PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 20 ISSUE 4 (2022), Page 255 – 270

THE BENEFITS OF GREEN INFRASTRUCTURE PLANNING IN ADDRESSING LOST SPACES UNDERNEATH ELEVATED URBAN HIGHWAYS

Mohamed Ikhwan Nasir Bin Mohamed Anuar[1], Saiful Arif Abdullah[2]

[1,2]*Institute for Environment and Development* (LESTARI)
UNIVERSITI KEBANGSAAN MALAYSIA
[1]*Centre of Studies for Landscape Architecture,*
Faculty of Architecture, Planning and Surveying,
UNIVERSITI TEKNOLOGI MARA PUNCAK ALAM

Abstract

Traditional planning practices, wherein attention is directed at the provision of single functions or zoning, have led to the emergence of lost spaces in cities like Kuala Lumpur. Elevated highways are a prominent contributor to the formation of these lost spaces and are seen as a hurdle in achieving a sustainable compact city. Studies suggest that green infrastructure (GI) planning, which aims to promote multifunctionality in spatial planning, is a suitable approach to address this dilemma. To identify the benefits of the GI approach in mitigating lost spaces underneath elevated highways in Kuala Lumpur City, this study utilized two methods: site observation and expert interviews. The results suggest that GI planning can achieve benefits ranging from economic aspects, such as increasing property value, to social aspects, such as promoting a healthier urban lifestyle. However, such benefits may vary as these spaces have different typologies in terms of accessibility, size, location, and surrounding context. Nonetheless, the GI approach can be seen as the key to achieving a sustainable compact city, since it supports the ability of urban spaces to provide multiple benefits concurrently. Thus, the identification of its benefits could lead to the more sustainable planning, design, and management of lost spaces.

Keywords: urban landscape planning, lost space, green infrastructure, infrastructural landscape.

[1] Lecturer at Universiti Teknologi Mara. Email: ikhwannasir@uitm.edu.my

INTRODUCTION

One of the 21st century's most transformative forces is urbanization, which brings with it intense social, economic, and environmental changes and demands (Van Zyl et al., 2021; Pakzad & Osmond, 2016). As this process has accelerated rapidly, so has the demand for more transportation infrastructures, including elevated highways (Bürgi et al., 2004; Forman et al., 2003). Due to the nature of planning and the limited space in urban areas, elevated highways are often built in urban peripheries, riverbanks, industrial areas, and low-income housing areas (Biesecker, 2015). The development of this infrastructure type increases the accessibility and mobility of urban dwellers; however, due to its monofunctional manner of traditional planning, it also creates a vast amount of lost spaces and adds to urban sprawl. Thus, the development of elevated highways has resulted in the formation of empty and leftover spaces (Sanches & Pellegrino, 2016; Franck, 2011), a phenomenon which Kuala Lumpur City is currently experiencing (Qamaruz-Zaman et al., 2013; Anuar & Abdullah 2020).

Redefining modern infrastructure requires a multi-disciplinary team of designers, planners, and engineers to fully realize benefits to cultural, social, and natural systems. In relation to this, the United Nations (UN) has strengthened its emphasis on urban areas, as seen in its Sustainable Development Goals (SDGs) announced in 2015 as part of the 2030 Agenda for Sustainable Development. Specifically, the urban goal is expressed in SDG 11, which is to "*Make cities and human settlements inclusive, safe, resilient, and sustainable*" with the support of ten specific targets (Van Zyl et al., 2021; Hansen et al., 2019). Thus, an alternative multifunctional development approach in the form of green infrastructure (GI) planning is seen as the key to sustainable urban development that fulfils the multiple targets set under SDG 11 (Van Zyl et al., 2021; Hansen et al., 2019). Indeed, the application of multifunctional planning solutions to complement or replace traditional urban development approaches is an area of increasing research interest. GI, also termed sustainable infrastructure (Chatzimentor et al., 2020), is now a major transdisciplinary research theme that links geography, ecology, and urban planning (Benton-Short et al., 2019). GI advocates a hybrid network of natural, semi-natural, and engineered features in and around urban areas at various scales, which is curated to provide multiple ecosystem services and benefits to humans that offer environmental, social, and economic value (Pauliet et al., 2021; Choi et al., 2021; Tzoulas et al., 2007; Hansen & Pauleit, 2014). Such benefits include reduced urban heat island (UHI) effects, increased carbon dioxide sequestration, improved water and air quality, better social cohesion, more recreation and tourism opportunities, and higher property values, among many others (La Rossa & Pappalardo, 2021; Choi et al., 2021; Mell, 2016; Naumann et al., 2011).

In general, there have been numerous studies on the overall advantages of GI. However, there is a limited amount of research on its benefits with regard to vacant or lost space utilization (Kim et al., 2018; Minor & Anderson, 2017; Nemeth & Langhorst, 2014). This is largely attributed to the limited systematic synchronization of its benefits towards the categorization of different types of vacant land. Specifically, few comprehensive studies have looked into how different types of vacant land can collectively contribute to the urban landscape as a whole. Despite its potential, the limited knowledge on the potential uses of different types of urban vacant land suggests that such land is often overlooked and not fully valued as part of the urban landscape. The design, planning, and management of vacant land has been minimal, further indicating that it has been neglected as a valuable resource (Kim, 2016). With this view, the objective of this study was to identify the benefits of the GI planning approach in addressing residual spaces underneath elevated highways, particularly taking into consideration the spaces' various typologies. By delivering a preliminary understanding of GI benefits, this paper also sought to provide insights on the nexus between GI planning and lost space planning and design within the context of Kuala Lumpur City. Prior to achieving these objectives, the current situation of traditional spatial planning and the formation of residual spaces, especially pertaining to elevated highways, should be understood. Thus, this paper begins with a brief discussion on the topic of residual urban space formation caused by traditional spatial planning. This is followed by a review of GI planning as an approach to address residual spaces in urban areas. Next, the methods used in this study are described. The analysis results and discussion are then explained and finally, the study's conclusions are presented.

GI PLANNING FOR LOST URBAN SPACES

Various works of literature have noted that the issue of lost spaces or residual spaces in relation to transport infrastructure is a result of two phenomena: 1) traditional planning; and 2) a lack of integration during the early stages of development, primarily during the planning and design process. The problem of residual spaces caused by traditional planning is indeed a gap that needs to be addressed (Akinci et al., 2016; Mossop, 2006; Prasetyo & Iverson, 2015). Challenges emerging from rapid urbanization require a monumental change in planning processes and practices to holistically integrate ecological dimensions alongside traditional planning interests. In this context, one of the contemporary approaches to resolve residual space problems in the city is GI planning. GI has emerged as a potential concept that may be used to operationalize an ecosystem-services-based approach within spatial planning policies and practices. It moves beyond traditional site-based ideas of 'protect and preserve' towards a more holistic ecosystem, which includes not only protecting but also enhancing, restoring, creating, and designing new ecological networks characterized by multifunctionality and connectivity (Lennon & Scott, 2014). Moreover, the strategy of greening residual, derelict, and vacant land is a suitable opportunity to enhance the quality of life, leisure, recreation, and social cohesion in the city (Sanches & Pellegrino, 2016). The GI approach can thus be considered an opportunistic one which acknowledges the potential of managing or structuring lost spaces in a different manner to provide specific functions, such as pedestrian paths, cycling paths, or greenways (Ahern, 2007). In distinguishing GI planning from traditional planning, Benedict and McMahon (2012) noted that the main point of difference is that traditional planning is monofunctional, wherein attention is directed at the provision of single functions or zoning; in contrast, GI planning is multifunctional.

Implementing the GI concept in the urban planning process carries important impacts. From the ecological perspective, it can increase the resilience of ecosystems, contribute to biodiversity conservation and habitat enhancement, and relieve pressures on the environment resulting from human activities, such as habitat fragmentation, climate change, land use change, and agriculture intensification (Pakzad & Osmond, 2016). In relation to climate change mitigation, greenery can also play an important role in carbon sequestration (Hutyra et al., 2011; McPhearson et al., 2013; Nowak et al., 2013). From the community to city levels, GI provides various types of empirically documented benefits, both directly and indirectly. Its economic benefits include higher land and property value, inward investments, visitor spending, environmental cost-saving, health improvement, market sales, and employment generation (Donovan & Butry, 2010; Gore et al., 2013; Kim, 2016). The social and cultural benefits associated with GI planning are stronger spiritual attachments, recreation experiences, and aesthetic values. These gains, in turn, may catalyze greater community engagement within a space (Nemeth & Langhorst, 2014). Additionally, the exposure to nature and real or perceived biodiversity through GI may be advantageous to people by improving their psychological well-being, physical health, and cognitive function (Anderson & Minor, 2017; Kim, 2016; Nemeth & Langhorst, 2014; Sanches & Pellegrino, 2016). Adding to this, the introduction of GI in residual spaces, which entails climatic and microclimatic modifications, brings environmental benefits to locals in terms of UHI mitigation (Armson et al., 2012) as well as enhanced ecosystem services (Gore et al., 2013; Hensen & Pauleit, 2014; Kim, 2016; Pauleit et al., 2017; Sanches & Pellegrino, 2016).

Considering its numerous uses and benefits, GI is seen as a strategic spatial planning framework which integrates adaptation and mitigation objectives (i.e., environmental, social, and economic) with co-benefits for broader sustainable development than that provided by the traditional planning approach of zoning (Choi et al., 2021; Locatelli et al., 2015; Yiannakou & Salata, 2017). For example, a well-managed greening strategy can simultaneously contribute to adaptation by reducing storm water runoff and UHI effects as well as to mitigation by increasing carbon sequestration and decreasing building energy consumption, all while providing aesthetic benefits and habitats for biodiversity (Godspeed et al., 2021; Mell, 2016). In this sense, evidence from the literature asserts that GI offers alternative interventions in spatial planning that are more flexible, cost-effective, and broadly applicable for climate action compared to the conventional or traditional planning of grey infrastructure (Choi et al., 2021; Vignola et al., 2009). It is in this regard that GI is posited as a suitable planning approach to mitigate and offset lost space issues stemming from traditional planning, particularly related to spaces underneath elevated highways in the city.

METHODOLOGY

Duta Ulu Kelang Expressway (DUKE - E33), Ampang Kuala Lumpur Elevated Highway (AKLEH - E12), and Maju Expressway (MEX - E20) were selected as case studies for this research. These sites were purposively selected as they represent the largest 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 various parts that run across not only dense urban communities and neighborhoods but also green areas, resulting in two typologies for the residual spaces beneath them: Typology 1 being easy to access and Typology 2 being hard to access (Anuar & Abdullah, 2020). The classification of the typologies mainly revolved around the spaces' accessibility and current function.

Apart from the case studies, this study utilized data collected from previous case studies of residual spaces underneath elevated highways in Kuala Lumpur City. Based on the data, a set of suitable GI elements were identified for the two major typologies of these spaces (Anuar & Abdullah, 2020). The categories, characteristics, and suggested elements are presented in Table 1. Subsequently, the typology-based environmental, social, and economic benefits of the identified GI elements were investigated through a series of expert interviews. Drawing from a review of several published local and international research works, the general benefits of GI in cities were listed based on environmental, social, and economic aspects. The benefits were then structured and categorized in a scoring sheet before being presented to the interviewees.

Table 1: Categories, General Related Characteristics, and Suggested GI Elements in Relation to the Typologies of Spaces Underneath Three Elevated Highways in Kuala Lumpur City

Typology	Characteristics	Category	Suggested GI Elements
Public Space	Access to pedestrians only. Activities and functions are determined by surrounding businesses and people. Designed and maintained by the city's authorities.	**Typology 1** Easy to Access DUKE - E33	

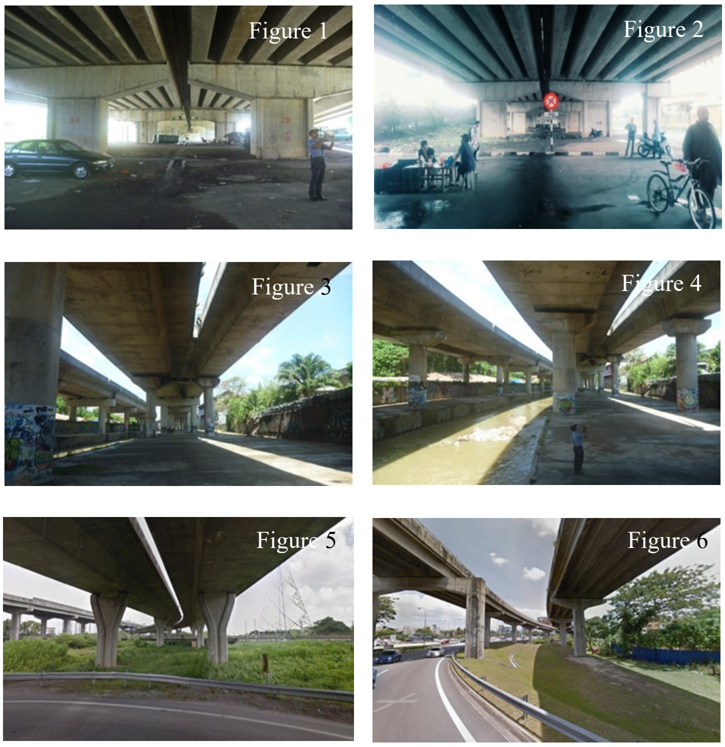
Public Space with Service function	Most of the spaces are accessible by cars and motorized vehicles. Crammed between two to four roads adjoining the main road axis. Dominated by parking zones and partly furnished with some form of urban furniture. Presence of service space with limited public access.	(Sentul Interchange, Gombak Retention Pond) AKLEH - E12 (LRT Dato Keramat, LRT Damai, Tun Razak Junction)	Playlots, Recreational Lots, Community Gardens, Public Plaza.
Transit Space Hub	Commuter-friendly transit space. Provides shelter in times of adverse weather. Used as hub for transportation (bus/taxi stops)		
Transit Space Circulation	Solely dedicated to vehicular and pedestrian circulation. Presence of traffic lanes with minimal sidewalks and crossings.	**Typology 2** Hard to Access MEX E20 (Salak Selatan – Kuchai Lama)	Semi-Natural Area, Green Corridor, Functional Green Spaces, Linked to Sustainable Urban Drainage System (SUDS)
Inaccessible Space	Inaccessible to the public, only accessible to private business and mainly used for storage and transportation depots. Oftentimes fenced/gated.		

(*Source: Adapted from Anuar & Abdullah, 2020*)

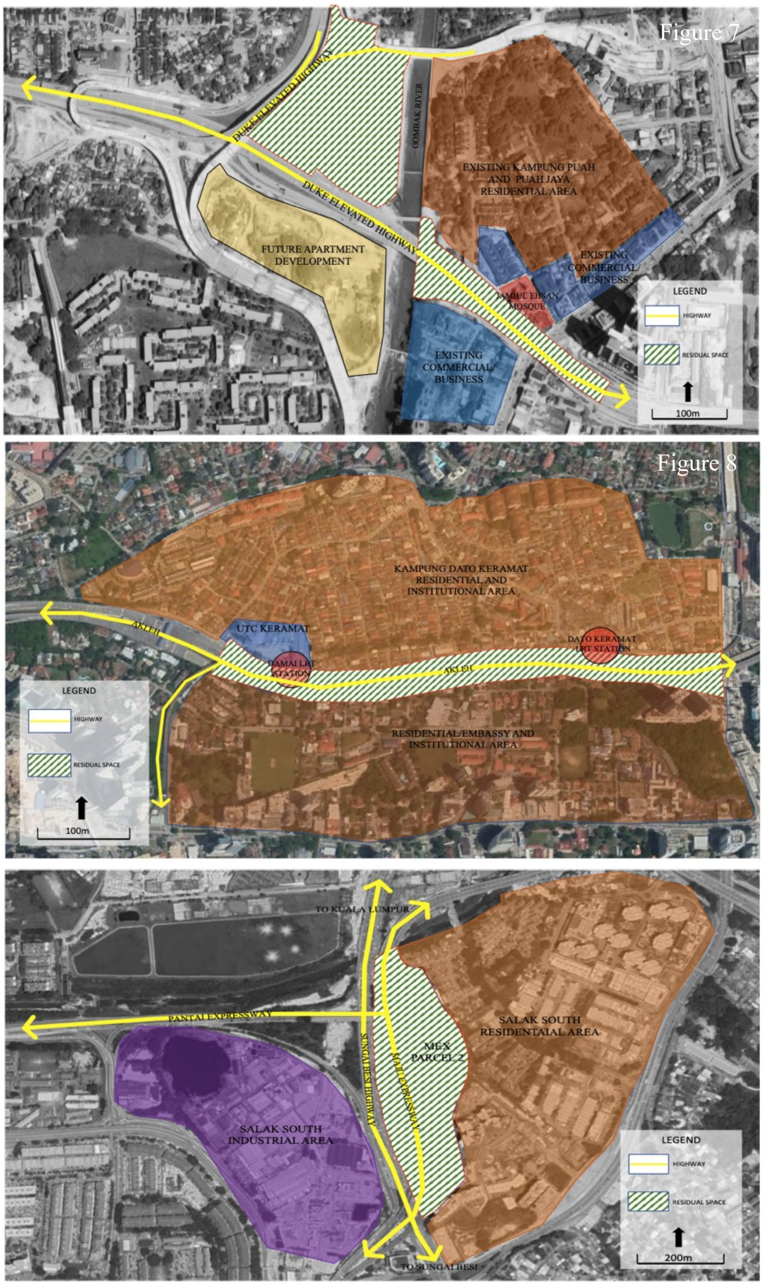
Expert Interviews

To gain exclusive insights into the typology-based benefits of GI planning in addressing lost spaces underneath elevated highways, brief but in-depth structured interviews were conducted with 10 experts. The experts comprised academicians with a PhD qualification in landscape architecture and planning, landscape architects with professional certifications and more than 10 years of industry experience, a representative from the Malaysian Highway Authority, and a highway developer. Sourcing expert opinions via interviews is considered a suitable method to gain critical input and reliable feedback on a presented matter (Elliott et al., 2020; Jacobs, 2015).

The interviewees were presented a series of structured questions arranged in two sections. The first was the scoring section, which had three sub-sections listing GI's economic benefits, social benefits, and environmental benefits as variables in relation to the two lost space typologies. The respondents were asked to rate these GI benefits with scores from 1 (not beneficial) to 5 (most beneficial). Scores were given based on the projected benefits of each GI aspect's implementation in the reviewed spatial typologies. In the second section, i.e., the general insight section, the interviewees were asked to discuss and clarify their views on their given scores. The respondents were also shown pictures (see Figures 1 to 6) and two-dimensional plans (see Figures 7 to 9) of the case study sites for them to better understand the context and locality of the sites. The interviewees' scores and views were recorded and transcribed. Based on the discussion transcripts, the key factors that encompass the benefits of the GI approach with regards to the case studies' spatial typologies were noted. Following this, the mean scores were calculated for each benefit in line with the themes raised by the interviewees for Typology 1 and Typology 2. The results and findings from the interview were then descriptively analyzed.



Figures 1 to 6: Different typologies and scenarios of the case study sites shown to the respondents to gain their insights on the potential benefits of GI planning in addressing these lost spaces. Figures 1 and 2 depict spaces underneath DUKE; Figures 3 and 4 depict spaces underneath AKLEH; and Figures 5 and 6 depict spaces underneath MEX.
Source: Author



Figures 7 to 9: Various contexts of the case study sites found and explained to the respondents. Figure 7 shows DUKE (Typology 1); Figure 8 shows AKLEH (Typology 1); and Figure 9 shows MEX (Typology 2) (Salak Selatan – Kuchai Lama)
Source: Adapted from Anuar & Abdullah, 2020

RESULTS AND DISCUSSION

Benefits of the GI Approach for Residual Space Underneath Elevated Highways

The interviewed experts rated the predicted benefits of the GI planning approach if applied at lost spaces underneath elevated highways according to their spatial typologies. Based on their responses, the key factors in determining the benefits of GI implementation were found to be locality and site context, accessibility, safety, community needs, and approval from the local authority. The mean scores of each benefit are presented in Table 2, wherein the scores range from '1 = least beneficial' to '5 = most beneficial'.

Table 2: Mean scores of the potential environmental, social, and economic benefits of the GI approach in lost spaces underneath elevated highways based on spatial typology

GI Benefits	**Score**	
Environmental Aspect	Typology 1 (easily accessible)	Typology 2 (hard to access)
Climate and microclimatic modifications (e.g., UHI effect mitigation; temperature moderation through evapotranspiration and shading; wind speed modification)	4.8	4.7
Air quality improvement (e.g., pollutant removal; lower emissions)	4.5	4.8
Reduced building energy use for heating and cooling (e.g., shade via trees; building covered by green roof and green walls)	4.4	4.3
Hydrological regulation (e.g., flow control and flood reduction; regulation of water quality; water purification)	4.2	4.7
Improved soil quality and erosion prevention (e.g., soil fertility; soil stabilization)	4.4	4.8
Noise level attenuation	4.2	4.7
Biodiversity protection and enhancement (e.g., communities; species; genetic resources; habitats)	4.7	4.8
Social Aspect		
Food production (e.g., urban agriculture; kitchen gardens; edible landscape and community gardens)	4.1	4
Opportunities for recreation, tourism, and social interaction (i.e., community livability)	4.8	3.9
Improved pedestrian paths and connectivity (e.g., higher safety; quality of path; connectivity and linkage with other modes)	4.2	3.7
Improved accessibility	4.2	3.9
Provision of outdoor sites for education and research	4.4	4
Reduction of crimes and fear of crime (e.g., comfort; amenity and safety)	3.2	3.8
Attachment to place and sense of belonging (i.e., cultural and symbolic value)	4	3.6

Enhanced city attractiveness (e.g., more desirable views; restriction of undesirable views)	4.8	4.5
Improved physical well-being (e.g., physical outdoor activity; healthy food; healthy environments)	4.5	4.5
Better social well-being (e.g., social interaction; social integration; community cohesion)	4.1	3.8
Improved mental well-being (e.g., reduced depression and anxiety; recovery from stress; attention restoration; positive emotions)	4.4	4
Economic Aspect		
Increased property values	4.8	4
Greater local economic activity (e.g., tourism, recreation, cultural activities)	4.7	3.6
Healthcare cost savings	4	3.7
Profits from provisioning services (e.g., raw materials; food products; fresh water)	3.5	3.8
Value of less CO2 emissions and carbon sequestration	4.4	4
Value of lower energy consumption (e.g., reduced demands for cooling and heating)	4	4

(*Source: Author*)

The interview results denote that most of the benefits of GI planning are generally applicable in the lost spaces under study if this multifunctional approach were to be implemented. This is because a majority of the presented variables exhibited high scores in each category (environmental, social, and economic), regardless of typology. Climate and microclimatic modifications (4.8) and biodiversity protection and enhancement (4.7) were ranked the highest among the presented environmental benefits under Typology 1. In terms of social benefits, opportunities for recreation, tourism, and social interaction (4.8) and enhanced city attractiveness (4.8) were the top ranked aspects, while increased property values (4.8) was the top-scoring economic benefit (see Figures 10 and 11). As for Typology 2 (see Figures 12 and 13), the results highlight that the top ranked benefits pertained to the environmental aspect, with air quality improvement, improved soil quality and erosion prevention, and biodiversity protection and enhancement scoring an average of 4.8 respectively. When viewed by theme (i.e., environmental, social, economic), Typology 1 spaces appeared to greatly benefit from social advantages with an average score of 4.5, whereas Typology 2 spaces were found to mainly benefit from the environmental aspect with an average score of 4.7. This is explained by the fact that spaces under Typology 2 are somewhat hard to access, thus limiting social opportunities there. Although the scores were relatively high, with total average scores for all benefits at 4.35 for Typology 1 and 4.15 for Typology 2**,** further clarification by the interviewees in the subsequent discussion section revealed deeper insights. Specifically, the discussion findings indicated that the key factors influencing the overarching benefits of GI in lost spaces are space typology, locality and site context, accessibility, safety, and responsiveness to the surrounding community's needs.

Figures 10 and 11: Example of spaces underneath elevated highway categorized under Typology 1. Figure 10 is an example of residual spaces underneath DUKE (Typology 1) and Figure 11 shows a portion of residual space underneath AKLEH. These spaces are relatively easy to access and generally utilized for public usage such as informal parking and passageway thus is considered suitable for social benefits such as opportunities for recreation, tourism, social interaction as well as enhanced city attractiveness
Source: Author

Figures 12 and 13: Example of spaces underneath elevated highway categorised under Typology 2. Figure 12 and 13 is an example of residual spaces underneath MEX (Typology 2). These spaces are considered hard to access and generally restricted from any public usage due to its location and surrounding context and thus considered suitable for environmental benefits such as air quality improvement, improved soil quality and erosion prevention as well as biodiversity protection and enhancement
Source: Author

The results have shown that employing GI planning to address lost spaces underneath elevated highways brings myriad benefits, which nonetheless vary according to the typologies of the spaces. The findings of this study are in line with several preceding studies which identified an array of GI's environmental, social, health, and economic benefits with regard to spatial planning and design in urban areas. Its benefits, such as more green spaces, can be considered an opportunity to increase biodiversity in the city and thereby promote a better quality of life (Van Zyl et al., 2021; Liu & Russo, 2021; Ramyar et al., 2021; Weththasinghe & Wijesundara, 2017). Apart from that, economic benefits in terms of higher land and property value, increased investment and spending, as well as environmental cost-saving are also the direct outcomes of spaces and cities with more GI elements (Choi et al., 2021; Hansen et al., 2019; Kim, 2016; Gore et al., 2013). Moreover, improved physical and mental health benefits following the recent global Covid-19 pandemic are linked with urban areas that have more GI elements (Pamukcu-Albers et al. 2021; Heckert & Bristowe 2021; Hanzl, 2021). In particular, scholars have highlighted the importance and advantage of a tactical approach in transforming urban spaces to create more green areas that benefit the general public. Therefore, based on the core principles and elements of GI which revolve around multifunctionality (Choi et al., 2021; Van Zyl et al., 2021; Hansen et al., 2019; Benedict & McMahon, 2012), it can be concluded that GI is a suitable planning and design approach to address residual spaces. This claim is made on the basis that GI planning can offset the issues generated by traditional monofunctional planning and provide a wide range of environmental, social, and economic benefits to the city.

The overall aim of this study was to identify the benefits of GI planning in addressing residual spaces underneath elevated highways. To this end, the revealed typologies prove to be a useful first step to cultivate a better appreciation and understanding of the potential benefits of addressing lost spaces through GI. This study also represents an early attempt to gain inclusive insights into the benefits of the GI planning approach as opposed to the conventional zoning planning method. As proven by the present empirical findings, GI has various advantages over traditional planning; this should entice landscape architects, planners, urban designers, and policy makers to undertake GI for the more holistic and informed planning of infrastructure and residual spaces, particularly underneath elevated highways, to mitigate the current lost space situation in urban areas. Through GI's multifunctional approach to spatial planning, lost spaces can be transformed or, to a certain extent, avoided. Ultimately, a comprehensive understanding of the potential benefits of lost space redesign and planning through GI is highly valuable to the city in general. By acknowledging the benefits provided by GI along with its suitability for redesign and development, this study has important implications in driving a more holistic spatial planning approach for the achievement of a sustainable compact city, in line with Kuala Lumpur's 2040 aspirations.

CONCLUSION

In conclusion, despite the expanding discussion on the applications and benefits of GI, there is little knowledge on how its benefits can address residual and lost spaces, especially in Kuala Lumpur City. In response to this, the findings from this study have, to a certain extent, shed light on the advantages of GI planning in lost spaces, specifically based on the two typologies of residual spaces underneath elevated highways. In line with the objective of this study, it was discovered that the typologies of lost spaces (i.e., easily accessible and hard to access) present two extremes of benefits; Typology 1 leans towards social and economic benefits while Typology 2 leans towards environmental benefits. Against the highlighted GI benefits, it is evident that the current monofunctional planning approach of infrastructure requires new approaches and more sustainable design concepts — a gap which the GI planning approach can fill. Difficult spaces, particularly those under elevated highways, are a result of previous traditional planning. Notably, they constitute a large proportion of urban land and are of interest to many stakeholder groups. This study suggests that while lost spaces are often viewed as hazardous or unsightly, GI planning can turn them into an economic, social, and environmental resource that contributes to the compact city goal. With the rate of urbanization predicted to intensify in future years, mitigating the monofunctional effects of traditional spatial planning and managing dwindling urban spaces is a key factor in ensuring cities are compact and sustainable. Future studies are recommended to look deeper into specific GI benefits with regard to urban spatial planning and design (e.g., ecosystem services, quality of life) as well into GI's technical aspects (e.g., safety, regulations, and planning policy).

REFERENCES

Ahern, J., (2007). Green infrastructure for cities: the spatial dimension. In: Novotny, V., Brown, P. (Eds.), Cities of the Future: Towards Integrated Sustainable Water and Landscape Management. IWA Publishing, London.

Allen, W. L. (2014). A Green Infrastructure framework for vacant and underutilized urban lands. *Journal of Conservation Planning, 10*, 43–51.

Anderson, E. C., & Minor, E. S. (2017). Vacant lots: An underexplored resource for ecological and social benefits in cities. *Urban Forestry and Urban Greening*, 21(December), 146–152.

Anuar, M. I. N. M., & Abdullah, S. A. (2020). Reappropriation of elevated highway residual space through green infrastructure planning. *Planning Malaysia*, *18*.

Armson, D.; Stringer, P.; Ennos, A.R. (2012). *The effect of tree shade and grass on surface and globe temperatures in an urban area. Urban Forestry & Urban Greening 11* (3), 245-255.

Benedict, M. A., & McMahon, E. T. (2012). Green infrastructure: linking landscapes and communities. Island press.

Benton-Short, L., Keeley, M., and Rowland, J. (2019). Green infrastructure, green space, and sustainable urbanism: geography's important role. *Urban Geogr*. 40, 330–351. doi: 10.1080/02723638.2017.1360105

Biesecker, C. (2015). Designing urban under highway spaces. Masters' dissertation, University of Georgia.

Bürgi, M., A. M. Hersperger, and N. Schneeberger. (2004). Driving forces of landscape change—current and new directions. Landscape Ecology 19:857–868.

Chatzimentor, A., Apostolopoulou, E., and Mazaris, A. D. (2020). A review of green infrastructure research in Europe: challenges and opportunities. *Landsc. Urban Plan*. 198:103775. doi: 10.1016/j.landurbplan.2020.103775

Choi, C., Berry, P., & Smith, A. (2021). The climate benefits, co-benefits, and trade-offs of green infrastructure: A systematic literature review. *Journal of Environmental Management*, *291*, 112583.

Donovan, G.H.; Butry, D.T. (2010). Trees in the city: Valuing Street trees in Portland, Oregon. Landscape and Urban Planning 94 (2), 77-83.

Elliott, R. M., Motzny, A. E., Majd, S., Chavez, F. J. V., Laimer, D., Orlove, B. S., & Culligan, P. J. (2020). Identifying linkages between urban green infrastructure and ecosystem services using an expert opinion methodology. *Ambio*, *49*(2), 569-583.

Forman RTT, Sperling D, Bissonette JA, Clevenger AP, Cut- shall CD, Dale VH, Fahrig L, France R, Goldman CR, Heanue K, Jones JA, Swanson FJ, Turrentine T, Winter TC (2003) Road ecology: science and solutions. Island Press, Washington, DC

Franck, K. A. (2011). Occupying the Edge and the Underneath- "Other" Urban Public Spaces. In T. Hauck, R. Keller, & V. Kleinekort (Eds.), Infrastructural Urbanism Addressing the In- between (pp. 117–129). Berlin: DOM Publishers.

Goodspeed, R., Liu, R., Gounaridis, D., Lizundia, C., & Newell, J. (2021). A regional spatial planning model for multifunctional green infrastructure. *Environment and Planning B: Urban Analytics and City Science*, 23998083211033610.

Gore, T., Eadson, W., Ozdemiroglu, E., Gianferrara, E., & Phang, Z. (2013). Green Infrastructure's contribution to economic growth: a review.

Hansen, R., Olafsson, A. S., Van Der Jagt, A. P., Rall, E., & Pauleit, S. (2019). Planning multifunctional green infrastructure for compact cities: What is the state of practice? *Ecological Indicators*, *96*, 99-110.

Hansen, R., & Pauleit, S. (2014). From multifunctionality to multiple ecosystem services? A conceptual framework for multifunctionality in green infrastructure planning for urban areas. *Ambio*, *43*(4), 516-529.

Hanzl, M. (2021). Urban forms and green infrastructure–the implications for public health during the COVID-19 pandemic. *Cities & Health*, *5*(sup1), S232-S236.

Heckert, M., & Bristowe, A. (2021). Parks and the Pandemic: A Scoping Review of Research on Green Infrastructure Use and Health Outcomes during COVID-19. *International Journal of Environmental Research and Public Health*, *18*(24), 13096.

Hutyra LR, Yoon B and Alberti M (2011) Terrestrial carbon stocks across a gradient of urbanization: A study of the Seattle, WA region: Urban terrestrial carbon stocks. Global Change Biology 17(2): 783–797.

Jacobs, S., Burkhard, B., Van Daele, T., Staes, J., & Schneiders, A. (2015). 'The Matrix Reloaded': A review of expert knowledge use for mapping ecosystem services. *Ecological Modelling*, *295*, 21-30.

Kim, G. (2016). The public value of urban vacant land: Social responses and ecological value. *Sustainability*, *8*(5), 486.

Kim, G., Miller, P. A., & Nowak, D. J. (2018). Urban vacant land typology: A tool for managing urban vacant land. *Sustainable Cities and Society*, 36(October 2017), 144–156.

La Rosa, D., & Pappalardo, V. (2021). Policies and planning of urban green infrastructure and sustainable urban drainage systems. In *Urban Services to Ecosystems* (pp. 297-316). Springer, Cham.

Lennon, M., & Scott, M. (2014). Delivering ecosystems services via spatial planning: reviewing the possibilities and implications of a green infrastructure approach. *Town Planning Review, 85*(5), 563–587.

Liu, O. Y., & Russo, A. (2021). Assessing the contribution of urban green spaces in green infrastructure strategy planning for urban ecosystem conditions and services. *Sustainable Cities and Society*, *68*, 102772

Locatelli, B., Pavageau, C., Pramova, E., Di Gregorio, M. (2015). Integrating climate change mitigation and adaptation in agriculture and forestry: opportunities and trade-offs. Wiley Interdisciplinary Reviews: Climate Change 6 (6), 585–598. https:// doi.org/10.1002/wcc.357.

Matthews, T., Lo, A. Y., & Byrne, J. A. (2015). Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. *Landscape and urban planning, 138*, 155-163.

McPhearson T, Kremer P and Hamstead ZA (2013) Mapping ecosystem services in New York City: Applying a social–ecological approach in urban vacant land. Ecosystem Services 5: 11–26. https:// doi.org/10.1016/j.ecoser.2013.06.005

Mell, I. (2016). Global green infrastructure: lessons for successful policy-making, investment and management. Routledge.

Naumann, S., Davis, M., Kaphengst, T., Pieterse, M., & Rayment, M. (2011). Design, implementation and cost elements of Green Infrastructure projects. *Final report, European Commission, Brussels*, *138*.

Pakzad, P., & Osmond, P. (2016). Developing a sustainability indicator set for measuring green infrastructure performance. *Procedia-social and behavioral sciences*, *216*, 68-79.

Pamukcu-Albers, P., Ugolini, F., La Rosa, D., Grădinaru, S. R., Azevedo, J. C., & Wu, J. (2021). Building green infrastructure to enhance urban resilience to climate change and pandemics. *Landscape ecology*, *36*(3), 665-673.

Pauleit, S., Hansen, R., Rall, E. L., Zölch, T., Andersson, E., Luz, A. C., ... & Vierikko, K. (2017). Urban landscapes and green infrastructure. In *Oxford Research Encyclopedia of Environmental Science*.

Pauleit, S., Vasquéz, A., Maruthaveeran, S., Liu, L., & Cilliers, S. S. (2021). Urban green infrastructure in the Global South. In *Urban ecology in the Global South* (pp. 107-143). Springer, Cham.

Prasetyo, F.A. & Martin-Iverson, S., (2015). Playing under the fly over A collaborative creative community in Bandung. *Procedia-Social and Behavioral Sciences*, 184, pp.30-39.

Qamaruz-Zaman, N., Samadi, Z., Farhanah, N., & Azhari, N. (2013). Under the Flyovers of Kuala Lumpur: User Centered Activities in Leftover Spaces. *Journal of Asian Behavioural Studies, 3*(10).

Ramyar, R., Ackerman, A., & Johnston, D. M. (2021). Adapting cities for climate change through urban green infrastructure planning. *Cities*, *117*, 103316.

Sanches, P. M., & Pellegrino, P. R. M. (2016). Greening potential of derelict and vacant lands in urban areas. *Urban Forestry and Urban Greening, 19,* 128–139.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Ka ́zmierczak, A., Niemela, J., James, P.(2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: a literature review. Landsc. *Urban Plann. 81* (3), 167–178. https:// doi.org/10.1016/j.landurbplan.2007.02.001.

Weththasinghe, A., & Wijesundara, J. (2017). Reclaiming Traffic Influenced Urban Residual Spaces for the Public in Colombo, Sri Lanka. Cities People Places: *An International Journal on Urban Environments, 2*(1).

Van Zyl, B., Lategan, L. G., Cilliers, E. J., & Cilliers, S. S. (2021). An Exploratory Case-Study Approach to Understand Multifunctionality in Urban Green Infrastructure Planning in a South African Context. *Frontiers in Sustainable Cities*.

Vignola, R., Locatelli, B., Martinez, C., Imbach, P. (2009). Ecosystem-based adaptation to climate change: what role for policy-makers, society and scientists? Mitig. Adapt. Strategies Glob. Change 14 (8), 691. https://doi.org/10.1007/s11027-009-9193-6.

Yiannakou, A., Salata, K.D. (2017). Adaptation to climate change through spatial planning in compact urban areas: a case study in the city of Thessaloniki. *Sustainability 9* (2), 271. https://doi.org/10.3390/su9020271.

Received: 15th September 2022. Accepted: 23rd November 2022

