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The Integration of Digital Technologies in Urban Landscape Design: A Study on Malaysia's Progress and Potential

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Abstract

Digital technologies are increasingly becoming ubiquitous tools in the design of modern-day urban spaces, allowing for new mechanisms of designing, managing, and maintaining public green areas. Technologies such as Geographic Information Systems (GIS), Building Information Modelling (BIM), digital twins, drone mapping, augmented reality (AR), virtual reality (VR), and parametric landscape modelling are increasingly used to maximise ecological performance, community engagement, and spatial efficiency in urban landscape design. Thus, this research identifies how digital technologies are leading to climate-resilient, sustainable, and people-oriented landscape solutions. The research discovers key gaps, challenges, and opportunities by contrasting these global strategies with Malaysia's existing urban landscape practices. The study uses quantitative methods, including literature review and insights from landscape architecture practices and academia, to conceptualise a framework for how Malaysia can integrate digital technologies into its urban landscape design. Findings from 36 respondents indicate that while awareness of tools like GIS and BIM is high, the practical adoption of advanced technologies such as AR/VR and smart irrigation remains limited. Nonetheless, digital technologies show strong potential to enhance design quality, improve environmental resilience, and enrich the daily experience of urban green spaces.

Keyword: Urban Landscape Design, Digital Technologies, Smart Cities

INTRODUCTION

With urban populations continuing to rise, cities worldwide are turning to digital technologies to enhance livability, sustainability, and resilience. It is against this background that the concept of digital urbanism, which involves integrating digital tools and computational systems into designing, managing, and governing urban space, has evolved (Batty, 2018). Digital urbanism takes advantage of technologies such as Geographic Information Systems (GIS), Building Information Modelling (BIM), digital twins, artificial intelligence (AI), and real-time data analytics to facilitate efficient spatial planning and resource allocation (Kitchin, 2021). These innovations are changing how cities are made functional and how the public spaces and landscape are conceptualised and maintained. In urban landscape design, digital technology enables designers to simulate climate conditions, optimise green infrastructure, and involve communities through immersive media like virtual reality (VR) and augmented reality (AR) (Ghani et al., 2019; Zhong et al., 2020).

In Malaysia, the application of digital technologies in urban development is gaining momentum, particularly through national-level smart city strategies and urban policy frameworks. Initiatives such as the Malaysia Smart City Framework (MSCF) and Kuala Lumpur Smart City Master Plan (2021-2025) have introduced digital platforms to improve urban infrastructure and public service delivery (PLANMalaysia, 2019; Kuala Lumpur City Hall, 2021). However, while these efforts often emphasise transportation, governance, and digital infrastructure, integrating digital tools into urban landscape design remains relatively underexplored.

Recent developments in cities like Johor Bahru, Putrajaya, and Penang show increasing use of GIS for green space planning, drone-based site analysis, and BIM for landscape infrastructure modelling (Rahman et al., 2022; Ismail & Yusof, 2023). Despite this progress, challenges such as limited expertise, lack of integrated policies, and uneven technological access continue to hinder the complete digital transformation of Malaysia's landscape architecture sector.

The use of digital technologies helps to advance the United Nations' Sustainable Development Goals (SDGs), namely SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action), by ensuring resilience, inclusiveness, and efficiency in cities (World Urban Forum, 2024). However, using these technologies poses the risk of data privacy, digital equity, and widening socio-economic disparities if poorly managed (Chen & Gonzalez, 2024).

This study aims to identify the scope of digital technologies utilised by individuals in landscape architecture, including those involved in practice, academia, or pursuing their studies in Malaysia. It will also assess the adoption rate of these technologies by landscape architects, as well as in urban areas such as Shah Alam and Lembah Klang. Through data analysis, literature review, and case studies, this study also aims to contribute knowledge on leveraging digital technologies to support vibrant and resilient urban development.

LITERATURE REVIEW

Introduction to Digital Technologies in Urban Landscape Design

Digital technology in urban landscape design uses modern computational tools and systems that assist landscape architects in designing, visualising, and managing outdoor urban landscapes. They allow designers to analyse the conditions of a site, simulate the impact of design, control ecological data, and communicate more effectively with stakeholders. These technologies are not used for visualisation alone but are essential to improve sustainability, precision, and flexibility in urban green space planning. For instance, GIS facilitates the spatial analysis of land use, flood zones, and vegetation cover to make decisions that improve resilience and connectivity in urban landscapes (Pereira, Cerda, & Novara, 2020). BIM is increasingly used to combine infrastructure design with landscape elements to reduce errors and construction processes (Krüger, Taha, & Moricca, 2021). At the same time, digital twins provide real-time feedback information that can be used to monitor landscape performance over time, enabling responsive management and climate adaptation (Zhong, Schmitt, & Arisona, 2020). Together, the tools represent a new trend in landscape architecture, moving away from traditional static design and towards dynamic, data-driven, and human-centred design solutions. As shown in Table 1 below, the functionality of digital technologies in urban landscape design varies across different tools and systems, each offering unique advantages that support design, analysis, and management processes.

Table 1: Digital Technology functionality in Urban Landscape Design

Digital Technology	Functionality in Urban Landscape Design	Sources
Geographic Information Systems (GIS)	Spatial analysis for green space planning, flood mitigation, and vegetation mapping	Pereira, Cerda, & Novara (2020)
Building Information Modelling (BIM)	3D modelling and project coordination between landscape and infrastructure components	Krüger, Taha, & Moricca (2021)
Digital Twins	Real-time monitoring and simulation of ecological systems and urban performance	Zhong, Schmitt, & Arisona (2020)
Drone Mapping	High-resolution aerial site analysis, topographic data collection, and vegetation health monitoring	Rahman, Abdullah, & Mohamad (2022)
Parametric Design	Responsive landscape forms based on environmental data (e.g., sun/shade, water flow)	Lee & Lim (2021)
Augmented Reality (AR) / Virtual Reality (VR)	Stakeholder engagement through immersive design visualisations and walkthroughs	Yusof & Ahmad (2024)
Smart Irrigation & IoT Sensors	Monitoring soil moisture, water use efficiency, and plant health in real-time	Tan & Chong (2023)

Challenges and Opportunities

While digital technologies offer numerous benefits, Malaysia also needs to deal with data privacy concerns, the high initial investment cost, and the need for trained expertise in new tools (Yigitcanlar et al., 2019; Mahidin & Yusof, 2021). In addition, integrating such technologies into traditional practices is also challenging for most urban designers and city governments (Ismail et al., 2020). Future research should develop scalable, low-cost, and inclusive digital tools to foster widespread access and even distribution of gains in urban design practice (Batty, 2018).

Despite these challenges, the revolutionary potential of digital technologies in urban design remains apparent. Digital technologies like Geographic Information Systems (GIS), Building Information Modelling (BIM), and Digital Twins have proven to be useful in rendering design more efficient, sustainable, and inclusive (Zhong, Schmitt, & Arisona, 2020; Krüger, Taha, & Moricca, 2021). In Malaysia, smart city planning examples in Putrajaya and Johor Bahru are testaments to the successful application of such technologies in developing adaptive and resilient cities (MAMPU, 2019; Smart City Handbook Malaysia, 2021).

Continued research, development, and policy support will be crucial in promoting the use of digital technologies in Malaysia's urban planning processes. This will play a very significant role in the country's aspiration for sustainable, smart cities by ensuring that digital tools are used to their full potential in planning the future of cities (PLANMalaysia, 2020).

RESEARCH METHODOLOGY

This study utilises a quantitative research method with a structured questionnaire as the principal data collection tool. Quantitative methods are best for collecting data that can be quantified, which can then be analysed by statistics to show patterns and correlations (Creswell, 2014). The reason behind the selected methodology is due to its ability to explain how digital technologies are being applied in current practice and the landscape architects' disposition towards such technologies in Malaysia's urban planning sector. For example, Mohamed and Sulaiman (2023) argued that current literature should not only focus towards widening the application of information technologies, i.e., GIS and BIM, into the design process, but also emphasised the need for more localised empirical findings. Therefore, the selected study area focuses on city design practitioners within the Malaysian context, particularly within the Lembah Klang region, including the rapidly developing city of Shah Alam.

Site Selection

The Lembah Klang region is selected due to its high concentration of landscape architecture consultancy firms registered with the Institute of Landscape Architects Malaysia (ILAM) and the presence of key academic institutions offering landscape architecture programs, making it an ideal setting for assessing current professional practices and technological adoption in urban landscape design (ILAM, 2024). Table 2 lists several landscape architecture firms within the Lembah Klang region based on the ILAM Registered Consultant Firms directory. These firms were selected not only because they are ILAM-registered, ensuring professional credibility and adherence to industry standards, but also due to their strong reputation. Many are award-winning, top-ranked, and recognised as pioneers in the field. Some of them have a long-standing presence and are known as early adopters of digital technologies, making them valuable case studies in understanding Malaysia's progress and potential in integrating digital tools within urban landscape design:

Table 2: List of Landscape Architecture Firms Situated in The Lembah Klang Region

No.	Firm Name	Location	Director(s)	Email
1	Verona Design Sdn. Bhd.	Kuala Lumpur	LAr. Wan Salamatul Juita Wan Hashim	veronadesignsdnbhd@gmail.com
2	Malik Lip & Associates Sdn. Bhd.	Petaling Jaya, Selangor	LAr. Hj. Nik Malik Zainal Abidin, LAr. Michael Lip Yoke Cheong	mlattdi@maliklip.com.my
3	LandArc Associates Sdn. Bhd.	Shah Alam, Selangor	LAr. Lee Kwai Pheng	landarcassociates@gmail.com
4	Sitelink (M) Sdn. Bhd.	Shah Alam, Selangor	LAr. Ahmad Shazli Hashim LAr. Anuar Mohd Noor	sitelink_05@yahoo.com
5	Veritas Landscape Sdn. Bhd.	Kuala Lumpur	LAr. Khalifah bin Jamaluddin	landscape@veritas.com.my

However, this study does come with several limitations. The geographic scope is confined to the Lembah Klang area, with priority consideration given to Shah Alam, due to its high concentration of landscape architecture firms such as Verona Design Sdn. Bhd. and Malik Lip & Associates Sdn. Bhd. and its involvement in smart city initiatives such as Smart Selangor. Accessibility of the sample is also a constraint, as the study primarily targets professionals who are reachable through online networks and digital platforms such as LinkedIn, email surveys, or Google Forms. This reliance on digital communication may limit the diversity and representation of the responses, especially from firms or practitioners less active on these platforms.

A purposive sampling approach is employed to ensure that the participants possess sufficient knowledge of employing digital technologies in city landscape planning. This non-probability sampling method allows the researcher to intentionally select the most relevant and informative individuals for the research topic. This study chooses respondents based on their active involvement in landscape architecture or related fields, where digital tools like GIS and BIM are applied. The respondent group comprises landscape architects within the private and public sectors, urban planners and designers, officers of local authorities such as Majlis Bandaraya Shah Alam (MBSA) and Dewan Bandaraya Kuala Lumpur (DBKL), academics, including students and lecturers of landscape architecture, and technologists in technology-based firms. This targeted selection increases the likelihood of gathering meaningful insights. According to the Central Limit Theorem, a minimum sample size of 30 respondents is sufficient to assume a normal data distribution for inferential statistical analysis, such as t- tests and ANOVA (Ghasemi & Zahediasl, 2012). This means that even if the sample size is not large, the data can still be validly analysed under the assumption of normal distribution.

Data will be collected through a self-completion online questionnaire, distributed digitally to landscape architecture professionals, urban planners, and relevant government departments. This method is selected for its ability to reach a broad audience efficiently and allow participants to respond conveniently. The online format also supports easier data management and analysis, especially for geographically concentrated areas like Lembah Klang.

The questionnaire is designed to gather quantitative data on the use and recognition of digital technologies such as GIS, BIM, and digital twins, the perceived benefits and challenges associated with their application in urban planning, and expectations regarding future adoption. The survey comprises closed-ended questions, including Likert-scale items, multiple-choice questions, and ranking formats. The Likert-scale section will measure agreement or perception levels on a 5-point scale (5-point scale: Strongly Disagree to Strongly Agree), enabling structured responses suitable for statistical interpretation.

ANALYSIS AND DISCUSSION

This section presents the analysis and findings derived from a survey conducted among 36 respondents involved in the field of landscape architecture across Malaysia, with a particular emphasis on urban areas in Shah Alam and Lembah Klang.

These findings are structured based on two main objectives: (1) to identify the scope of digital technologies utilised by individuals working in landscape architecture, including those in practice, academia, or currently pursuing their studies in Malaysia; and (2) to assess the adoption rate of these technologies by landscape architects, particularly in urban areas in Shah Alam and the Klang Valley.

Data collected through the survey is visualised in several figures, including bar charts and cross-tabulations, which display demographic details, occupation profiles, city of residence, and levels of digital technology familiarity. According to the Central Limit Theorem, a minimum sample size of 30 is sufficient to approximate a normal distribution, making the sample size of 36 valid for reliable descriptive analysis (Ghasemi & Zahediasl, 2012).

With the increasing global shift towards digitalisation in design and planning, tools such as GIS, Building Information Modelling (BIM), and Virtual Reality (VR) are transforming the way urban landscapes are developed (Rahman et al., 2019; Stiles, 2016). Each figure in this section is accompanied by a concise explanation highlighting the observed patterns and their relevance to Malaysia's progress and potential in integrating digital technologies within the landscape architecture industry.

Respondent's Demographics

Figure 1 shows the distribution of respondents by gender, with a higher number of male participants (58.3%) than female participants (41.7%). This indicates that the majority of the respondents involved in landscape architecture or related professions are male.

Figure 2 illustrates the age range of respondents, where the majority (69.4%) fall within the 18–24 age group, followed by 25–34 (16.7%), 35–44 (11.1%), and only 2.8% from the 45–54 age range. This suggests that most participants are younger professionals or students, which may reflect a more tech-savvy demographic who are more inclined to participate in an online survey related to digital technology.

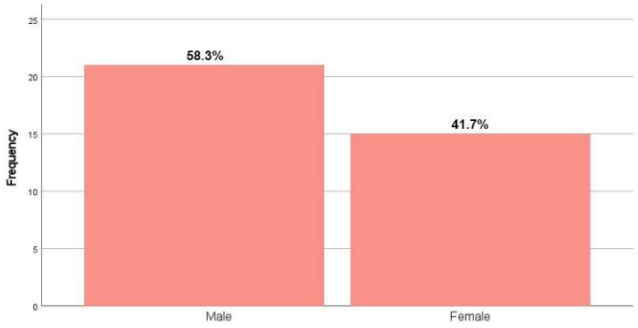

Figure 1 – Gender

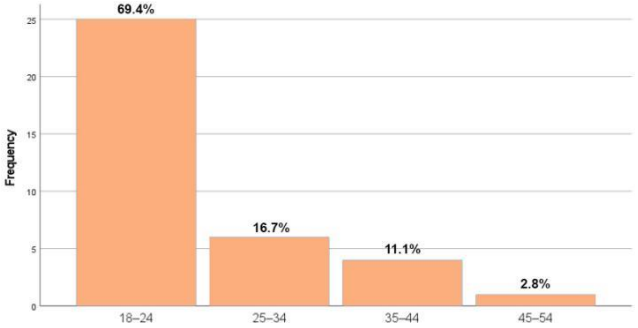

Figure 2 – Age

Figure 3 displays the occupation of respondents, showing that students make up the largest group at 72.2%, followed by equal representation from academicians, landscape designers, and landscape architects at 72.2%, 72.2%, and 16.7% respectively. A small proportion (2.8%) categorised themselves under "Other." This breakdown highlights the academic-heavy sample, with strong representation from those in education and early-career stages.

Figure 4 presents the respondents' current city of residence, with Kuala Lumpur and Shah Alam each contributing 36.1% of the responses. Klang and Rawang follow at 5.6% each, while 16.7% come from other locations. The concentration in major urban areas like Kuala Lumpur and Shah Alam aligns with the study's objective to assess digital technology adoption in urban settings.

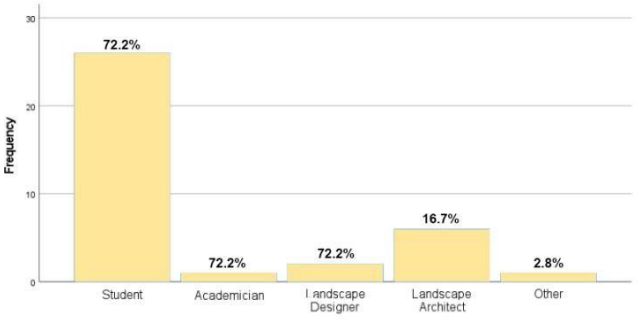

Figure 3 – Occupation

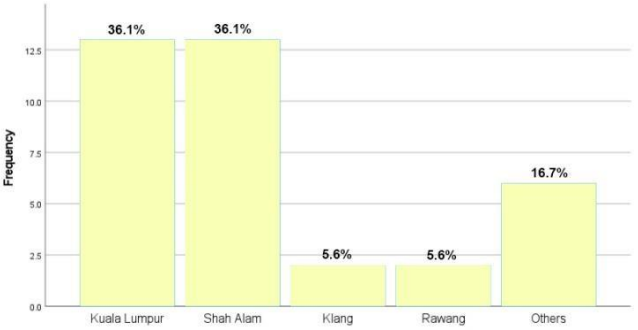

Figure 4 – Current City of Residence

Figure 5 examines respondents' familiarity with digital technologies, where the majority (65.6%) report being "Very Familiar," 38.9% "Somewhat Familiar," and only 5.6% "Not Familiar." These results indicate a high level of digital awareness and engagement among participants, which supports the relevance of exploring digital integration in urban landscape design within this sample.

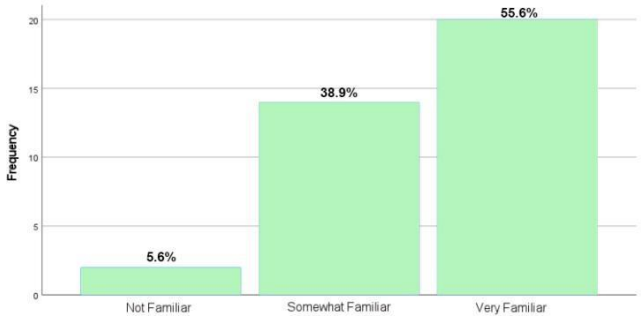

Figure 5 – Familiarity with Digital Technologies

This chapter presents the analysis and interpretation of data collected from 36 respondents involved in the field of landscape architecture, including professionals, academics, and students in Malaysia. The findings are organised into three key thematic areas derived from the research questions: knowledge, application, and challenges, summarised in Tables 3, 4, and 5, respectively. Each table includes the mean scores, standard deviations, and supporting interpretation to highlight respondents' understanding, usage, and barriers to integrating digital technologies in urban landscape design. These insights collectively reveal Malaysia's current progress and potential in advancing towards digital transformation in the landscape architecture sector.

Table 3: Knowledge of Digital Technologies in Urban Landscape Design (N = 36)

Knowledge Domain	Frequency (Percentage)					Mean
	Excellent (5)	Good (4)	Average (3)	Poor (2)	Very poor (1)	
a) I am aware that digital technologies are used in urban landscape design	18 (46.42)	11 (28.2)	7 (17.9)	1 (2.6)	2 (5.1)	**4.08**
b) I know that tools like GIS, BIM, or drones are applied in landscape architectural work	18 (46.2)	14 (35.9)	4 (10.3)	2 (5.1)	1 (2.6)	**4.14**
c) I can explain how digital tools are applied in the planning and design of public spaces	7 (17.9)	21 (53.8)	6 (15.4)	5 (12.8)	0 (0)	**3.75**
d) Digital tools help improve the quality of urban landscape design	15 (38.5)	18 (46.2)	4 (10.3)	1 (2.6)	1 (2.6)	**4.11**
e) I am knowledgeable about the principles of a "smart city" and how it influences urban landscape design	9 (23.1)	20 (51.3)	6 (15.4)	2 (5.1)	2 (5.1)	**3.75**

Table 3 illustrates the level of awareness and understanding of digital technologies among 36 respondents involved in landscape architecture. The highest mean value (m=4.14) was recorded for the statement "I know that tools like GIS, BIM, or drones are applied in landscape architectural work," indicating that a majority of respondents are familiar with the digital tools commonly used in the profession. This is closely followed by "Digital tools help improve the quality of urban landscape design" with a mean of (m=4.11), suggesting a general agreement on the value these technologies bring to the design process. Meanwhile, the lowest mean values (m=3.75) were found in two areas: the ability to explain how digital tools are applied in planning and design, and knowledge of smart city principles. This indicates that while general awareness is strong, deeper conceptual and technical understanding may not be evenly distributed among professionals.

Table 4: Application of Digital Technologies in Urban Landscape Design (N = 36)

Application Domain	Frequency (Percentage)					Mean
	Excellent (5)	Good (4)	Average (3)	Poor (2)	Very poor (1)	
a) I use digital tools such as GIS, CAD, or BIM in landscape architecture design	14 (35.9)	17 (43.6)	6 (15.4)	1 (2.6)	1 (2.6)	**4.06**
b) I apply 3D modelling and simulation software in designing the landscape	14 (35.9)	18 (46.2)	5 (12.8)	1 (2.6)	1 (2.6)	**4.00**
c) I integrate drone or satellite data in site analysis for urban landscape design	13 (33.3)	13 (33.3)	6 (15.4)	6 (15.4)	1 (2.6)	**3.72**
d) I have experience using smart irrigation systems or sensors in urban landscape design	9 (23.1)	13 (33.3)	7 (17.9)	8 (20.5)	2 (5.1)	**2.94**
e) I utilise augmented reality (AR) or virtual reality (VR) for landscape design presentations	6 (15.4)	9 (23.1)	11 (28.2)	10 (25.6)	3 (7.7)	**3.06**

Table 4 highlights the extent to which respondents apply digital technologies in their professional practice. The highest mean (m=4.06) is associated with the statement "I use digital tools such as GIS, CAD, or BIM in landscape architecture design," reflecting common and widespread use of standard digital tools in the field. This is followed by "I apply 3D modelling and simulation software in designing the landscape" with a mean (m=4.00), showing that 3D tools are also regularly used among practitioners. However, the application of more advanced or emerging technologies showed lower means. For example, "I utilise augmented reality (AR) or virtual reality (VR) for landscape design presentations" scored only (m=3.06), while "I have experience using smart irrigation systems or sensors" recorded the lowest mean at (m=2.94). These results suggest that while fundamental digital design tools are well integrated, the adoption of more innovative technologies is still in its early stages among many professionals.

Table 5: Challenges in Using Digital Tools in Urban Landscape Design (N = 36)

Challenge Domain	Frequency (Percentage)					Mean
	Excellent (5)	Good (4)	Average (3)	Poor (2)	Very poor (1)	
a) High cost of implementation	14 (35.9)	19 (48.7)	4 (10.3)	1 (2.6)	1 (2.6)	**4.00**
b) Lack of training or digital skills	10 (25.6)	19 (48.7)	4 (10.3)	2 (5.1)	2 (5.1)	**3.81**
c) Adapting to digital tools requires a shift in mindset that not all designers are ready for	9 (23.1)	17 (43.6)	8 (20.5)	4 (10.3)	1 (2.6)	**3.72**
d) Shortage of skilled professionals to operate and manage digital technologies in urban landscape design	12 (30.8)	14 (35.9)	10 (25.6)	2 (5.1)	1 (2.6)	**3.81**
e) Concerns about data security or privacy	12 (30.8)	13 (33.3)	8 (20.5)	4 (10.3)	2 (5.1)	**3.67**

Table 5 presents the challenges faced by professionals in adopting digital tools in urban landscape design, based on responses from 36 participants. The highest mean (m=4.00) corresponds to the statement "High cost of implementation," indicating that financial barriers are a significant concern for most respondents. This is followed by "Lack of training or digital skills" and "Shortage of skilled professionals," both with a mean of (m=3.81), highlighting the importance of capacity-building and professional development in facilitating digital integration. Additionally, "Adapting to digital tools requires a shift in mindset" (m=3.72) and "Concerns about data security or privacy" (m=3.67) suggest that both cultural and technical concerns play a role in slowing down adoption. Overall, the findings underscore that while digital tools are valued, widespread integration is hindered by practical, financial, and human resource challenges.

Discussion

The findings from the analysis provide important insights into the current state of digital technology integration within the field of urban landscape design in Malaysia. Based on responses from 36 individuals actively involved in the profession or study of landscape architecture, several key themes have emerged related to knowledge, application, and challenges in using digital tools.

The results indicate a generally high level of awareness among respondents regarding digital technologies and their relevance to urban landscape design. A significant majority acknowledged understanding the principles of digital tools such as GIS and BIM, and recognised their value in enhancing design processes. However, while conceptual knowledge was rated highly (M = 4.19), the ability to articulate specific applications showed slightly lower confidence (M = 3.75). This suggests a gap between theoretical understanding and practical implementation skills, especially when it comes to integrating digital methods into everyday design workflows. This finding aligns with Mohamed and Sulaiman (2023), who emphasised the need for more localised, practice- oriented digital training in the Malaysian landscape architecture field.

As seen in Table 4, foundational tools like GIS and CAD are already widely utilised (M = 4.06), reflecting the profession's gradual shift towards technology-enhanced practices. However, adoption of more advanced technologies such as augmented/virtual reality (M = 2.44) and smart integration systems (M = 2.94) remains limited. This points to a lag in embracing cutting-edge innovations despite growing global trends towards digital transformation in urban design (Kensek, 2014; Eastman et al., 2018). This may be attributed to a lack of institutional support, training, or infrastructure to support emerging technologies within Malaysia's urban landscape planning ecosystem.

Respondents identified several key barriers that hinder the broader integration of digital tools. High implementation costs (M = 4.08) and lack of technical expertise or training (M = 4.00) emerged as the most critical issues. These challenges reflect ongoing systemic limitations in both public and private sectors, particularly in providing access to digital resources and upskilling opportunities. Additionally, concerns about data privacy and security (M = 3.97) highlight the necessity for clear guidelines and secure digital infrastructure. These findings mirror global challenges identified by scholars like Batty (2013), who emphasised the digital divide as a significant obstacle in implementing smart and sustainable urban solutions.

Given that Shah Alam and Lembah Klang are major urban centres with a high concentration of landscape architecture firms and academic institutions, the relatively high awareness but low adoption of advanced digital tools points to untapped potential. These cities are ideal starting points for pilot programs, partnerships, and government incentives to foster digital innovation. The results reinforce the relevance of purposive sampling in this study, as the selected respondents are situated in regions primed for digital evolution yet still facing practical limitations moving forward.

CONCLUSION

This research has explored the integration of digital technologies in urban landscape design within the Malaysian context, focusing particularly on the practices and perceptions of professionals in the Klang Valley region. Through quantitative analysis and supported by literature and global precedents, the study concludes that while there is a high level of awareness and theoretical knowledge among Malaysian landscape architects, particularly regarding tools such as GIS and BIM. The practical adoption of more advanced technologies like AR/VR, digital twins, and smart sensors remains limited.

The results indicate that foundational digital tools are becoming commonplace, especially in firms and academic institutions in urban hubs such as Shah Alam and Kuala Lumpur. However, several barriers persist, including high implementation costs, a lack of technical training, and concerns over data privacy. These findings align with international observations of digital transformation in urban planning and highlight Malaysia's need for more structured policy support, funding mechanisms, and educational initiatives tailored toward technological upskilling in the landscape architecture sector.

The study reinforces the importance of fostering a digitally competent workforce and creating supportive ecosystems where innovative landscape design technologies can thrive. Malaysia has significant potential to lead in digital urbanism within Southeast Asia, provided systemic constraints are addressed and interdisciplinary collaboration is promoted across public, private, and academic domains.

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