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Environmental Quality Assessment of Bien Hoa City, Dong Nai Province by UEQ Index

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ABSTRACT

Poor surface water quality, air pollution, solid waste collection, domestic water supply, and many more environmental issues are plaguing urban areas due to policies encouraging fast urbanization but failing to synchronize infrastructure. This has heightened the importance of urban environmental management. This project conducts an urban environmental quality assessment (UEQ) in Bien Hoa City, the political, economic, cultural, and social heart of Dong Nai province, and a Grade I urban region in the Southern Key Economic Region. The PRS framework serves as the basis for the process used to establish environmental indicators, with the indicator's parameters and weight being established using a Delphi process. Seven component indicators and twenty-sixth indicators were calculated as a result. With a score of 44.4 on the UEQI, Bien Hoa City is deemed to have a merely "average" urban environment. The indicators for the individual parts are middling at best. Although Bien Hoa City's urban environmental quality index is subpar, timely improvements have steadily raised it and each of its indicators and will continue to do so.

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1. Introduction

Vietnam is just one of several countries that have experienced urbanization and urban growth. The urbanization strategy significantly affects both the local ecosystem and the economy. The term "urbanization" is used to describe the alteration of economic and labor structures as a result of population concentration and industrial development. Despite its numerous benefits, urbanization is not without its drawbacks. Rapid migration to urban areas that exceeds the rate of urbanization and socio-economic growth places enormous pressure and stress on existing infrastructure and highlights the importance of coordinated planning for managing urban development and building infrastructure. In addition, problems like traffic jams, floods, pollution, and the results of climate change emerge.

UNESCO's 'People and the Biosphere' research project [1] took Carson's idea of urban ecological quality (UEQ) and ran with it. Harmonious development is the focus of UEQ, which is why it blends the social, economic, and environmental spheres with 'human ecology' theories and viewpoints. Several earlier studies have reported measurements based on UEQ's original index [2], [3]. UEQ, on the other hand, is founded on several different indications that together form a thorough evaluation. Land surface temperature (LST) and standardized plant differential index (NDVI) [2], [4], [5] are two examples of indicators used in UEQ evaluation studies. Other indicators used are those based on remote sensing and socioeconomic indicators [6], [7]. Optimal indication selection, however, has no such technological constraints [8]. Hydrometeorological, land resource-related, socioeconomic, and topographic indicators were the four broad categories Liu et al. (2017) attempted to divide them into [9].

In addition, numerous theoretical frameworks are available to incorporate these variables [8], [10], [11], including "asset structural pressure", "stress management and response", "pressure and control status", "urban ecological infrastructure", and "ecological and feedback environmental pressures". However, these models all share the same drawbacks: they are theoretically complicated, have limited applicability, see the environment as a fixed state, and incorporate solely environmental variables [8].

To fully understand the process of environmental degradation and its dynamics [12], it is necessary to consider the environment from a variety of perspectives (spatial, physical, economic, and social characteristics of the city environment) when assessing the quality of the urban environment (UEQ). Better mapping is just one benefit of identifying UEQ's performance indicators, which may also be used to advance city planning and sustainable development through effective management.

The Urban Environmental Quality Assessment (UEQ) primarily offers data on things like land surface temperature, atmospheric parameters like air humidity and suspended particles, vegetation state and biomass amount, land use and land cover, and water cover [12].

There have been numerous international studies assessing and categorizing urban environmental quality. Some researchers have looked at how good urban schools are by using remote sensing data combined with GIS and signs like the Normalized Plant Differentiation Index (NDVI) [13] and the land surface temperature [14]–[19]. Environmental sustainability indicators (ESIs), like the Environmental Performance Index (EPI) and the Urban Prosperity Index (CPI), were used to rate and classify the urban environment in the study municipalities [20]–[22]. These were based on things like air quality, surface water quality, the quality of clean water services, the state of infrastructure, noise levels, and the efficiency of solid waste management. Expert interviews and the use of the PSR framework [14]–[16] are commonly used to choose which assessment indicators will be combined into composite indicators to reveal the state of the environment in the study areas.

Classified as a first-tier municipality, the city of Bien Hoa serves as the administrative, commercial, cultural, and social hub of Dong Nai Province. Its 264.08 km^2 of land area will be home to around 1,226,700 people in the year 2022. Transportation systems, sewage systems, and environmental sanitation have all felt the strain of the city's rapid population increase. In addition, the city of Bien Hoa is home to numerous industrial parks, the mining and manufacture of which have contributed significantly to environmental pollution. Lack of green space and consequent pollution of the environment are direct results of unsustainable urban expansion. The EUQ is an efficient method for gauging the state of the environment in the Bien Hoa metropolitan area; it serves both the public and city officials well.

2. Materials and Methods

2.1. Research diagram

There are several stages (Fig. 1) involved in creating and assessing an UEQI. The first is to suggest certain guidelines and standards for assessment based on the PSR Framework. Following the conclusion of the expert meetings, the weight is calculated using a formalized set of guidelines and indications. The indication weight and the indicator weight are both part of the weights. Scores for indicators require normalization of data in addition to weighting, which is a prerequisite for scoring. The acquired data must be normalized to ensure consistency along a single axis. The indicators used to derive sub-indicators can be consolidated in this way. Decision No. 1459/QD-TCMT and 1460/QD-TCMT are used to determine the air quality and water quality indicators, respectively [23], [24].

2.2. Research methodology

Data collection method: Using specialized reports from the Department of Natural Resources and Environment, Dong Nai Province, data on natural, socioeconomic, and the current level of environmental quality in Bien Hoa City were gathered.

Expert consultation (Delphi) is used to decide which components and indicators should be factored into the UEQI index calculation. This approach is based on gathering, reviewing, and confirming information from 21 specialists throughout multiple rounds to establish indicator groupings appropriate for the study region. Phase I: Identify potential participants and solicit feedback on research-related topics from those individuals. The second phase is to double-check any information that hasn't yet garnered widespread agreement and to assign numerical values to any content on which everyone can agree. Third round: fill in the blanks, become more granular with your quantification, and tie together what you've learned so far by connecting the dots between what you've learned in rounds one and two [25].

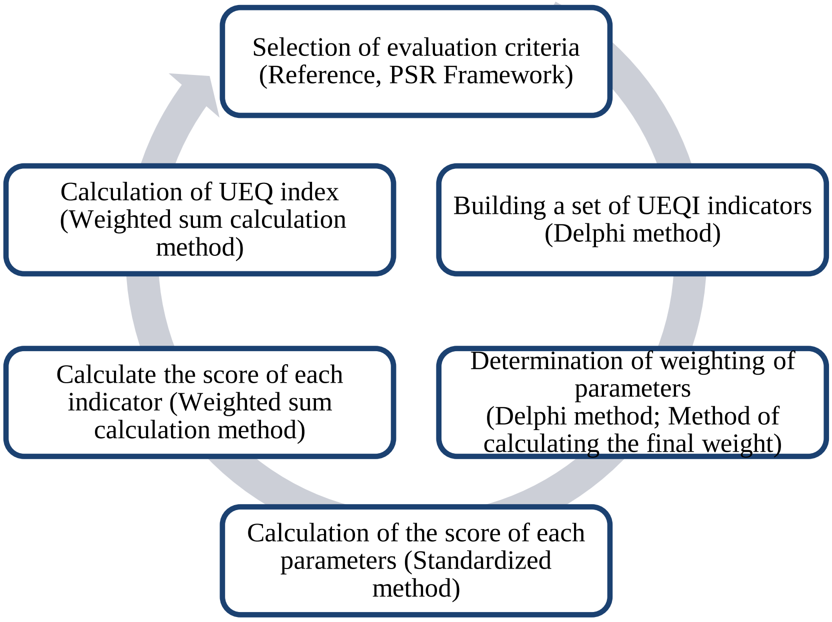

Figure 1. *Research Implementation Process*

The research uncovered a total of 26 parameters across 7 groups of component indicators: surface water quality (7 parameters), air quality (7 parameters), urban noise (1 parameters), solid waste management efficiency (5 parameters), infrastructure (2 parameters), clean water supply services (2 parameters), and environmental sanitation (2 parameters).

To determine the WQI index, the project monitored nine parameters (temperature, pH, DO, BOD_5, COD, TSS, Coliform, PO_4^-, NH_4^+ at three different sites following Decision 1460/QD-TCMT [24].

According to Decision 1459/QD-TCMT [23], the Air Quality Index (AQI) and Noise Index are determined by collecting data from three randomly chosen locations. The following eight parameters are measured: TSP dust (1-hour average), $PM_{2.5}$ dust (1-hour average), PM_{10} dust (10-hour average), SO_2, CO, NO_2, O_3 (8-hour average), and noise.

The samples were collected at three different places surrounding a monitoring station throughout the wet, dry, and transitional months of the year and presented in Figure 2.

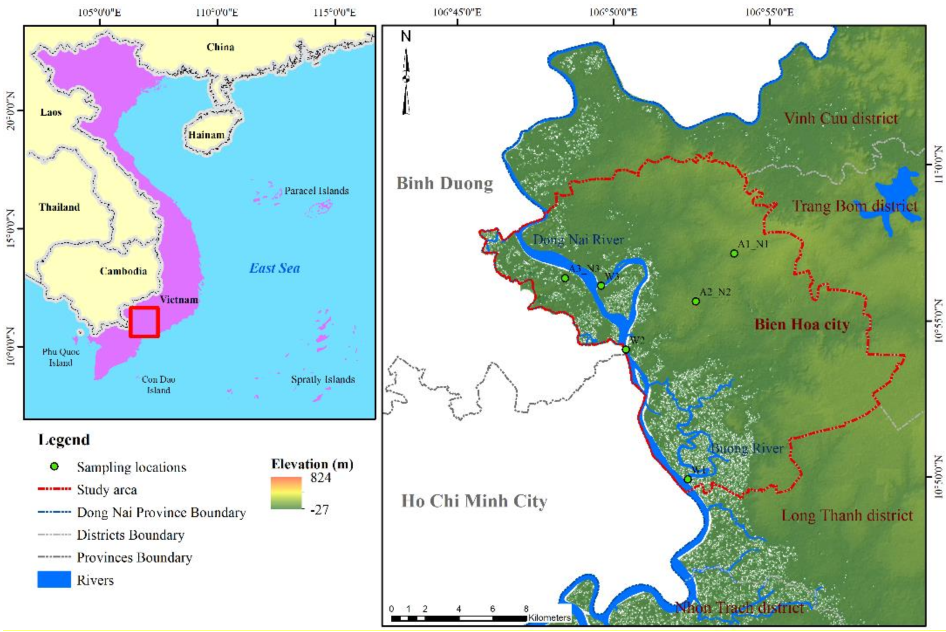

Figure 2. *Sampling sites on Bien Hoa City*

Means of arriving at a conclusive weight: The final weight is calculated by dividing the total provisional weight by the weight at the halfway point. Preliminary weighting is calculated using the important assessment score scale. Here, the respondent selects a scale from 1 to 10, with 1 representing the highest priority and 10 the lowest. The formula determines the precise final weighting following this convention as follows:

- Determine the ranking score of each selected factor through the formula:

Rating score (mi) = (Total score of each element / Total number of votes)

- Calculate the intermediate contribution weight of each selected element (wi'): Accept the smallest mi with wi' equal to 1, and calculate the wi' of other parameters using the formula: $=w_i{}' \frac{m_{i(\min)}}{m_i}$

- Calculate the official contribution weight portion of each parameter. $w_i = \frac{w_i{}'}{\sum_1^n w_i{}'}$

- The total weight contribution of the entire component/evaluation indicator is equal to 1.

Data normalization methods: The collected figures will be converted into scores using the upper and lower boundary values as the basis for normalization into scores. In particular, each collected indicator will select boundary values (upper and lower borders) as the basis for standardizing the collected data of that indicator on a scale of 1-100, according to the formula [17]

$$A_{ij} = 99\frac{(A_i - minA_j)}{(maxA_j - minA_j)} + 1 \quad (1)$$

$$\text{Or} \quad A_{ij} = 101 - \left(99\frac{(A_i - minA_j)}{(maxA_j - minA_j)} + 1\right) \quad (2)$$

where (1) is a group of indicators whose value is as large as possible reflecting that indicator and (2) is a group of indicators whose greater value reflects the worse of that indicator.

The weighted sum calculation method is applied to calculate the total weighted score for each indicator as well as for all component elements. The total score for each indicator can be considered the first step in calculating component indicators. All component indicators are then aggregated into a final index (UEQI). The formula for calculating the weighted total score of component indices, or UEQI indices, is calculated using the formula [22]

$$UEQI = \sum_1^n A_j W_j \quad (3)$$

Where: Aj is the score of the component indices in UEQI and W_j is the corresponding weight of the component index.

Assessment and classification of urban environmental quality based on the UEQI index is carried out according to Table 1.

Table 1. *Urban environmental quality classification is based on the UEQ index [22].*

The rate of achievement of the norms compared to the best	UEQI value	Classification
Reach from 90% - 100%	88 ≤UEQI ≤100	Excellent
Reach from 80% - less than 90%	63 ≤UEQI ≤ 88	Very Good
Reach from 65% - less than 80%	49 ≤UEQI ≤ 63	Good
Reach from 50% - less than 65%	38 ≤UEQI ≤ 49	Average
Reach <50%	UEQI ≤38	Poor

3. Results and Discussion

3.1. Urban Environmental Quality Index (UEQI)

The UEQI index consists of 7 criteria with 26 parameters proposed and included in the evaluation of the study through the PSR framework and 02 expert consultations based on the availability of locally available data. Each criterion has different levels of importance and priority, which are presented in Table 2.

Table 2. *Groups of indicators and indicators used to calculate the UEQ index.*

No.	Component indicators	Parameters	Unit
1	Surface Water Quality	Group I: pH parameters	
		Group IV: organic and nutritional parameters (BOD, COD,...)	mg/l
		Group V: microbiological parameters (coliform)	MPN/100ml
2	Air quality	Average hourly TPS dust concentration	µg/m^3
		Average hourly $PM_{2.5}$ dust concentration	µg/m^3
		Average hourly PM_{10} dust concentration	µg/m^3
		Average O_3 concentration 8h	µg/m^3
		Average hourly CO concentration	µg/m^3
		Hourly average SO_2 concentration	µg/m^3
		Hourly average NO_2 concentration	µg/m^3
3	Urban noise	Noise levels measured in urban areas	dB_A
4	Infrastructure	Greenland area per capita	m^2/người
		The ratio of traffic land to construction land	%
3	Effective solid waste management	The rate of domestic solid waste collected and treated	%
		The percentage of domestic solid waste recycled	%
		The proportion of domestic solid waste buried in a hygienic manner	%
		The proportion of medical waste safely treated, destroyed and buried	%
		The proportion of hazardous solid waste collected and treated up to standards	%
6	Clean water supply services	The proportion of urban people supplied with clean and hygienic water	%
		Water loss rate	%
7	Environmental sanitation	The percentage of municipal wastewater collected and treated	%
		The proportion of the population connected to the urban drainage system	%

3.2. Determination of weighting

The topic makes use of the weighting algorithm laid out in the section on research methods. The directive and indicator weighting procedures are laid out in detail in Tables 3 and 4. Provide a brief summary of the final indicator group and indicator weight.

As a general rule, the aggregate weight of all indicators is 1, and within each rule, the aggregate weight of the entire indicator is also 1. This directive's weight is typically set at 1 when there is just 1 indicator in play. As a result, 1 is assigned to the WQI, AQI, and noise level. To normalize the acquired data for each indicator on a scale from 0 to 100, the topic will choose boundary values (upper and lower borders) for the indicator.

Here are the specifics of the upper and lower bounds (marginal values) for every metric:

Using the WQI calculation data from three different measurement points in Bien Hoa City in 2022, we determine the top and lower limit values for this indicator. The maximum WQI in the sample set of 3 stations is 96, and the minimum WQI in the sample set of 3 stations is 29.

The AQI's upper and lower bounds for 2022 are derived from the AQI calculation data of three different measurement points in Bien Hoa City. The maximum AQI measured at three stations is 355, and the minimum AQI measured at three stations is 59.

Noise limit: 56 dBA is the quietest level recorded in all of Bien Hoa City's three monitoring stations. The maximum allowed value is 67, the highest noise value at any of the three Bien Hoa City measurement locations for a period of the year. MONRE and the Dong Nai Department of Construction rely on expert opinions and internal studies to define any remaining guidelines.

Table 3. *The result of calculating the weight for the criteria*

Evaluation criteria	Total score	Rating points (m_i)	Intermediate weighting (w_i')	Final weighting (w_i)
The rate of domestic solid waste collected and treated (%)	10.1	0.48	1.22	0.21
The percentage of domestic solid waste recycled (%)	8.6	0.41	1.43	0.24
The proportion of domestic solid waste buried in a hygienic manner (%)	9.9	0.47	1.24	0.21
The proportion of medical waste safely treated, destroyed, and buried (%)	12.3	0.59	1.00	0.17
The proportion of hazardous solid waste collected and treated up to standards (%)	11.8	0.56	1.04	0.18
Greenland area per capita	8.1	0.39	1.00	0.47
The ratio of traffic land to construction land(%)	7.2	0.34	1.13	0.53
The proportion of urban people supplied with clean and hygienic water (%)	6.6	0.31	1.08	0.52
Water loss rate (%)	7.1	0.34	1.00	0.48
The percentage of municipal wastewater collected and treated (%)	11.3	0.54	1.00	0.44
The proportion of the population connected to the urban drainage system(%)	8.7	0.41	1.30	0.57

Table 4. *The result of the final weighting calculation for indicators*

Component indicators	Total score	Rating points (m_i)	Intermediate weighting (w_i')	Final weighting (w_i)
Surface Water Quality	5.6	0.27	1.46	0.15
Air quality	5.9	0.28	1.39	0.14
Urban noise	4.8	0.23	1.71	0.18
Effective CTR management	8.2	0.39	1.00	0.10
Urban infrastructure	4.9	0.23	1.67	0.17
Clean water supply services	5.7	0.27	1.44	0.15
Environmental sanitation	7.8	0.37	1.05	0.11

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3.3. Calculation of UEQ index and classification

Table 5 displays the outcomes of the UEQ index. Table 5 shows that Bien Hoa City has an average UEQI of 44.4, placing it in the range of 38 to 49. The closer to 0 you go on any of the seven evaluation factors that range from extremely poor to poor to average to good to very good on a scale from 0 to 100, the worse it is. As can be seen in Figure 3, just three out of a possible nine categories (air quality, urban noise, and clean water supply services) have above-average ratings, while four (surface water quality, solid waste management, urban infrastructure, and environmental sanitation) have below-average ratings.

Table 5. *The calculation results of the UEQ index*

No.	Component indicators	Weighting	Score	Value	UEQI
1	Surface Water Quality	0.15	38.56	5.9	44.38
2	Air quality	0.14	64.92	9.4	
3	Urban noise	0.18	67.00	11.9	
4	Effective solid waste management	0.10	17.76	1.9	
5	Urban infrastructure	0.17	20.91	3.6	
6	Clean water supply services	0.14	42.10	6.0	
7	Environmental sanitation	0.11	53.95	5.8	

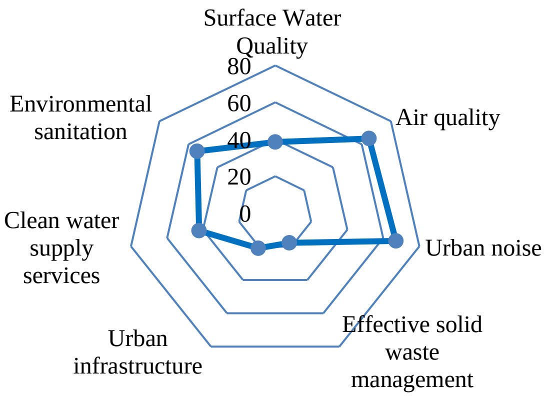

Figure 3. *Component index of Bien Hoa City*

Bien Hoa City's UEQI is compared to those of Ho Chi Minh City, Da Nang City, and Hue [22]. Hue City was found to have the best urban environment, with a score of 77.8 (out of a possible 88) and earning a "very good" rating. Comparable to Ho Chi Minh City in terms of urban environment quality is Bien Hoa City. HCM scores of 44.4 and 40.7, both in the range of 38–49, were below the "average" threshold. The quality of life in Da Nang City's urban environment is 60.5, placing it in the "good" category of cities.

4. Conclusions

Bien Hoa City was evaluated using the urban environmental quality index (UEQI), and it was found to have an average value of 44.4 at the urban level.

In Vietnam, this line of inquiry is just getting started, particularly at the local commune level. Because the UEQI index is an aggregate index, it requires a large number of indicators to be fully statistical, making the process of research and data collection more challenging than usual. The Vietnam probe and data handling aren't finished yet. There is a lack of statistical significance or lack of interest in a lot of data. The collected data are just indicative of the actual state of the environment. After all the data has been collected and organized, it can be input into additional programs like SLSI and GIS to produce more reliable numerical and statistical outputs. These findings will then be ready for implementation in environmental management.

Acknowledgments

Conflict of Interest

The authors declare no conflict of interest.

REFERENCES

[1] G. Kou, W. Wu, Y. Zhao, Y. Peng, N. E. Yaw, and Y. Shi, "A dynamic assessment method for urban eco-environmental quality evaluation," *J. Multi. Criteria Decis. Anal.*, vol. 18, no. 1-2, pp. 23-38, 2011. doi: 10.1002/mcda.

[2] S. Chakraborti, A. Banerjee, S. Sannigrahi, S. Pramanik, A. Maiti, and S. Jha, "Assessing the dynamic relationship among land use pattern and land surface temperature: a spatial regression approach," *Asian Geogr.*, vol. 36, pp. 93–116, 2019, doi: https://doi.org/10.1080/10225706.2019.1623054.

[3] S. Pramanik, M. Punia, and S. Chakraborty, "Does urban landscape composition and configuration regulate heat-related health risk? A spatial regression-based study in world's dense city Delhi, India," *Preprints*, 2020, Art. no. 2020110046.

[4] S. Pramanik and M. Punia, "Land use/land cover change and surface urban heat island intensity: source–sink landscape-based study in Delhi, India," *Environ. Dev. Sustain.*, vol. 22, pp. 7331–7356, 2019.

[5] S. Pramanik and M. Punia, "Assessment of green space cooling effects in dense urban landscape: a case study of Delhi, India," *Model Earth Syst. Environ.*, vol. 5, no. 3, pp. 867-884, 2019.

[6] J. He, S. Wang, Y. Liu, H. Ma, and Q. Liu, "Examining the relationship between urbanization and the eco-environment using a coupling analysis: case study of Shanghai, China," *Ecol. Indic.*, vol. 77, pp. 185-193, 2017.

[7] M. A. Musse, D. A. Barona, and L. M. S. Rodriguez, "Urban environmental quality assessment using remote sensing and census data," *Int. J. Appl. Earth Obs. Geoinf.*, vol. 71, pp. 95-108, 2018.

[8] D. Chen, X. Lu, X. Liu, and X. Wang, "Measurement of the eco-environmental effects of urban sprawl: theoretical mechanism and spatiotemporal differentiation," *Ecol. Indic.*, vol. 105, pp. 6-15, 2019.

[9] Y. Liu, W. Yue, P. Fan, Z. Zhang, and J. Huang, "Assessing the urban environmental quality of mountainous cities: a case study in Chongqing, China," *Ecol. Indic.*, vol. 81, pp. 132-145, 2017.

[10] N. Liu, C. Liu, Y. Xia, and B. Da, "Examining the coordination between urbanization and eco-environment using coupling and spatial analyses: a case study in China," *Ecol. Indic.*, vol. 93, pp. 1163-1175, 2018.

[11] X. Sun, X. Liu, F. Li, Y. Tao, and Y. Song, "Comprehensive evaluation of different scale cities' sustainable development for economy, society, and ecological infrastructure in China," *J. Clean Prod.*, vol. 163, pp. S329-S337, 2017.

[12] B. Liang and Q. Weng, "Assessing urban environmental quality change of Indianapolis, United States, by the remote sensing and GIS integration," *IEEE J. Sel. Top. Appl. Earth Obs.*, vol. 4, no. 1, pp. 43-55, 2011.

[13] Y. Zha, J. Gao, and S. Ni, "Use of normalized difference built-up index in automatically mapping urban areas from TM imagery," *Int. J. Remote Sens.*, vol. 24, no. 3, pp. 583-594, 2003.

[14] Md. J. B. Alam, M. J. B. Alam, M. H. Rahman, S. K. Khan, and G. M. Munna, "Unplanned urbanization: Assessment through calculation of environmental degradation index," *Int. J. Environ. Sci. Tech.*, vol. 3, no. 2, pp. 119-130, 2006.

[15] S. Pramanik, G. Areendran, M. Punia, and S. Sahoo, "Spatio-temporal pattern of urban eco-environmental quality of Indian megacities using geo-spatial techniques," *Geocarto International*, vol. 37, no. 17, pp. 5067-5090, 2021.

[16] S. Ghosh *et al.*, "Impact of COVID-19 Induced Lockdown on Environmental Quality in Four Indian Megacities Using Landsat 8 OLI and TIRS-Derived Data and Mamdani Fuzzy Logic Modelling Approach," *Sustainability*, vol. 12, no. 13, p. 5464, 2020.

[17] J. A. P. Sousa *et al.*, "Developing Of An Urban Environmental Quality Indicator," *Geography Environment Sustainability*, vol. 14, no. 2, pp. 30-41, 2021.

[18] A. Malah *et al.*, "Assessment of Urban Environmental Quality: A case study of Casablanca, Morocco," in *The International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences*, 2021, pp.205-210.

[19] O. Gunawan, R. P. Armitage, and P. James, "An Urban Environmental Quality index for Salford, Greater Manchester: A disaggregated approach," in *GISRUK2012*, 2020, Paper 71.

[20] H. M. Dung *et al.*, "Research on developing a set of green growth criteria applying assessment, classification and proposing solutions to promote green growth for urban districts of Ho Chi Minh City," 2015.

[21] H. T. T. Tien, "Developing a set of directives and indicators to assess performance and environmental sustainability of Binh Duong province," 2011.

[22] T. Q. Loc *et al.*, "Research on developing an urban environmental quality index (UEQI) and applying it to some urban areas in Vietnam," 2011.

[23] Ministry of natural resources and environment of Vietnam, decision 1459/QĐ-TCMT (2019, Nov. 12), *Promulgation of technical guidelines for calculation and publication of Vietnam air quality index (VN_AQI)*.

[24] Ministry of natural resources and environment of Vietnam, decision 1460/QĐ-TCMT (2019, Nov. 12), *Promulgation of technical guidelines for calculation and publication of Vietnam Water Quality Index (VN-WQI).*

[25] L. T. N. Anh, "Using Delphi method in developing a research framework to assess competitiveness and weaknesses in tourism," 2017.

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