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IMPLEMENTATION OF VERTICAL GREENERY SYSTEMS IN BUILDING PROJECTS IN MALAYSIA

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Abstract

Rapid real estate development in Malaysia has led to the depletion of green areas, resulting in various environmental issues, some of which may have irreversible consequences. To address and mitigate these negative impacts, sustainable development practices that prioritize environmental concerns are essential. Vertical Greenery System (VGS) has emerged as a promising solution to enhance the environmental quality of dense urban areas in a sustainable manner. However, despite its potential benefits, VGS implementation remains limited in Malaysia due to system-related challenges and low public awareness. This paper aims to evaluate the application of VGS in Malaysian buildings and identify the primary obstacles to its widespread adoption. To gather insights, a comprehensive survey was distributed to 118 construction professionals and tenants of VGS-equipped buildings, examining multiple aspects of VGS such as energy consumption, indoor air quality, cost-effectiveness, property value enhancement, noise reduction, fire safety, architectural features, and their overall effects on occupant health and well-being. The data was analysed using descriptive statistics and Factor Analysis and revealed key VGS attributes, challenges to implementation in Malaysia, potential solutions and critical barriers to wider adoption. The findings offer valuable insights for policymakers, planners, and building professionals in devising strategies to effectively integrate VGS into Malaysian cities.

Keywords: Vertical Greenery System (VGS), Sustainable Development, Environmental Quality, Energy Consumption, Indoor Air Quality, Architectural Features

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INTRODUCTION

Increasing urbanisation worldwide can reduce green spaces, raise pollution, and waste energy. Vegetated facades, also known as Vertical Greenery Systems (VGS), represent an effective approach to restoring green areas on urban building exteriors, particularly where ground-level planting space is limited. VGS encompasses a range of applications, including vertical gardens, green walls, and bio-walls. By strategically integrating plants into building facades, VGS contributes to reducing ambient temperatures in metropolitan areas. This system further mitigates heat transfer through the building envelope, thereby enhancing thermal comfort for occupants and improving overall energy efficiency.

Owing to limited awareness and certain disadvantages, the adoption of Vertical Greenery Systems (VGS) in Malaysia remains at an early stage. Rapid urbanisation, driven by the country's dense population, where 77% of Malaysians now reside in urban areas has resulted in significant loss of open green spaces. This percentage is likely to have increased, highlighting the severe impact of urbanisation on Kuala Lumpur's green spaces and the resulting environmental challenges. The city experiences a pronounced urban heat island (UHI) effect, with nighttime UHI intensity reaching 6.0 °C and daytime urban cool island (UCI) intensity measuring 4.0 °C because urban commercial areas are hotter than green regions.

The hypothesis of this study is to determine whether installing VGS in Malaysian buildings can improve their sustainability and liveability by resolving the stated difficulties and raising public awareness. Policymakers, urban planners, and building experts will be able to create efficient strategies for the promotion and integration of VGS, resulting in a greener and more sustainable future for Malaysian cities, by comprehending and resolving the challenges to its implementation.

LITERATURE REVIEW

The practise of adding flora to vertical building surfaces, such as walls, facades, balconies, or roofs, is known as a vertical greenery system (VGS). A vertical garden or living wall is created by carefully placing plants, climbing vines, and other greenery (Wang et. al., 2019). To make up for the loss of green spaces brought on by growing urbanisation, the VGS idea seeks to reintroduce nature back into urban settings (Hanna, G. and Jerzy, S., 2019). VGS offers a variety of advantages for both the built environment and its occupants by integrating vegetation vertically.

The vegetation in VGS serves as a natural air filter, absorbing pollutants and particulates from the air and enhancing air quality in general (Heindri et. al., 2024). By providing shade, lowering solar heat absorption, and releasing moisture through evapotranspiration, they also aid in minimising the urban heat island

effect. Besides, VGS contributes significantly to improving energy efficiency. The plant layer serves as an insulating barrier, lowering the amount of heat transmission through building walls and lowering the demand for excessive air conditioning (Heindri et. al., 2024). This can therefore result in less energy being used and fewer greenhouse gas emissions.

In addition, by absorbing and holding onto rainwater, VGS helps to manage stormwater flow by easing the burden on urban drainage systems and lowering the risk of flooding. In addition to supporting habitat and biodiversity, the plants in VGS can aid in ecological preservation in urban settings (Moravej et. al., 2025). VGS has aesthetic and psychological benefits in addition to environmental ones. Greenery in the built environment benefits human wellbeing by lowering stress levels, elevating mood, and encouraging a sense of connection with nature (Salleh et. al., 2022, Lipczyńska et. al., 2024). By converting dull concrete walls into vivid green spaces, VGS can design visually appealing landscapes.

Careful planning and design considerations are required for the VGS implementation. To ensure the long-term viability of the green projects, factors including plant selection, irrigation systems, structural support, and maintenance requirements must be taken into consideration. Overall, VGS offers a creative and sustainable method for greening metropolitan areas. It provides a means of reintegrating nature into the constructed environment, resulting in cities that are healthier and more habitable (Manouchehri et. al., 2024). Wong, et al. (2010b) revealed that VGS does not improve rainfall retention or façade longevity. If neglected, aggressive vegetation on the façade can harm the building wall (Kontoleon & Eumorfopoulou, 2010).

RESEARCH METHODOLOGY

A questionnaire survey was adopted to understand the overall detailed needs and demands of VGS customers (end users who are those living or working in the buildings which have implemented VGS) and particularly construction professionals (landscape architects, engineers, contractors) who are more familiar and have related knowledge on VGS. 200 questionnaire surveys were sent to construction professionals from a non-probability sampling method. Whereas, the case studies of Vertical Greenery Systems (VGS) include Digi Technology Operation Centre, Platinum Sentral, and Jamnah View Condominium inhabitants were surveyed, and these buildings were described in Table 2. The case studies were selected due to several factors as in Table 1.

Table 1: Key Factors for Selecting the Case Studies.

Key Factors	Explanation
Location	Case studies should be chosen from areas that are like the research's target area or context. Regional aspects including temperature, building codes, and cultural preferences should be considered to get insights that are more relevant to the desired study area
Project Scale	It is crucial to include case studies that address a variety of project scales, from modest installations in private residences to sizable ones in public or commercial structures. This guarantees a thorough comprehension of the potential applications and difficulties across various project sizes
Project Type	A wider understanding of how VGS can be incorporated into various architectural typologies can be gained by including several project kinds. Residential complexes, office buildings, healthcare facilities, educational institutions, and public areas are a few examples. Every project type may have different factors to consider and requirements to implement VGS
Design Innovation	Choosing case studies that show cutting-edge design strategies or distinctive VGS implementation aspects might provide helpful insights into original solutions and best practises. Projects with excellent aesthetic integration, inventive plant species use, or new structural systems are a few examples.
Performance Metrics	Consider case studies that include performance metrics that have been measured and recorded in relation to the desired study objectives. Data on energy savings, improvements to air quality, thermal comfort, stormwater management, or tenant satisfaction may be included. The benefits of VGS can be supported by facts in projects with thorough performance evaluations
Success and Durability	Look for case studies that have been in use for long enough to have their long-term effectiveness assessed. Projects that have successfully established and maintained the VGS throughout time might offer insightful information on the robustness and efficacy of the system.
Diversity	Make sure that the case studies you choose to use reflect the various architects, designers, developers, and project teams. This aids in capturing a variety of viewpoints, strategies, and lessons discovered from different stakeholders participating in the implementation of VGS
Lessons Discovered	Case studies can offer insightful advice for overcoming obstacles and maximising the success of VGS initiatives by documenting problems, lessons learned, and recommendations for future implementations

Table 2: Profile of Selected Buildings with VGS Features

Building Name	Digi Technology Operation Centre	Platinum Sentral	Jamnah View Condominium
Perspective			
Building Type	Office	Commercial	Residential
Location	Subang High Tech Park, Shah Alam, Selangor	Lot E, Kuala Lumpur Sentral Park,	Damansara Height
Number of Storey	4-storey (23.5m high)	7-storey	23-storey
Green Building Index	GBI Gold rating	N.A.	N.A.
Plant Type	Climber plants	Climber plants	Bougainvillea

Building Name	Digi Technology Operation Centre	Platinum Sentral	Jamnah View Condominium
Plant Age	7 years	5 years	22 years
Plant Condition	Healthily grown with +/-20 cm thickness	Healthily grown with +/-10 cm thickness	Well grown in planter boxes
Orientation of VGS	All directions	Surrounding building	Northwest
Façade Materials	Plaster and paint with groove line	Plaster and paint	Plaster and paint

Structure of Questionnaire

The questionnaire survey was divided into three sections. The first section gathered respondents' demographic information, the second section contained the degree of importance & degree of satisfaction of demanded qualities of VGS and the third section assessed challenges/constraints encountered in VGS implementation. VGS's lacking features are shown by the disparity between importance and satisfaction in second section and the the third section covered VGS implementation issues and requested responders for solutions. At the end of the last part, construction professionals can answer three optional questions to learn more about project client requirements for VGS, key technical considerations for VGS implementation, and any thoughts on VGS implementation in Malaysia.

Second section and third section of the questionnaire survey were measured using a 4-point Likert scale, to avoid mid-points like "neutral". The data is collected through online platform and is self-administrated. Data is verified for readability and completeness before being coded and loaded into SPSS for analysis. 52 construction professionals and 66 building tenants completed the surveys. The response rate is 59% which is good. Reliability is assessed using Cronbach's Alpha before analysis (Nunnally, 1978). Table 2 shows good instrument reliability, i.e., above 0.7.

Table 3: Reliability of the measurement instrument

Section	Cronbach's Alpha	Number of Items
Demanded qualities of VGS	0.878	24
Challenges encountered in VGS implementation	0.829	16

Results and Discussion

Implementation and Benefits of VGS

VGS was considered moderately implemented by 57 respondents (48%) and lowly implemented by 61 respondents (52%). The most perceived benefits are energy savings (45 respondents), environmental benefits (38 respondents), aesthetic benefits (31 respondents), economic advantages (2 respondents), acoustic benefit (1 respondents), and others (1 respondents).

Degree of Importance and Satisfaction of Demanded Qualities

Table 3 shows the discrepancy between VGS mandated attributes' importance and satisfaction. This displays the desired attributes; however, respondents are unsatisfied with their performance. The total mean value for importance is 3.39 and satisfaction is 2.93, indicating that VGS implementation has to be improved. For the following items, importance and satisfaction differ most: VGS requires regular maintenance to maintain good condition and avoid damages, careful selection of vegetation to provide high durability and long lifespan, low life cycle cost (operation and maintenance cost) and low installation cost. VGS maintenance and cost must be improved. The mean ranking of desired attributes from responders from different backgrounds is also shown.

VGS's most desired traits are architecturally appealing VGS, VGS cools and comforts occupants (Taib et. al., 2018), VGS restores urban greenspaces, VGS filters dust and harmful gases, improving indoor air quality and VGS harmonises nature in cities. ANOVA reveals the significance of respondents' viewpoints from varied backgrounds (i.e. construction professionals and building occupants). Significance is 0.05 or less. All respondents agreed on the importance and satisfaction of these qualities, except for "VGS helps in reducing the temperature and provides thermal comfort to occupants," which had a significant level of 0.013, indicating that respondents from different backgrounds did not agree on this item. So, this study's top VGS features are architectural attractiveness and practicality in improving air quality, recovering green areas, and attaining urban sustainability.

VGS represents a novel green infrastructure idea combining vertical walls and living plants. VGS can improve a building's architectural design and produce a greener skyline to relieve the urban environment. Rapid urban development is replacing ground-level green spaces with concrete roads and pavement. Yusof and Johari (2012) found that Kuala Lumpur's green areas decreased by 59.4% from 24,222 to 14,386 hectares. Since most land is used for development, there is less land for planting vegetation to increase green areas. Hence, instead of planting on the ground, VGS allows vertical planting on building walls, which maximises space.

VGS is an alternative way to restore and increase green spaces in urban areas by planting vegetation vertically on building walls or facades. Vegetation is limited in modern cities due to the usage of land and space for construction. VGS also filters dust and hazardous gases. It inhibits dust (Johnson & Newton, 1993). According to Koyama et al. (2013), VGS traps airborne pollutants and filters indoor toxins emitted from the ventilation system. This is crucial in polluted cities. VGS are gigantic green lungs that filter airborne pollutants and improve air quality. Hence, VGS's dust and gas filtering is a sought-after feature. Respondents rate "bringing nature harmony" fifth. Flowers and greenery attract

birds, butterflies, and bees, creating a sense of natural harmony and a brighter, more relaxing environment. Building occupants may enjoy birds chirping in vegetated areas. Harmony in nature can refresh the mind and boost well-being. According to a landscape architect, Wong et al. (2010b) found that VGS can invigorate inhabitants in contact with vegetation. VGS can bring nature to towns lacking greenery.

Table 3 shows that construction professionals regard "VGS as one of the fire protection mediums," "raise the land price," and "decrease noise reflectivity" as the three least important attributes. As buildings have fire-fighting equipment and systems, VGS is not needed as a fire prevention medium. Most building professionals don't value VGS's ability to raise land prices. Most building experts don't prioritise VGS's sound reflectivity reduction. Not all VGS absorbs noise well. Wong et al., (2010a) found that VGS is a costly way to reduce noise. In the next step, Factor Analysis was used to gain greater insight into the desired attributes and main components.

Factor Analysis Results

Factor analysis was used to limit the many demanded features to certain factors (components) based on importance and reveals the most desired VGS attributes for future deployment. Data was pre-tested before factor analysis. Kaiser-Meyer-Olkin (KMO) sampling adequacy is 0.824, and Bartlett's Test of Sphericity has a Chi-Square of 1429.959, 276 degrees of freedom, and 0.000 significance level. This suggests factor analysis is possible with the data (Hair et al., 2010). Factor analysis using Principal Component Analysis extraction and Varimax with Kaiser Normalization rotation demonstrates that the twenty-four needed attributes can be grouped into six components. Table 4 shows that the components represent the set of items because the cumulative eigenvalue is > 67%. (Hair et al., 2010). The entries in Table 5 can be used to name each component. Hence, the six components expressing the desired attributes are energy and indoor air quality, VGS cost, VGS and property value, noise and fire danger reduction, VGS architectural characteristics and occupant health and well-being. Factor analysis

Barriers of VGS Application

Table 6 ranks barriers by highest mean value and the barriers hinder VGS implementation. Apart for "Vegetation might attract undesired insects and animals," all respondents ranked the barriers similarly. The majority of respondents believe VGS cost, including installation and life cycle cost, is the biggest obstacle to its adoption. Pérez et al. (2014) found that VGS usually has significant capital and life cycle costs for installation and operation and maintenance. Project size, VGS type, design complexity, local material availability, labour prices, and others affect VGS installation and life cycle costs

(Šuklje et al., 2013). VGS uses imported plants to enhance the building's aesthetics, which raises the expense of installation and maintenance. To maximise VGS cost while maintaining system quality, these parameters should be examined together.

Regular maintenance is one of the main challenges hindering the installation of Vertical Greenery Systems (VGS), as building management must ensure the durability and performance of the plantations. Respondents also noted that the lack of technical information is a significant barrier, as VGS remains a relatively new technology in Malaysia. The absence of clear design and installation guidelines further complicates adoption. Overall, insufficient technical knowledge, plant dependency on weather, and the need for strict regulation of design variables are the most significant hurdles in implementing VGS.

Ways to Overcome the Challenges in VGS

Respondents identified several enablers to overcome challenges in VGS implementation, including selecting suitable growing media, reducing costs through design, installation, and maintenance efficiency, and choosing the right plant types. They also suggested locating VGS where sunlight exposure is optimal, developing self-sustaining and low-maintenance systems, and creating a standardized database for design and performance. Cost was highlighted as the most pressing issue, as high capital and maintenance expenses hinder adoption. Plant selection and growth medium were also viewed as critical since inappropriate choices could reduce durability and waste investment. Overall, lowering costs and ensuring proper plant growth conditions were seen as essential to improving VGS feasibility.

In addition, respondents emphasized that VGS placement should balance sunlight access and aesthetic appeal, noting that improper orientation could hinder plant health. Self-sustaining VGS designs were recommended to reduce maintenance costs, though they require higher technical expertise and resources. A standards database was seen as vital for guiding architects, engineers, and landscape designers in ensuring quality and consistency. Raising awareness among developers, professionals, and the public was also identified as crucial, as limited knowledge continues to slow adoption. Finally, government support and incentives, alongside these technical strategies, were considered key to promoting wider implementation of VGS in Malaysia.

CONCLUSION

Construction professionals and end-users value Vertical Greenery Systems (VGS) for their aesthetics, cost efficiency, thermal comfort, energy savings, and contribution to restoring urban green spaces, though their priorities differ in

emphasis. Despite its potential, VGS adoption in Malaysia is constrained by high costs, intensive maintenance, limited technical knowledge, and plant suitability challenges. Respondents suggested solutions such as lowering costs, selecting appropriate vegetation, optimising placement for sunlight, developing low-maintenance systems, and creating standardised guidelines. Overall, VGS can enhance sustainability, environmental quality, and occupant well-being, but greater public awareness, technical support, and stakeholder collaboration are essential to accelerate widespread adoption in Malaysian cities.

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Table 6: Barriers of the implementation of VGS in Malaysia

Barriers	Mean	S.E. of Mean	ANOVA (Between Groups, df = 1)	
			F	Sig
High life cycle cost i.e., operation and maintenance cost	3.74	0.042	0.018	0.892
High installation cost	3.73	0.044	1.239	0.268
Requires regular maintenance of the vegetation throughout its lifetime	3.67	0.050	0.386	0.536
Lack of technical information (e.g., watering system, support structure)	3.58	0.052	0.101	0.751
Lack of knowledge on the suitability of plants used	3.58	0.053	0.000	0.991
Plant growth is largely influenced by weather condition	3.55	0.057	0.037	0.849
Architects and engineers have to consider the regular control of all design variables as it involves plants which are living life form	3.55	0.053	0.276	0.601
Lack of public awareness on VGS	3.50	0.055	2.453	0.120
Vegetation can attract unwanted insects and animals	3.50	0.052	5.457	0.021*
Poor workmanship	3.41	0.059	2.883	0.092
Complex design	3.39	0.069	0.845	0.360
Complex construction method	3.39	0.066	0.497	0.482
Possibility of damaging the building due to aggressively growing vegetation	3.29	0.070	2.923	0.090
Lack of incentives for implementing VGS	3.10	0.070	1.982	0.162
Overgrowing of plants makes VGS looks wild and unattractive	3.03	0.075	0.005	0.942
No established standardization of VGS	2.89	0.079	2.853	0.094

Table 3: Degree of importance and satisfaction of VGS demanded qualities.

Items of Demanded Qualities	Degree of Importance of Demanded Qualities		ANOVA (Between Groups, df = 1)		Degree of Satisfaction of Demanded Qualities		ANOVA (Between Groups, df = 1)		Absolute Difference Between Means	Grand Mean	Ranking (based on Grand Mean)
	Mean	S.E. of Mean	F	Sig.	Mean	S.E. of Mean	F	Sig.			
1. VGS helps in reducing the temperature and provides thermal comfort to occupants.	3.695	0.044	0.191	0.663	3.492	0.052	6.415	0.013*	0.203	3.593	2
2. VGS helps to improve air ventilation of the building.	3.441	0.063	0.085	0.771	3.085	0.068	1.240	0.268	0.356	3.263	12
3. VGS reduces energy consumption for air-conditioning.	3.636	0.055	0.407	0.525	3.178	0.061	0.123	0.727	0.458	3.407	7
4. VGS helps mitigating urban heat island (UHI) effects by reducing heat caused by UHI effects.	3.525	0.048	4.241	0.042*	3.297	0.054	0.033	0.857	0.229	3.411	6
5. VGS is able to absorb and filter dust and toxic gases, which helps to improve indoor air quality.	3.669	0.050	0.933	0.336	3.322	0.056	3.089	0.081	0.347	3.496	4
6. VGS helps to mitigate air pollution.	3.551	0.056	4.224	0.042*	3.017	0.066	0.555	0.458	0.534	3.284	11
7. VGS as a building's attractive architectural feature.	3.729	0.049	0.433	0.512	3.669	0.050	0.933	0.336	0.059	3.699	1
8. VGS hides displeasing building features (e.g. unevenly painted building wall).	3.398	0.066	5.249	0.024*	3.322	0.068	20.665	0.000**	0.076	3.360	8
9. VGS helps to hide service areas, mechanical equipment and storage access.	3.254	0.067	0.039	0.844	3.059	0.074	2.674	0.105	0.195	3.157	14
10. VGS absorbs and reduces noise disturbances.	3.102	0.061	2.239	0.137	2.644	0.062	0.475	0.492	0.458	2.873	21
11. VGS is able to reduce sound reflectivity.	3.059	0.064	1.851	0.176	2.610	0.063	0.382	0.538	0.449	2.835	22

Items of Demanded Qualities	Degree of Importance of Demanded Qualities		ANOVA (Between Groups, df = 1)		Degree of Satisfaction of Demanded Qualities		ANOVA (Between Groups, df = 1)		Absolute Difference Between Means	Grand Mean	Ranking (based on Grand Mean)
	Mean	S.E. of Mean	F	Sig.	Mean	S.E. of Mean	F	Sig.			
12. VGS acts as fire prevention.	1.890	0.073	3.331	0.071	1.915	0.086	0.501	0.480	0.025	1.903	24
13. VGS enhances urban environmental conditions by bringing nature harmony.	3.517	0.055	1.655	0.201	3.415	0.057	2.863	0.093	0.102	3.466	5
14. VGS helps to improve human health and well-being.	3.085	0.075	3.059	0.083	2.881	0.068	0.499	0.481	0.203	2.983	18
15. VGS helps to reduce human stress level by providing sense of nature in urban area.	3.432	0.056	0.021	0.885	3.229	0.056	2.279	0.134	0.203	3.331	9
16. VGS helps to restore green areas particularly in urban areas.	3.678	0.048	0.008	0.928	3.475	0.057	0.633	0.428	0.203	3.576	3
17. VGS as habitats for flora and fauna within urban areas.	3.297	0.063	10.382	0.002*	3.119	0.070	9.339	0.003*	0.178	3.208	13
18. VGS helps in increasing property value due to environmental benefits provided.	3.203	0.071	1.221	0.271	2.949	0.072	2.292	0.133	0.254	3.076	15
19. VGS helps in increasing the land price as a result of improvement of greenery quality levels.	2.924	0.073	0.880	0.350	2.576	0.084	7.366	0.008*	0.347	2.750	23
20. VGS contributes to sustainability features of a building.	3.449	0.068	7.188	0.008*	3.212	0.061	12.323	0.001**	0.237	3.331	10
21. Installation cost of VGS has to be lowered.	3.695	0.049	0.421	0.518	2.398	0.079	5.108	0.026*	1.297	3.047	16
22. Life cycle cost i.e. operation and maintenance cost of VGS has to be lowered.	3.754	0.047	0.081	0.776	2.271	0.087	4.679	0.033*	1.483	3.013	17
23. VGS requires regular maintenance to preserve good condition and avoid damages.	3.754	0.047	0.081	0.776	2.161	0.091	3.338	0.070	1.593	2.958	19
24. Vegetation used for VGS requires careful selection to ensure high durability i.e. long lifespan.	3.686	0.051	0.325	0.570	2.110	0.095	5.978	0.016*	1.576	2.898	20
Overall Mean	3.393				2.934				0.459	3.593	

Table 4: Cumulative eigenvalues and loadings

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.413	30.886	30.886	7.413	30.886	30.886	3.841	16.004	16.004
2	2.631	10.964	41.850	2.631	10.964	41.850	3.486	14.524	30.528
3	1.880	7.834	49.684	1.880	7.834	49.684	2.803	11.678	42.206
4	1.707	7.112	56.796	1.707	7.112	56.796	2.164	9.015	51.221
5	1.325	5.519	62.315	1.325	5.519	62.315	1.922	8.008	59.230
6	1.131	4.710	67.026	1.131	4.710	67.026	1.871	7.796	67.026
7	0.899	3.746	70.771						
8	0.819	3.411	74.182						
9	0.766	3.192	77.374						
10	0.689	2.872	80.246						
11	0.609	2.536	82.783						
12	0.565	2.352	85.135						
13	0.490	2.044	87.179						
14	0.460	1.918	89.096						
15	0.418	1.743	90.839						
16	0.399	1.663	92.502						
17	0.361	1.506	94.008						
18	0.301	1.256	95.263						
19	0.263	1.096	96.360						
20	0.227	0.947	97.306						
21	0.204	0.851	98.158						
22	0.198	0.827	98.985						
23	0.138	0.577	99.562						
24	0.105	0.438	100.000						

Table 5: Rotated components of demanded qualities of VGS

Items of Demanded Qualities	Component					
	1	2	3	4	5	6
2. VGS helps to improve air ventilation of the building.	0.763					
1. VGS helps in reducing the temperature and provides thermal comfort to occupants.	0.760					
3. VGS reduces energy consumption for air-conditioning.	0.756					
4. VGS helps mitigating urban heat island (UHI) effects by reducing heat caused by UHI effects.	0.686					
5. VGS is able to absorb and filter dust and toxic gases, which helps to improve indoor air quality.	0.664					
6. VGS helps to mitigate air pollution.	0.566					
22. Life cycle cost i.e. operation and maintenance cost of VGS has to be lower.		0.867				
21. Installation cost of VGS has to be lower.		0.863				
23. VGS requires regular maintenance to preserve good condition and avoid damages.		0.780				
24. Vegetation used for VGS requires careful selection to ensure high durability i.e. long lifespan.		0.623				
13. VGS enhances urban environmental conditions by bringing nature harmony.		0.450				
18. VGS helps in increasing property value due to environmental benefits provided.			0.830			
19. VGS helps in increasing the land price as a result of the improvement of greenery quality levels.			0.800			
20. VGS contributes to sustainability features of a building.			0.662			
17. VGS as habitats for flora and fauna within urban areas.			0.623			
16. VGS helps to restore green areas particularly in urban areas.			0.447			
11. VGS is able to reduce sound reflectivity.				0.889		
10. VGS absorbs and reduces noise disturbances.				0.874		
12. VGS acts as fire prevention.				0.525		
9. VGS helps to hide service areas, mechanical equipment, and storage access.					0.808	
8. VGS hides displeasing building features (e.g. unevenly painted building wall).					0.773	
7. VGS as a building's attractive architectural feature.					0.547	
14. VGS helps to improve human health and well-being.						0.769
15. VGS helps to reduce human stress levels by providing a sense of nature in the urban area.						0.751