Data Collection and Analysis for the Development of Environmental Resilience Index in Selangor

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ABSTRACT

Over the years, population surges resulted in urban sprawl in meeting the needs and demands of the future generation. However, excessive human activities in the environment cause environmental degradation, which affects cities resilience. In addition, the impact of global climate change has significantly affected the local environmental context in many towns. As a result, we experience constant incidences of natural disasters, such as monsoon floods, flash floods and landslides. The absence of a framework to address the resilience level in Selangor may lead to a problematic situation in planning and managing the development concerning the physical contexts, for instance, the location and topographic aspects. Therefore, this paper introduces the research to develop an Environmental Resilience Index (ERI) to measure Malaysia's level of environmental resilience by selecting Selangor as a case study because of the difference in economic activities that could result in different levels of environmental resilience. This paper also explains the general framework and indicator selected for this study by reviewing 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 essential in the analysis stage. Lastly, this paper elaborates on the methodology of data collection and data analysis with an example by measuring the ERI level for the component of environmental resources for the district of Kuala Selangor. Considering the latest secondary data, the results demonstrate that Selangor has an ERI of moderate level for the component of environmental resources.

Keywords: resilience, environment, index, Kuala Selangor, methodological

INTRODUCTION

Over the years, the global population surge resulted in forest clearing, opening up new lands and urban sprawl to meet the needs and demands of the current and future generations. However, excessive alteration to the natural environment creates degradation to the ecosystem crucial to human survival. Though environmental degradation activities are still ongoing, importance in conserving, protecting, and healing mother nature has been shed for future generations' needs. Actions towards environmental sustainability and resilience are put forward by formulating plans and policies. Sustainable Development Goals (SDG), designed by United Nations (UN), guides committed nations towards its implementation at the international level. On the other hand, in the local context, a country can achieve the national vision by the grassroots performance that needs the commitment, understanding and support of local government, authorities and agencies.

Environment plays a vital role in city and community resilience. Initially, the main dimensions of sustainability consist of the economy, environment, and social, as the Bruntland Commission defined in 1987 that also interrelates the interdependence between those dimensions (Keiner, 2005). Presently, several systems are related to environmental quality, such as Environmental Performance Index (EPI) ranking participating nations annually. According to the Sustainable Cities Index (Arcadis, 2018), Malaysia has an overall ranking of 67th- located in the third percentile and ranked 83rd in the planet-index (an environmental pillar in the Sustainable Cities Index). From this index, we can deduct that Malaysia pays less attention to environmental protection, conservation, and sustainability than other developed nations. This scenario is a losing factor to the nation gifted with abundant natural resources

biodiversity and safety of being away from the Pacific Ring of Fire. Urbanisation, urban sprawl, and opening agricultural land contribute to unsustainable and un-resilient cities with unethical development as the main contributing factor. Unethical developments are developments on environmentally sensitive areas (hilly areas, shorelines, water bodies) that weakens and destabilises the environment, rendering it prone to disasters such as landslides, flash floods, coastal erosion, and pollution to name a few.

Recent years, however, shows a turning point in Malaysia, that put-on commitments towards the sustainable agenda by integrating such ideas in 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 a framework to evaluate and measure environmental resilience.

Aim of Study

The environment is unique where no two land plots are the same or two nations have the same characteristics. Hence, this research aims to develop a framework to measure environmental resilience through an Environmental Resilience Index 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. Through the availability of this framework, it gives a clearer picture to local authorities, politicians, developers and stakeholders on the existing environmental condition and the impacts of development towards environmental resilience and sustainability.

Study Area

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 covering 795,736.59 hectares. Selangor is the third largest state in Peninsular Malaysia, holding the Federal Territories of Kuala Lumpur and Putrajaya within its boundary varying the range of economic activities and urbanisation among districts. With this, it can be deduced that the environmental resilience among those districts will differ too. Generally, based on the Department of Statistics Malaysia, in 2019, Selangor leads the nation's economy by contributing 24.2% to the Gross Domestic Product (GDP) mainly in the services and manufacturing sector.

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 Hi-tech industrial cluster
Kuala Langat	SME Halal industrial cluster	**Hulu Langat**	Hi-tech industrial cluster R&D institutions
Sepang	Aero-polis and aerospace, industrial cluster		

Source: Selangor, 2015

LITERATURE REVIEW

Since the establishment of sustainable and resilient cities, many researchers have researched at various levels such as intra-nations (Suárez, Gómez-Baggethun, Benayas, & Tilbury, 2016) and inter-nations such as Environmental Performance Index, Environmental Vulnerability Index and Sustainable Cities Index that rank cities according to the level of sustainability and resilience. By now, both the terms sustainability and resilience may seem like 'two peas in a pod'. However, the differences are tabulated as in Table 2.

Table 2: Comparison of sustainability and resilience

Sustainability	Criteria	Resilience
A condition where the current and future populations' needs are met without drawing down the carrying capacity of their hinterlands and regions that they are dependent on.	**Definition**	The ability of complex systems to change, adapt and transform in response to internal and external stresses and pressures.
A set of protection goals concerning the capital that should maintain for the future generation.		A way of thinking and a set of methods to cope with change.
A normative set of socially derived goals, combining social, economic and social aspects.	**Concept**	A conceptual and modelling framework to operationalise sustainability.
Timeframe to build sustainability is usually during the long-term timeframe**.**	**Timeframe**	Timeframes affecting resilience can occur both in the short-term and long-term periods.

Source: Romero-Lankao, Gnatz, Wilhelmi, & Hayden, 2016; Saunders & Becker, 2015

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). It is mainly due to cities' everchanging purposes and impacts on the environment, economy, and social well-being.

Through literature review, it can be found out that Earth's lithosphere holds an abundance of environmental resources through existing 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 primary protein supply for humans and water supply for domestic and industrial usage. The various types of soil have different potential, such as strategic areas for agriculture. On the other hand, below the Earth lay various valuable minerals such as goal, tin, and copper that contribute to an area's economic prosperity.

The rotation of Earth on its axis with the interaction of the atmosphere and the position of a country in the planet affect the climate condition such as temperature, humidity and rainfall. However, as men have altered the natural environment to meet their needs and desires, excessive human developments in the built environment have impacted significant setbacks on environmental issues such as pollution and natural disasters such as floods, earthquakes, landslides, haze and tsunamis. In the Quran (30:41), the consequences faced today is a sign for humankind to return to righteousness, that is, to take actions to fix the problem that has arisen over the years. This statement is supported by Gupta & Asher (1998).

Existing Frameworks to Analyse Environmental Performance

Through literature reviews, it can be identified that many researchers have conducted studies that generally analyses either sustainability performance or environmental performance. As existing researchers covering urban sustainability performances list out the components to analyse the environment, various frameworks have been referred to, for example, Sharifi & Yamagata (2014), Bharma (2015) and Romero-Lankao, Gnatz, Wilhelmi, & Hayden (2016). Case studies have also been undertaken to analyse city sustainability, such as Suárez, Gómez-Baggethun, Benayas, & Tilbury (2016) ranking sustainability for 50 Spanish cities Many organisations have also developed framework analysing urban sustainability performance such as the Sustainable Cities Index by Arcadis (2018) and the Climate Disaster Resilience Index funded by the Global Center of Excellence (GCOE) Program (Kyoto University, 2019). Moreover, frameworks that focus on environmental performance have also been referred to, such as Environmental Performance Index, Environmantal Vulnerability Index and Environmental Sustainability Index (Morse & Morse, 2019; Pratt, Kaly, & Mitchell, 2004; Yale Center for Environmental Law & Policy; Yale University & Center for International Earth Science Information Network, 2005). Similar environmental indicators among frameworks are forest cover, biodiversity, water quality, natural disasters, geographical landforms, and environmental pollution performances.

From literature reviews, researchers use multiple methods to evaluate the indicators used in their respective frameworks such as mathematical calculations by normalising data, weighting, and aggregating to measure resilience (Suárez et al., 2016).

On the other hand, sustainability indexes such as Environmental Sustainability Index (ESI), Environmental Performance Index (EPI) and Sustainable Cities Index (SCI) use weightage to each component to calculate this index. Another method to measure environmental performance is through scaling the indicator performances based on its availability. Below is an example extracted from the Environmental Vulnerability Index (Figure 2).

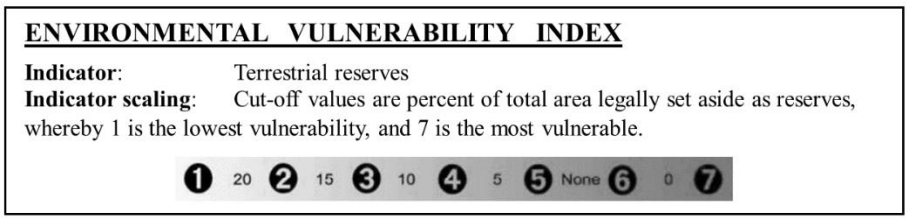

Figure 1: Example of EVI indicator scaling

Source: Pratt et al., 2004

On the national level, the Department of Town and Country Planning Malaysia has developed a framework to measure sustainable development, which is the Malaysian Urban-Rural Indicators Network for Sustainable Development (MURNINets) with six dimensions covering economy, environmental quality, communities, land use, infrastructure and transportation as well as governance. However, focusing on the dimension of environmental quality, it can be identified that this dimension does not cover environmental resources. Hence, this study aims to fill in the existing gap by developing a holistic framework to measure environmental performance in Selangor.

METHODOLOGY

As stated by Bharma (2015), indicators are essential to qualify resilience. From the literature review on existing frameworks, this study also reviews national policies in the environment to identify critical components and indicators. Such policies are the National Water Resources Policy, National Policy on Biological Diversity, Malaysian Forestry Policy, National Policy on Climate Change and Low Carbon Cities Framework and Assessment System. In addition, national plans are also reviewed, such as National Physical Plan, State Structure Plan and Local Area Plan. From these literature reviews, the components, sub-components have been identified that can be referred to in Table 3.

Table 3: Selected ERI components and sub-components

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

Source: ERI research study, 2020

The basis of this study is quantitative data based on the measurement of quantity or amount. Due to time constraints, data collection for this study focuses on secondary data with three ways of collection in general. First is the extraction of data from the GiS landuse database requested from the Department of Town and Country Planning Malaysia (PLANMalaysia). These data are usually concerned with indicators related to area and acreage (such as forest cover, wildlife reserves).The second way of collecting data is by extracting data and information from annual reports, environmental compendiums and journal papers. In ensuring the validity and reliability of data, the documents are published by federal ministries, related departments, and agencies (Goundar, 2019).The third alternative in extracting data is through LANDSAT imagery used to collect data on acreage or coastal areas.

As this study focus on the environmental performance for the year 2019, the data requested and collected are for that year. However, there are some scenarios whereby data for the year 2019 could not be collected. For instance, the annual report by the Department of Statistics Malaysia is back-dated, whereby 2019's report reflects data of 2018, but the latest information is still unpublished. Another instance is a survey report not published annually, such as endangered species count by the Department of Wildlife and National Parks Peninsular Malaysia. Hence, as both these instances are limitations, the latest published reports are taken into account for data analysis.

Table 4: Department/agencies referred for data collection

Department/ agencies referred for data collection	Components
PLANMalaysia	ER, BE, EI
Laporan Tinjauan RSN Selangor 2035 (2015)	ER, EI
National Physical Plan 2	ER
National Disaster Management Agency (NADMA)	ND
Department of Statistics Malaysia (DSM)	ER, CC
Department of Environment (DOE)	ER, ND
Department of Irrigation and Drainage (DID)	ER, ND
Department of Wildlife and National Parks Peninsular Malaysia (PERHILITAN)	ER
Lembaga Urus Air Selangor (LUAS)	ER
International Birdlife Society	ER
Reef Check Malaysia	ER

ER= Environmental Resources, BE= Built Environment, EI= Environmental Issues, ND= Natural Disasters, CC= Climate Condition

Source: ERI research study, 2020

For data analysis, the performance or the availability of indicators are put into categories that are divided into three, which are low, moderate and high resilience. These three categories in ERI are scored from 1 to 3, from low to high accordingly. Scores from each indicator are aggregated, and the average value is calculated to generate the overall ERI. Figure 3 show an example to score an indicator in ERI.

ENVIRONMENTAL RESILIENCE INDEX

Component: Environmental resources **Sub- component**: Forest/Flora

Indicator: Forest cover **Indicator scaling**: The percentage of forest area to the total measurements of the district.

Indicator	Low resilience	Moderate resilience	High resilience
Score	1	2	3
Forest cover	0 - 25(%)	26 – 50 (%)	More than 50%

Figure 2: Example of ERI indicator scaling

Source: ERI research study, 2020

For categorising the data into categories, two methods are being used to analyse the data. The first is through identifying the range and average of data for an indicator, taking the example from Table 3. The range is identified by computing the percentage of forest cover for all nine districts in Selangor extracted from the PLANMalaysia GiS landuse database. From the range of data, it is then divided into three categories accordingly.Another method for data analysis to categorise an indicator is based on the standard indexes such as the national water quality index (WQI) formulated by the Department of Environment divided into clean, semi polluted, and polluted. Hence, The three categories from WQI are then catagories as high, moderate, and low resilience. This study's other standard indexes are Air Pollution Index (DOE) and Live Coral Cover (Reef Check Malaysia).

The process of ERI involves ranking the level of environmental resilience of districts in Selangor. According to the level of availability of an indicator, the data for the indicator is being placed into different resilience class, which are low, moderate and high with the score of 1, 2 and 3, respectively. For example, if the availability of an indicator is being placed in the moderate resilience level, a total of 2 scores is being 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 districts of Selangor can then be ranked by repeating the above step for each district, whereby the district with the highest score will be placed first. An example will be shown in the next section.

ANALYSIS AND DISCUSSION

Table 5 shows an ERI pilot study on the district of Kuala Selangor for the component of environmental resources. This component consists of 10 sub-components and 27 indicators, respectively. By summing up the total scores, it can be computed that Kuala Selangor has a moderate overall ERI level for the component of environmental resources

Table 5: ERI analysis of Kuala Selangor, environmental resources component

Sub-component	Score	Sub-component	Score
Forest/flora	3 / 6	Marine areas	4 / 12
Wildlife/fauna	8 / 12	Fisheries	3 / 3
River water	3 / 6	Agricultural soil	3 / 3
Coastal areas	5 / 15	Mineral reserves	3 / 3
Hills & mountains	6 / 12	Air quality	7 / 9
Total score			**45 / 81**

OVERALL ERI LEVEL		
LOW	**MODERATE**	HIGH
0 - 27	**28 – 54**	55 - 81

CONCLUSION

To summarise, the environment is a vital dimension needed to analyse in evaluating the resilience of an area. This is hugely due to the dependencies of man on the environment in sustaining life on Earth. This paper has introduced the research background of this study 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 environmental resilience. 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. An example of data analysis is also shared for further understanding by computing the ERI level for environmental resources for the district of Kuala Selangor.

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