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Environmental Resilience Index: A Methodology for Data Collection and Data Analysis

M. Zainora Asmawi[1*], Sharifah Husna Syed Zainal Yussof[2], Wan Nurul Mardiah Wan Mohd Rani[3], Illyani Ibrahim[4], Syakir Amir Ab. Rahman[5]

[1]Department of Urban and Regional Planning, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, Jalan Gombak, 53100, Kuala Lumpur, Malaysia.
Email: zainora@iium.edu.my
[2]Department of Urban and Regional Planning, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, Jalan Gombak, 53100, Kuala Lumpur, Malaysia.
Email: Husnajamallullail96@gmail.com
[3]Institute Sultan Iskandar, Blok J1, UTM, Jalan Sultan Yahya Petra, 54100 Kuala Lumpur, Malaysia.
Email: wnurul.kl@utm.my
[4]Department of Urban and Regional Planning, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, Jalan Gombak, 53100, Kuala Lumpur, Malaysia.
Email: illyani_i@iium.edu.my
[5]Department of Urban and Regional Planning, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, Jalan Gombak, 53100, Kuala Lumpur, Malaysia.
Email: syakiramir@iium.edu.my

CORRESPONDING AUTHOR (*):
M. Zainora Asmawi
(zainora@iium.edu.my)

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ABSTRACT

Over the years, population growth resulted from urban sprawl in meeting the needs and demands of the future generation globally and locally. Consequently, excessive anthropogenic activities on the environment cause environmental degradation, which affects cities' resilience. Therefore, this paper introduces the study to develop an Environmental Resilience Index (ERI) designed to measure the level of environmental resilience in Malaysia by selecting Selangor as a case study because of the difference in economic activities that could result in a different level of resilience. This paper also explains the general framework and indicator selected for this study by a literature review of environmental systems and reviews of past research and established indicators. Though this study uses secondary data as the basis of data collection, data from authorised departments and agencies are gathered to verify the reliability and validity of data that is important in analysation. Lastly, this paper elaborates on the methodology of data analysis with an example by measuring the ERI level for the component of environmental resources for the State of Selangor.

Contribution/Originality: This study contributes to the existing literature on the significance of resilience in disaster risk management, with specific reference to the Malaysian context. Consequently, this study offers an alternative method of data collection and analysis in evaluating the level of environmental resilience of any city.

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1. Introduction

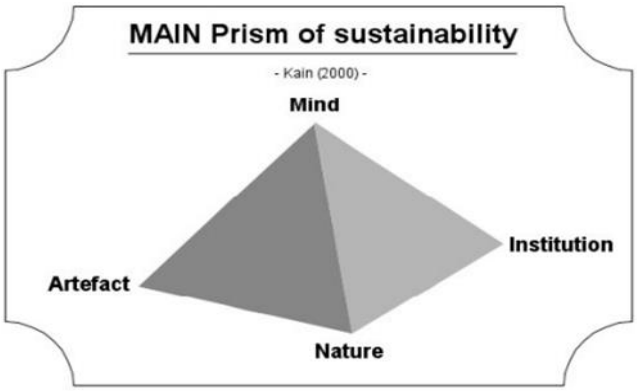
Of late, the population surge has resulted in forest clearing, opening up of new lands, and urban sprawl to meet the needs and demands of the current and future generations. However, excessive alteration to the natural environment prompts humans' degradation of the ecosystem. Though the activities impacting environmental degradation are still ongoing, the importance of conserving, protecting, and healing mother nature has been shed for the needs of future generations. Actions towards environmental sustainability and resilience are put forward by formulating plans and policies. At the international level, Sustainable Development Goals (SDGs) designed by the United Nations (UN) guide committed nations towards their implementation. On the other hand, a national vision can only be achieved by a grassroots implementation that needs the commitment, understanding, and support of local government, authorities, and agencies.

Rapid urbanisation for human activities and climate change contribute to the poor performance of environmental resilience. As the environment is vital for economic stability and community well-being, global commitments have been formulated toward environmental protection and resilience towards urban sustainability. At the international level, many existing frameworks and indexes the environmental performance. In Malaysia, PLANMalaysia has developed an index for assessing sustainable development, MURNInets, that has a gap in the dimension of sustainable development and does not touch on environmental resources. Thus, this paper addresses the Environmental Resilience Index (ERI) as a holistic mechanism for assessing environmental resilience the suitability to be used in the Malaysian planning landscape. This framework is developed by undergoing content analysis on existing international and local indexes and studies covering sustainable development and environmental performances as well as global and regional plan and policies.

2. Literature Review

Environment plays an important role in city and community resilience. Initially, the main dimensions of sustainability consist of three main components: economy, environment, and social, as defined by the Bruntland Report (United Nations,1987). Keiner (2005) studied on many aspects of sustainable development in which he modified a model adapted by other researchers and thus, developed a new model, the MAIN Prism of sustainability, as shown in Figure 1. The figure shows the economy's and society's linkage and dependency on the environment.

Figure 1: MAIN Prism of sustainability



Source: Keiner (2005)

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According to the Sustainable Cities Index (Arcadis, 2018), Malaysia has an overall ranking of 67th in the third percentile and 83rd in the planet index (an environmental pillar in the Sustainable Cities Index). From this index, Malaysia pays less attention to environmental protection, conservation, and sustainability than that other developed nations. This scenario is a loss factor to the nation gifted with an abundance of natural resources, biodiversity, and safety of being away from the Ring of Fire.

The increase in population, urbanisation, urban sprawl and agricultural land opening contribute to unsustainable and un-resilient cities. However, unethical development is the main contributing factor. Unethical developments are developments on environmentally sensitive areas (such as hilly areas, shorelines, and water bodies) that weakens and destabilise the environment rendering it prone to disasters such as landslides, flash flood, coastal erosion, and pollution, to name a few.

Recent years, however, show a turning point in Malaysia, that put on commitments towards the sustainable agenda by integrating such ideas into national policies (National Physical Plan, National Urbanisation Plan, states and districts plans), formulation of laws (Environmental Quality Act (Act 172)) and planning manuals and guidelines (Planning Guidelines on Environmental Sensitive Areas). Though plans and policies are excellent tools in highlighting the development direction of a nation- environmental sustainability, there is a need for the presence of a framework to evaluate and measure environmental resilience.

The environment is unique; no two plots of land are the same, nor do two nations have the same characteristics. Hence, this research aims to develop a framework to measure environmental resilience through an Environmental Resilience Index (ERI), taking Selangor state as a case study. The output from this research is to produce a framework that can be used by local planning authorities to measure the level of environmental resilience at the municipal level, whereby composite ERI can also be evaluated at the state level. The availability of this framework, it gives a clearer picture to local authorities, politicians, developers, and stakeholders of the existing environmental condition and the impacts of development on environmental resilience and sustainability.

3. Method

The case study area selected for this study is Selangor. Selangor is a state located in central peninsular Malaysia consisting of nine districts: Sabak Bernam, Kuala Selangor, Hulu Selangor, Klang, Petaling Gombak, Kuala Langat, Hulu Langat, and Sepang. The state is bounded by Perak (North), Negeri Sembilan (South), and Pahang (East), with a total acreage of 795,736.59 hectares.

As Selangor is the third largest state in peninsular Malaysia, having Federal Territories of Kuala Lumpur and Putrajaya within its boundary, the range of development, urbanisation, and economic activities varies among the districts. With this, it can deduce that the environmental resilience among those districts will differ too. Generally, based on the Department of Statistics Malaysia, in 2019 Selangor led the nation's economy by contributing 24.2% to the Gross Domestic Product (GDP). Though this state's two largest land uses are agricultural land and forest area, the main contributing GDP sectors are services (62.2%) and manufacturing (27.8%). Table 1 shows the main economic activities of districts in Selangor.

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Table 1: Main economic activities of districts in Selangor

Districts	Main Economic Activities	Districts	Main Economic Activities
Sabak Bernam	Agricultural activities focusing on paddy	Kuala Selangor	Eco-tourism and supporting tourism services
Hulu Selangor	Clean industrial cluster	Gombak	Heavy industries, services and recycling industries
Klang	Port and maritime industrial cluster	Petaling	State financial centre High-technology industrial cluster
Kuala Langat	SME Halal industrial cluster	Hulu Langat	High technology industrial cluster R&D institutions
Sepang	Aero-polis and aerospace industrial cluster		

Source: PLANMalaysia Selangor (2017)

Though the Bruntland Commission has derived the fundamental pillars of sustainability, as decades passed, researchers have added additional components according to their interest field (all still having the three main components). This situation is largely due to cities' ever-changing purposes and impacts on the environment, economy, and social well-being.

From literature reviews, researchers use multiple methods to evaluate the indicators used in their respective frameworks. Assessing resilience is a trick as it needs indicators to operationalize the component, and these indicators have different measurement units. For example, the land area can be measured by acres, hectares, or squared kilometres, and climate temperature can be measured by degree Celsius or degrees Fahrenheit. However, land area and climate temperature could not be calculated together as these components do not share the same measurement unit.

Thus, researchers such as Suárez et al. (2016) use mathematical calculations to normalise data, weighting, and aggregating in measuring resilience. Without a doubt, this technique is rather complicated. On the other hand, sustainability indexes such as Environmental Sustainability Index (ESI), Environmental Performance Index (EPI), and Sustainable Cities Index (SCI) use weightage for each component to calculate this index. This technique somehow limits the influence of different components and sub-components on the level of sustainability and resilience of an area.

However, this study uses an analysis methodology closely related to the Environmental Vulnerability Index, which scales performance or availability based on the level of resilience. Each level is then given a score whereby it could calculate composite resilience. Below (Figure 2) is an example extracted from EVI.

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Figure 2: Example of EVI indicator scaling

Environmental Vulnerability Index

Indicator: Terrestrial reserves
Indicator scaling: Cut-off values are percent of total land area legally set aside as reserves, whereby 1 is the lowest vulnerability/ highest resilience and 7 is the highest vulnerability/ lowest resilience.



Source: South Pacific Applied Geoscience Commission (2004)

Differing from the EVI, which measures environmental vulnerability, this study, ERI, measures environmental resilience. Other than that, ERI only has three categories which are low, moderate, and high stability, unlike EVI, which has seven. These three categories in ERI are scaled from 1 to 3, from low to high, accordingly. The scores from each indicator are then aggregated, and the average is calculated to generate the overall ERI of a district. Figure 3 shows an example of scoring an indicator in ERI.

Figure 3: Example of ERI indicator scaling

Environmental Resilience Index
Component: Environmental resources
Sub-component: Forest/ flora
Indicator: Forest cover
Indicator scaling: The percentage of forest area to the total areas of the district.

Indicator	Low resilience	Moderate resilience	High resilience
Score	1	2	3
Forest cover	0 – 25 (%)	25 – 50 (%)	More than 50%

4. Result

Bharma (2015) states that indicators are important to qualify resilience. This is because the progress and performance of plans can be monitored and identified. In selecting indicators for this study, a literature review on environmental research has been done to understand the nature of environmental systems. In addition, past investigations by researchers in urban resilience and environmental indexes are researched to analyse components chosen in measuring environmental resilience.

In the Qur'an (40:64), Allah stated that Earth is being made as a settlement place for humankind that provides good things. Though the Earth is a spherical layered structure with different materials, the physical environment that is usually referred to is the interaction between the thinnest and outset Earth's crust (lithosphere), Earth's water surface (hydrosphere), and the air in between the Earth (atmosphere) (Gupta & Asher, 1998). As for humans, we depend on the interaction of all these spheres for life continuity.

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Through literature review, it can be found that Earth's lithosphere holds an abundance of environmental resources through forest areas, grows valuable logs for economic resources, is home to various biodiversity, and has green lungs for healthy and clean air supply. Water bodies such as rivers and lakes provide the main protein supply for humans and water supply for domestic and industrial usage. The various types of soil have different potentials, such as strategic areas for agriculture. Meanwhile, below the Earth lay various valuable minerals such as coal, tin, and copper that contribute to the economic prosperity of an area.

The rotation of Earth on its axis with the interaction of the atmosphere and the position of a country on the planet affects the climate condition such as temperature, humidity, and rainfall. However, as the natural environment have been altered by men to meet their needs and desires, excessive human developments in the built environment have impacted major setbacks such as environmental issues such as pollution and natural disasters such as flood, earthquake, landslides, haze, and tsunamis. This statement is supported by Gupta and Asher (1998). It has been mentioned in the Qur'an (30:41) that today's consequences are a sign for humanity to return to righteousness, that is, to take action to fix the problem that has arisen over the years.

In identifying the selected environmental indicators for this study, precedent studies have been referred to identify components and sub-components used to measure resilience. Many researchers have been undergone that can be divided into general categories: urban resilience and environmental performance. Researchers such as Sharifi and Yamagata (2014), Suárez et al. (2016), Bharma (2015), Romero-Lankao, Gnatz, Wilhelmi and Hayden (2016) have identified environmental components and sub-components in measuring resilience. In addition, Sustainable Cities Index also developed four frameworks that measure the economic performance, social performance, environmental performance, and overall performance of nations worldwide.

On the other hand, environmental performance indexes are also referred to, such as Environmental Performance Index, Environmental Vulnerability Index, and Environmental Sustainability Index. These components from these researches and indexes have been guided and adapted to Malaysia's environmental structure, planning landscape, and data availability of Malaysia. Table 2 details the selected ERI components and sub-components used in this study.

Table 2: Selected ERI components and sub-components

Component	Sub-component	
Environmental resources	Forest/ flora	Marine
	Fauna/wildlife	Fisheries
	River water	Agricultural soil
	Coastal areas	Mineral reserves
	Hills and mountains	Air quality
Built environment	Land uses	
Climate condition	Temperature	Rainfall
Natural disasters	Flood	Landslide
	Earthquakes	Haze
	Tsunami	
Environmental issues	Solid waste	Noise pollution
	Industrial activity	

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Each indicator indicates the level of environmental resilience of districts in Selangor. According to an indicator level of availability, the data for the indicator is placed into different resilience classes, which are low, moderate, and high. Each of these classes is scored 1, 2, and 3, respectively. For example, if an indicator availability is placed in the moderate resilience level, a total of 2 scores is given for that specific indicator. After all the indicators have been classified and scored, the overall ERI level of a district can be computed by summing up all the total scores for every indicator of the district.

The ERI framework comprises five key components: environmental resources, built environment, climate conditions, natural disasters, and environmental issues. There are three ERI levels; low for scores between 1 - 25, moderate for scores between 26 - 50, and high for scores between 51 - 75. This research study is undertaken to assess only the component of environmental resources for the state of Selangor, which has nine districts. This state is chosen as each district have different characteristics and contribution in terms of environmental balance and economic function. The objectives for this research are 1) to identify the key indicators for the component of environmental resources, 2) to generate the ERI results for the component of environmental resources for the year 2019 using the ERI framework calculation table, and 3) to produce the ERI framework in the form of GIS database system chosen that is MapInfo secondary data collected from a government department and related agencies, LANDSAT imagery and GIS land use data from the year 2012- 2020 based on the latest available data. The data collected is then analysed by context analysis, land use classification, and data extraction to turn data into information that will be input into the ERI framework calculation table. Thus, it will generate the results for individual district ERI results and the Composite ERI results for the state of Selangor. The results are produced in a GIS database system to generate the ERI map for the district ERI and Composite ERI for Selangor. From the results generated, it is identified that eight out of nine districts in Selangor have a moderate level of ERI, ranging from a score of 29 to 32. Only Petaling district is categorised as low for having a score of 22. On the other hand, the Composite ERI of Selangor is also categorised at a moderate level for the component of environmental resources. This study enables environmental performance assessment with recommendations for expanding the scope of indicators covering agricultural soil and carbon emission.

5. Conclusion

To summarise, the environment is a vital dimension needed to evaluate an area's resilience as it is hugely due to the dependencies of man on the environment in sustaining life on Earth. This paper has introduced the research background to develop a framework to measure environmental resilience. Next, this paper gives a general understanding of the chosen case study site, which varies according to economic activities that may impact the environmental resilience level. The general ERI framework and selected indicators are elaborated using literature studies of environmental systems and reviews from past research. In addition, the methodology for data collection is a list to ensure the reliability and validity of data.

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Conflict of Interests

The authors reported no conflicts of interest for this work and declare that there is no potential conflict of interest with respect to the research, authorship, or publication of this article.

References

Arcadis. (2018). Citizen centric cities : The sustainable cities index 2018. *Arcadis*. https://www.arcadis.com/en/global/our-perspectives/sustainable-cities-index-2018/ citizen-centric-cities.

Bharma, Anshul S. (2015). Resilience framework for measuring development. Brief for GSDR 2015. *United Nations*. https://sustainabledevelopment.un.org.

Gupta, A., & Asher, M. G. (1998). *Environment and the developing world: principles, policies, and management*. John Wiley & Sons, Ltd. (UK).

Keiner, M. (2005). *History, definition(s) and models of sustainable development*. Retrieved from https://www.research-collection.ethz.ch/

Romero-Lankao, P., Gnatz, D. M., Wilhelmi, O., & Hayden, M. (2016). Urban sustainability and resilience: From theory to practice. *Sustainability (Switzerland)*, *8*(1224).

PLANMalaysia Selangor. (2017). Selangor State Structure Plan 2035. *PLANMalaysia*. https://www.planmalaysia.gov.my/documents/penerbitan-planmalaysia /rancangan-struktur/RSN_Selangor_2035. pdf.

Sharifi, A., & Yamagata, Y. (2014). Resilient urban planning: Major principles and criteria. *Energy Procedia*, *61*, 1491–1495.

South Pacific Applied Geoscience Commission. (2004). Environmental Vulnerability Index Manual. *United Nations Environment Programme*. http://islands.unep.ch/EVI%202004%20Technical %20Report. pdf.

Suárez, M., Gómez-Baggethun, E., Benayas, J., & Tilbury, D. (2016). Towards an urban resilience index: A case study in 50 Spanish cities. *Sustainability (Switzerland)*, *8*(8).

The Qur'an. (2005). Translated by M.A.S. Abdel Haleem. Oxford UP.

United Nations. (1987). Report of the World Commission on Environment: Our Common Future. *United Nations*. https://sustainabledevelopment.un.org/content/ documents/5987our-common-future.pdf

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