of scale. Although much of the 110,010m^2 space underneath AKLEH is somewhat easily accessible, the residual spaces generally appear to be undefined in use, ownership, management, and function. These residual spaces project a sense of abandonment and lost opportunities in contrast to the highly-managed and planned roadway above it. The observed activities in the space underneath AKLEH observed were limited to people using the concrete bank of the river as passage ways (see Figure 5) and people fished for aquatic life on some parts of the riverbank (see Figure 6). No activities involving commerce were observed in the site or any activities during night time.

Figure 5&6: Activities observed underneath AKLEH, using the concrete bank as passage ways and fishing for aquatic life in the Klang River
Source: Author

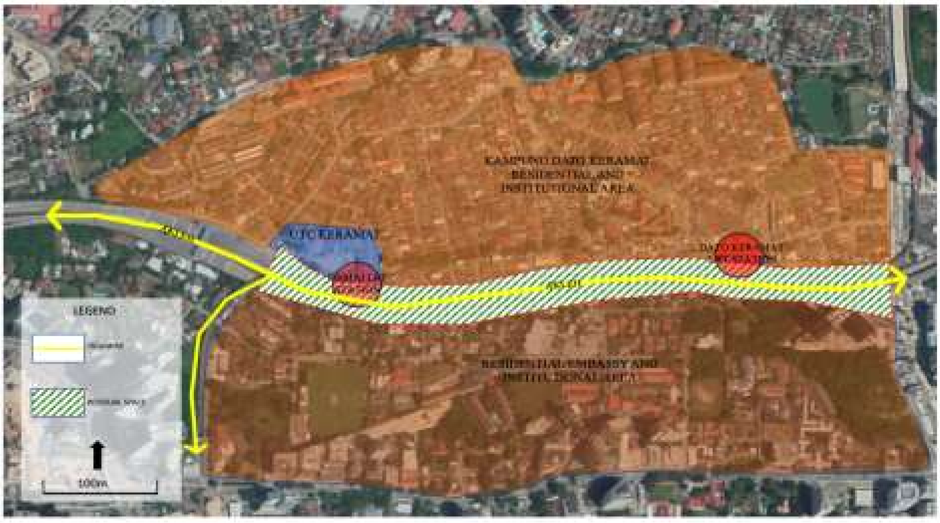

Figure 7: Residential land use surrounds the residual space underneath AKLEH
Source: Author

Maju Expressway (MEX E20)

There were two parcels which was studied underneath MEX. The first parcel (Tun Razak – Jalan Peel) which has a total area of 54,850 m^2 was still in use for commerce (see Figure 8), while the second parcel (Salak Selatan – Kuchai Lama) which has a total area of 314,843 m^2 was covered by informal vegetated space (see Figure 9). The spaces studied were surrounded by residential and industrial areas. Some parts of the space still remained empty and vague. The manifestation of human activity that involved in and out movement of the space was mainly due to the ease of access into the area, particularly in the first parcel. In contrast, the second space of MEX was left unused because the accessibility and continuity of human-scaled movement were obstructed by physical barriers. This was because this area is surrounded by a major highway and fences in some parts.

Figure 8&9: Spaces under MEX are currently being used as a space for commerce in Parcel 1 (Figure 8) and informal vegetated space in Parcel 2 (Figure 9)
Source: Author

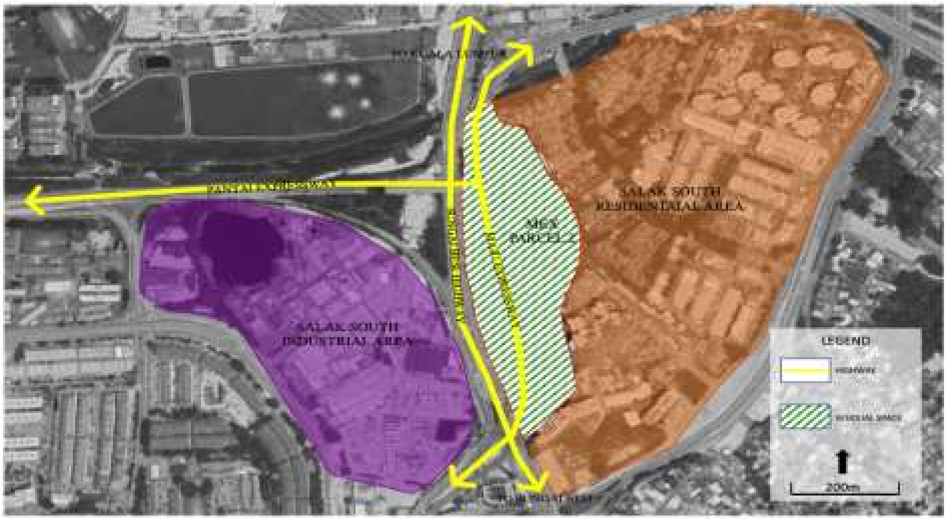

Figure 10: The residual space underneath MEX (Parcel 2: Salak Selatan – Kuchai Lama) is cut off by a major highway making it hard to access
Source: Author

Second phase: Expert Interviews

The second phase addressed the second objective of the study which was to explore the possibilities of usage for the residual spaces through green infrastructure (GI) planning approach. It involved a brief but in-depth interview. A series of structured interview was conducted with experts ranging from landscape architects with professional certification and more than ten years of industrial experience to academicians with a Doctor of Philosophy (PhD) qualification relating to landscape architecture and planning background. To gain exclusive insights regarding the suitable usage of the studied residual spaces underneath elevated highways, a total of ten (10) experts were interviewed. A series of structured questions was presented and answers were recorded through scores and notes. The questions were arranged in two sections as suggested by the two common typologies of residual infrastructural spaces that were identified as underneath elevated highways in Kuala Lumpur City.

The respondents were shown pictures, as well as two dimensional plans of the sites and were asked to give scores from 1 (not suitable) to 5 (most suitable) with regards to the green infrastructure elements. The respondents thought that these green infrastructure elements would be suitable to be applied in the two typologies of residual spaces underneath elevated highways. These typologies were identified through the initial conducted fieldwork based on the framework adapted from Maltere-Barthes (2011). The list of green infrastructure elements that was presented to the interviewees was based on a review of several published local and international documents. Elements, such as parks (neighbourhood parks, playing field, playlot, and recreational plots), green roof and wall, natural and semi natural green areas, green corridors, community garden and allocation for urban farming, public social space, as well as functional green space were listed as variables. Scores were given to each of them in accordance to the suitability of their implementation in the reviewed typologies. Based on the interview transcripts, key words and themes that determined the suitability of the application of green infrastructure elements in the studied spaces were also noted. Results of the interview were then descriptively analysed.

RESULTS AND DISCUSSION

Typologies of Spaces Underneath Observed Elevated Highways

Through the recorded observation of the case studies, two key typologies of the spaces underneath the highways in Kuala Lumpur were suggested. The observation had considered the typologies of spaces underneath elevated highways as suggested by Malterre-Barthes (2011). Conversely, as opposed to the five categories, the categorisation of the typologies had been further categorised into two main categories which were (i) easily accessible space and

(ii) hard to access or inaccessible space. Results of the fieldwork were presented in Table 2

Table 2: Typologies associated with the spaces underneath the three studied elevated highways

	Typology 1 (Easily Accessible)			**Typology 2 (Hard to Access)**	
Site	Public space	Public space with service function	Transit space hub	Transit space circulation	Inaccessible space
DUKE (Sentul Interchange)	X	X	X	X	
DUKE (Gombak Retention Pond)	X	X			
DUKE (SK Sentul Interchange)			X	X	X
AKLEH (LRT Dato Keramat	X			X	
AKLEH (LRT Damai)	X			X	
AKLEH (Tun Razak Junction)	X			X	
MEX (Tun Razak – Jalan Peel)	X	X	X	X	
MEX (Salak Selatan-Kuchai Lama)			X	X	X

(*Source: Author*)

The result indicated that the spaces underneath elevated highways showcased an array of typologies. All of the studied sites possessed some characteristics of the observed typologies at certain locations with varied scales and form. DUKE (Sentul Interchange) and MEX (Tun Razak – Jalan Peel) were dominated with Typology 1, in which most of the observed sites were public-friendly and easily accessible with some form of informal, modular and makeshift urban furniture. Pertaining to Typology 2, the spaces underneath MEX (Salak Selatan – Kuchai Lama) and DUKE (SK Sentul – Interchange) exemplified this typology the most as the spaces in these areas were dominated by storage areas utilised by the city hall. Some of the areas were fenced, as well cut off from the surrounding area by major highways. The spaces underneath AKLEH were mainly associated with Typology 1 as most of the spaces in that particular site were mainly commuter- friendly and utilised as transit space but lacking in other forms of service or amenities.

Potential Green Infrastructure Elements for Residual Space Reutilisation

The interview with experts had revealed that based on a mean score of 1 that indicated less suitable to 5 that indicated most suitable, green infrastructure elements, such as play lots (4.6), recreational lots (4.5) and community gardens (4.5) were perceived as suitable to be planned and designed into the spaces with Typology 1 (easily accessible). Nevertheless, semi-natural (4.7), green corridors (4.5), as well as functional green spaces (4.5) which encompassed systems for sustainable urban drainage systems were more suitable for residual spaces which were categorised as Typology 2 (hard to access). The mean scores of the suitability of green infrastructure elements presented to the respondents were tabled in Table 3.

Table 3: Mean score of suitability of green infrastructure elements application underneath elevated highways based on the two observed typologies

Green Infrastructure Elements	Typology 1	Typology 2
Neighborhood park	3	1
Playing Field	3	1
Play lot	4.6	1
Recreational lot	4.5	2
Green roof and wall	4	3
Semi natural area	3	4.7
Green corridor	3	4.5
Community garden	4.5	3
Public plaza	4	2
Functional green space, SUDS	4	4.5

(*Source: Author*)

Results from the interview displayed that spaces underneath elevated highways with Typology 1 – DUKE (Sentul Interchange) and MEX (Tun Razak – Jalan Peel) – were suggested to be suitable for implementation of the green infrastructure elements in the form of play lots, recreational lots or community gardens. However, spaces of Typology 2, such as MEX (Salak Selatan – Kuchai Lama) and DUKE (SK Sentul – Interchange) were suitable in the form of semi-natural area, green corridor and functional green spaces, as well as linked to sustainable urban drainage system (SUDS). Following the scores given, the main factors which had been regarded by the respondents as key factors in determining the suitability of the application of green infrastructure elements were the typology of the spaces, the locality and site context, accessibility, safety, community needs, as well as approval from the local authority.

The study had shown that the spaces underneath elevated highways in Kuala Lumpur had an array of typologies. The residual spaces studied underneath elevated highways mentioned showcased that all the spaces to a certain extent possessed the various typologies, namely, Typologies 1 and 2. Conversely, upon investigation, the typologies varied primarily in terms of scale and location. The results from the study had shown that a comprehensive examination, as well as understanding the typologies of residual spaces underneath elevated highways could facilitate planners, designers and policy makers to engage in a more effective and informed planning for residual spaces, particularly underneath elevated highways. Various government bodies at different scales, as well as private agencies could create a suitable spatial programming for these residual spaces to encourage the use of transportation-related sites, as well as to enhance a green network system within the urban core and its outskirts.

The findings of the study are in line with several precedent studies (Allen, 2014; Biesecker, 2015; Weththasinghe & Wijesundara, 2017) which had identified an array of green uses for leftover spaces in urban areas, such as urban farming, community green spaces and an opportunity to increase biodiversity in the city. A synthesis of these green infrastructure efforts in conjunction with current and recent approaches generated a set of green infrastructure project typologies that were organised in broad categories, such as income generating (commerce), environmental services, as well as social or community benefit (Allen, 2014). The findings of this study suggested that each typology was evaluated for its relative suitability for re-use of residual spaces or underutilised property based on professional assessment, public preference, feasibility, opportunity, and the physical resource characteristics of each space, site or lot. Hence, based on the underlying principles and elements of green infrastructure, it was suggested that green infrastructure (GI) could be a suitable planning and design approach to address residual spaces as it would offset the issues generated by traditional mono-functional planning and provide a wide range of environmental, social as well as economic benefit to the city.

The overall aim in the study was to explore the potential reappropriation of these spaces through green infrastructure planning. The revealed typologies proved to be a useful first step as the understanding of the typology supported a better appreciation and understanding of the potential benefits of residual infrastructural spaces, namely, underneath elevated highways within the urban landscape. The study conducted exemplified the initial attempt to conduct a comprehensive survey of the current condition of residual spaces underneath highways in the city, as well as to develop a means to support city policies and guidelines in terms of the use or reuse of these vague spaces through the green infrastructure elements. The empirical data gained for this study could primarily assist the landscape architects, planners, as well as urban designers who aim to envisage in a more effective planning and design processes for residual spaces in terms of their ecological, social, as well as economic benefits in line with the Kuala Lumpur Structure Plan 2040, particularly with regards to sustainable use of space. These residual spaces could offer unconventional and imaginative ways to envision the public realm and landscape designs in cities. The spaces studied could be used as an important resource when the spaces were considered as a potential redevelopment opportunity that would primarily benefit the public at large. Although subjected to approval of local bylaws and regulations, the understanding of the typologies and their suitability for redesigning and development in this study may have important implications for policy development. The findings are also expected to help practitioners, as well as academicians to have a better comprehension about infrastructural residual spaces.

CONCLUSION

In conclusion, this initial study has highlighted the main types of residual space typologies underneath elevated highways in Kuala Lumpur, namely, easily accessible space and hard to access space. Through the understanding and appreciation of the typologies of residual spaces underneath elevated highways, suitable green infrastructure elements could be applied according to the typologies and thus, could lead to a more sustainable use of urban space and an appreciation of these spaces as an important urban resource. State and federal government agencies may create programmes that encourage residual elevated highway space use for public amenities, useful community assets, as well as natural city assets and to enhance the green network system of a city. Through the green infrastructure planning, residual spaces could be transformed as an interconnected network of multi-functional spaces rather than solitary element that would provide a range of ecological, social and economic benefits to the city. Future studies could include the studies on the needs of the surrounding communities in accordance to using residual infrastructural space as green spaces for leisure and enhancement of quality of life, as well as looking at the technical aspects, such as safety, planning policy and regulations.

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