

Developing a Conceptual Framework of an Environmental Resilience Index

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Abstract: Of late, the impact of the global climate change has significantly affected the local environmental context in many towns. Malaysia is fortunate to have an abundance of environmental resources that provide many environmental services to the development of the nation. Simultaneously, we experience a continuous occurrence of natural disaster, ranging from monsoon floods and flash floods, landslides, and even earthquake. In this regard, the environmentally sensitive areas such as forestry, coastal areas, wetland, and many others are essential to provide the ecosystem services and concurrently can become the natural agents for a resilient town. Thus, this paper aims to generally explain the importance of resilience and sustainability in the built environment, focusing on a domain of the environment. This paper also covers on importance of different land uses which are forest area, coastal area, and built-up area for the man. It addresses the issues and challenges, as well as environmental degradation faced on those land uses respectively. Global and national policies on preserving and protecting the environment are also tabulated. The research method involves the selection of environmental indicators in developing an overall conceptual Environmental Resilience Index (ERI), covering the key components of the environment. Through this ongoing research, it enables key players in the urban sectors to take actions in molding a better future for Malaysian cities and the communities in it.

Keywords: Resilience, Sustainability, Environment, Environmental Degradation, Index, Malaysia

1. Introduction

As the urban population is predicted to leap to 67% by 2050 [1], urban systems are pressured to be resilient in various dimensions such as social, economic, technology, environment and governance [2]. This research aims to reduce the gap on environmental resilience in urban systems by developing a framework entitled Environmental Resilience Index (ERI). This framework is developed based on the existing environmental landscape, urban planning

scenario and strategic plans in Malaysia for the ERI framework to be viable in measuring environmental resilience in the grassroots level namely local planning authorities. The contents of this paper will cover on the concept of sustainability and resilience; the potential and threats of different land uses; and lists of international and national policies covering on environmental protection. The last section of this paper will select suitable environmental indicators in developing the ERI framework.

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2. Concept of sustainability and resilience

From literature review, many authors states that the term sustainability and resilience are used interchangeably in describing the ability of a city to be self-sufficient and self-resilient in the field of urban planning [2]–[5]. An article by Marchese [5] proposes three framework where (1) resilience as a component of sustainability which is used in measuring economy, social and the environment; (2) sustainability as a component of resilience which is applied in the business sector; and the last framework where resilience and sustainability are separated according to objectives which is usually applied in economics, urban planning, community planning, public policy development and civil engineering. With this, it shows that these two terms may be linked or used independently, aiding the interchangeable usage of these terms.

Through literature review on both concepts, various authors highlight some similarities between these two terms [3], [5]. However, through literature review, it can be identified that there are numerous criteria in differentiating these two terms which are through definition, concept, and

timeframe [2]–[11]. Table 1 tabulates the comparison between sustainability and resilience.

From Table 1, it can be identified that there are two types timeframes to differentiate sustainability and resilience which are short-term and long-term, which can also co-exist simultaneously [8], [11]. Timeframes are used for the course of an action or plan, where a scenario can be applied to further understand on these timeframes. In a case of flooding, a few actions can be taken to alleviate livelihoods of victims after the disaster such as monetary aids or the constructions of levees. Monetary aids can be considered as a form of short-term resilience as it helps alleviating victims’ livelihood after flooding but it does not prepare the victims’ community to face the disaster in the future. In contrast to the construction of levee that is considered as a long-term timeframe, this is because such structure helps in reducing the risk and impacts of flooding. Though the construction cost of a levee may be expensive, the structure would last for a few decades which would out-weight the expenditure of monetary aids given over the same period.

Table 1 Comparison between sustainability and resilience.

Criteria	Sustainability and Resilience		Source
Similarities	a. The systems survivability over time during normal condition and in response to disturbances. b. Both terms are usually used in political agenda that promotes green and balanced urbanization c. The concept of both terms assumes that there is a state of harmony between human society and nature.		[3], [5]
Differences	Sustainability	Resilience	
Definition	Meeting the need of the current generation without jeopardizing the need of the future generation without degrading the environmental system.	The ability of a complex systems to change, adapt and to transform in response to both internal and external stresses and pressures.	[2], [7], [12]
Concept	Increasing the quality of life with considerations of the environment, social and economy for the present and future generation.	Focus on the response of systems during stress and disturbance.	[2]–[11].
	Prioritize on the outcome of the system.	Prioritize on the process of systems to adapt during stress and disturbance.	
	Incorporated in the institutional level for decision making.	Implemented in plans for the preparation and response during disruptions or disasters.	
	A general encompassing political agenda or policy that is not practical for implementation.	A framework that is used to operationalize and assess sustainability but is difficult to translate into policy.	
	Focus on areas needed for protection, conservation and to be kept from changing.	Focus on areas that could be adapted and change to form a new and better system.	
Timeframe	Timeframe to build sustainability is usually during the long-term timeframe.	Timeframe affecting resilience can occur both in the short-term and long-term period	[11]

3. Urban areas as drivers towards environmental sustainability

Urban areas are where majority of the world population lives, compromising inter-related complex systems of social, economic, technology, environment, and governance dimensions [3-5]. To cater the projected rapidly growing population, massive areas of natural environment are turned

into built-up areas as to expand the human-centric altered environment at the cost of jeopardizing the environment. Table 2 tabulates the importance; issues and challenges; and the impacts of environmental degradation to the environment that simultaneously gives adverse impacts to man, which is arranged based on different categories of land uses, namely forest area, coastal area, and built-up areas.

Table 2 Importance, issues, challenges, and impacts of environmental degradation of land uses.

Land use	Importance	Issues and Challenges	Impacts of environmental degradation
Forest area	<ul style="list-style-type: none"> •Wildlife biodiversity •Water catchment area •Natural flood mitigation •Climate balance •Source of economic raw materials •Recreational area and ecotourism •Research and development centers. 	<ul style="list-style-type: none"> •Deforestation and forest clearing •Illegal logging •Opening of new areas •Smuggling and poaching of wildlife 	<ul style="list-style-type: none"> •Loss of wildlife habitat •Soil runoff •Soil erosion •Land slide •River bed sedimentation •Flooding •Increase surface temperature •Imbalance of gaseous components and air humidity
Coastal area	<ul style="list-style-type: none"> •Ecotourism •Economic resources •Protect mainland from winds and tidal change •Maintaining shoreline contour •Reducing water pollution •Marine and aquatic biodiversity •Regulate hydrological cycle 	<ul style="list-style-type: none"> •Removal of mangrove forest •High density coastal development •Tourist influx •Poor coastal management 	<ul style="list-style-type: none"> •Tsunami •Coastal erosion •Vulnerable to strong winds •Reduction of natural resources •Increased sea surface temperature.
Urban/ Built-up area	<ul style="list-style-type: none"> •Area for human livelihood and well-being •Main economic center (commercial and industrial activities) 	<ul style="list-style-type: none"> •Littering and oil spills •Impermeable land cover •Heat absorbent construction material •High car dependency •Reduced green areas •Out-dated infrastructures 	<ul style="list-style-type: none"> •Prone to flash flood, landslides, and natural disasters •Air, water, and sound pollution •Increased surface runoff (grey water) •Loss of wildlife habitat •Urban heat island and climate change.

Sources: [6-17]

4. Policies on environmental resilience

Policies have prominent roles in pathing the way for the end goal wanted by a city as well as shaping the actions needed in reaching the end goal – resilient cities. Hence, many global commitments and national policies are done and formulated in achieving it. As shown in Table 2,

environment plays an important role for human as an economic resource, social wellbeing and regulating climatic balance. Thus, an action to further enforce environmental resilience, many global commitments and national plans and guidelines have been formulated is tabulated along with a short description (Table 3 and Table 4). Through

formulation of plans and guidelines, it helps in directing the the nation. Literature review on these policies is also vital in nation in achieving the goal of sustainable development of identifying key components of environmental resilience.

Table 3 Descriptions of global commitments.

Global commitments	Description
<i>17 Sustainable Development Goals</i>	<ul style="list-style-type: none"> • A framework formulated by United Nations that emphasize on holistic, inclusive, and sustainable development with a total of 17 goals. • There are 5 goals related to this research on environmental resilience which are Goal 6 (clean water and sanitation), Goal 11 (sustainable cities and communities), Goal 13 (climate action), Goal 14 (life below water) and Goal 15 (life on land).
<i>Sendai Framework for Disaster Risk Reduction 2015-2030</i>	<ul style="list-style-type: none"> • A framework formulated by United Nation which focus on disaster risk reduction that integrates various sectors such as economic, social, environment, and infrastructure in reducing vulnerability and increasing preparedness in response to disaster. • Priorities from the Sendai framework related to environmental resilience are: <ul style="list-style-type: none"> ▪ The integration of disaster risk management into land-use planning policy ▪ Assessment, mapping and management of natural resources, environmental sensitive areas, and disaster-prone areas. ▪ Review and update disaster preparedness plan with stakeholders and communities.
<i>Local Agenda 21</i>	<ul style="list-style-type: none"> • This agenda aims for a government-lead, and community participatory in establishing comprehensive action strategy integrating sectors such as economy, social and environment at the local level. • The second section of the agenda encompasses on the implementations focusing on conservation and management of resources for development. • Targets related to this study are <ul style="list-style-type: none"> ▪ Protection of the atmosphere (climate and air quality) ▪ The planning and management of land resources and related fragile ecosystems. ▪ Conservation of biodiversity. ▪ Protection and management on quality of ocean, seas, and freshwater resources. ▪ Management of toxic chemicals, hazardous waste, solid waste, and radioactive waste.
<i>New Urban Agenda</i>	<ul style="list-style-type: none"> • This agenda focusses on shared commitment towards sustainable development • The third implementation of this agenda highlights commitments in the environmental dimension which is ‘environmentally sustainable and resilient urban development’. • The commitments related to this study are: <ul style="list-style-type: none"> ▪ Management of natural resources (forest, biodiversity, topography, water, and food supply) environmental sensitive areas, and urban ecosystem ▪ Reduction of greenhouse gas emission and air pollution ▪ Emphasis on disaster risk reduction management.

Source: [1,18–20]

Table 4 Description of national plans and guidelines

National plans and guidelines	Description
<i>National Physical Plan (NPP)</i>	<ul style="list-style-type: none"> • Highest hierarchy of the statutory that formulates strategic policies in determining the direction of physical development and conservation for Peninsular Malaysia • Translates global commitments into national plans to be implemented at the grass-root level • Sustainable management of natural resources, food resources and heritage resources • Planning of holistic land use • Sustainable infrastructure and low carbon city
<i>National Urbanisation Plan (NUP)</i>	<ul style="list-style-type: none"> • Coordinate the planning and development of the nation’s urban areas to be efficient and systematic • Usage of green technology on resource management • Environmental management and sustainable waste management • Provide a safe, clean, comfortable, and low carbon neighborhoods and lifestyle
<i>State Structure Plans (SSP)</i>	<ul style="list-style-type: none"> • Second highest hierarchy of statutory plan • Formulated in the state level • Translates the direction from the federal level based on NPP
<i>District Local Plans</i>	<ul style="list-style-type: none"> • The grassroots level of statutory plans • Formulated by local municipals • Translates direction from NPP and SPP into implementation actions <p>Actions are usually in the form of land use zoning and development controls.</p>
<i>Planning Guidelines on the Development on Environmental Sensitive Area(s)</i>	<ul style="list-style-type: none"> • To control development in order to protect ESAs • Aids local authority to identify allowable developments according to the ESAs • For the preparation of development proposal report according to land use control and management of ESAs

Source: [8,21–23]

Other national policies covering on environment which has been reviewed for this study is listed below. The identification of these policies relates to the efforts undertaken by the Malaysian government in tackling environmental resilience. On the other hand, these identified policies assures on the availability, validity and reliability of data needed during the data collection and data analysis phase that is essential in producing quality and valid findings and output.

- i. National Water Resource Policy published by the Ministry of Natural Resources and Environment;
- ii. National policy on Biological Diversity by the Ministry of Natural Resources and Environment;
- iii. Malaysian Forestry Policy published by the Ministry of Natural Resources and Environment;

- iv. National Policy on Environment published by the Ministry of Science;
- v. National Policy on Climate Change published by the Ministry of Natural Resources and Environment; and
- vi. Low Carbon Cities Framework and Assessments Systems published by the Ministry of Energy, Green Technology and Water.

5. Conceptual framework and the selection of indicators

In developing the Environmental Resilience Index, it is important to identify suitable indicators to quantify resilience. This is because indicators help in tracking steps taken towards the aim of the research, formulating policies and plans, community awareness and analysis, projections and targets by experts and academicians. Hence, indicators should possess a few characteristics

which are specific, measurable, realistic, timebound and simple language. In addition, it should be revised and adjusted accordingly in reaching the desired goal. Lastly each selected indicator is related to bring change affecting urban resilience [10]. From the previous section on international and national policies, literature reviews from those documents identifies major areas or categories that affects environmental resilience such as climate and weather; natural disasters; environmental quality; and environmental resources. Hence, further studies are needed to identify key indicators for each category.

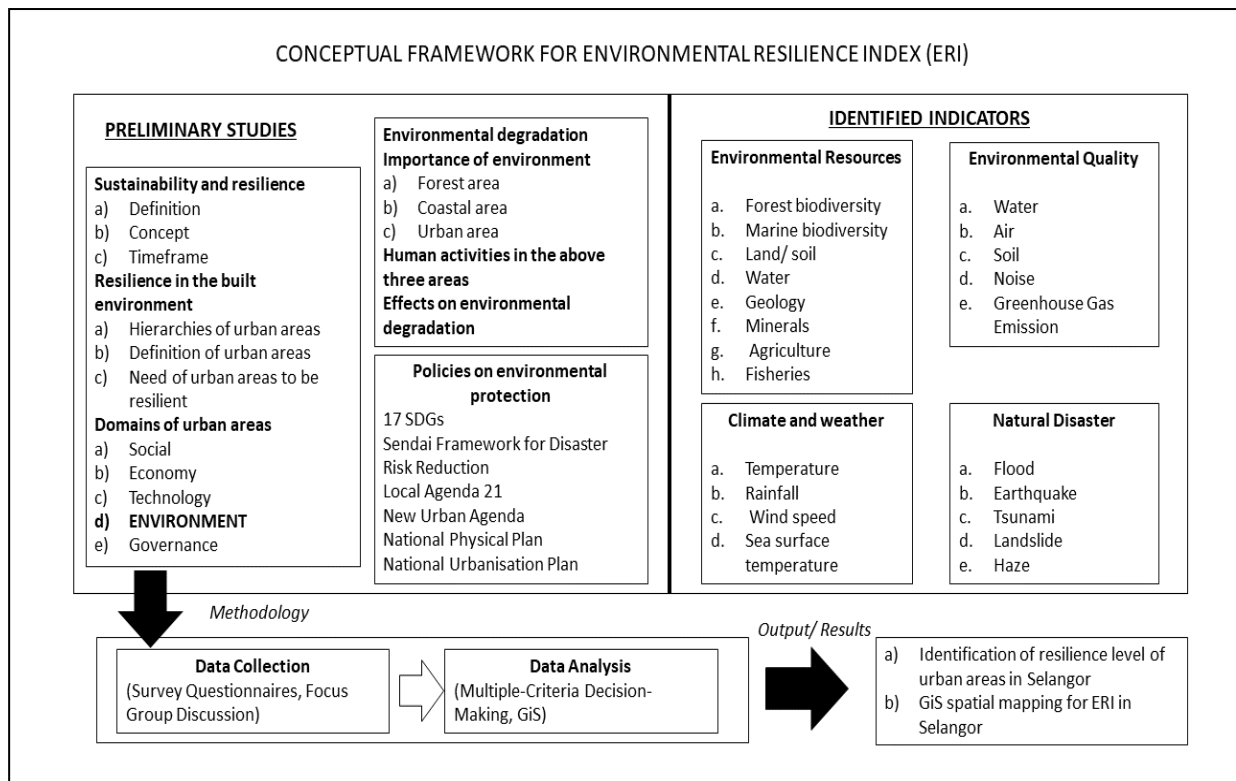
Through literature reviews from existing indexes and studies on urban resilience there are two main focus of study where some covers on urban sustainability performance [32]–[35]. These indexes cover on urban dimensions such as economic, social, infrastructures and environment. Thus, only the dimension on environment is extracted as further study suitable indicators necessary for this study. In addition, there are also numerous indexes focusing on environmental performances [36]–[38]. From these indexes, there are various fields covered on the environment which may integrate other dimensions such as the community, infrastructures, and governance. Hence, only indicators suitable to the need of this study is taken into considerations. There are also independent studies conducted by researchers that assesses environmental performances [2], [8], [10] that is crucial in process of identifying environmental indicators. The process of literature review and content analysis on these indexes and studies aids in developing the conceptual framework for this study and the selection of indicators. Moreover, the process of literature review also assists in the identification of suitable methodology to undertake this study in the later phase. Table 5 tabulates the category and selected key indicators in measuring environmental resilience suitable to the planning landscape of Malaysia and the availability of data to be collected form related agencies or departments.

Table 5 Selected environmental indicators for ERI.

Category	Selected key indicator
<i>Climate and weather</i>	Temperature, rainfall, windspeed and sea surface temperature
<i>Natural disaster</i>	Flood, earthquake, tsunami, landslide, and haze
<i>Environmental quality</i>	Water, air, soil, noise, and greenhouse gas emission
<i>Environmental resources</i>	Forest biodiversity, marine biodiversity, land/soil, water, geology, minerals, agriculture, and fisheries

Source: ERI study

Figure 1 pictures the overall proposed conceptual framework for this research. Generally, it begins with the fundamental theoretical studies related to sustainability and resilience relevant to the international and national policies discussed in the earlier section as well as the importance and issues faced in different land uses such as forest area, coastal area, and urban area which have also been discussed in this paper. Studies on environmental resilience helps in selecting indicators which are divided into four categories which are (1) climate and weather; (2) natural disaster; (3) environmental quality; and (4) environmental resources. The proposed methodology for data collection would be through survey questionnaires and focus group discussions (FGDs) while the proposed methodology for data analysis is through multi-criteria decision making and Geospatial Intelligence System (GIS). The expected outputs and results would be (1) the identification of environmental resilience level for urban areas or districts for the nine districts in Selangor namely Sabak Bernam, Kuala Selangor, Hulu Selangor, Klang, Petaling, Gombak, Kuala Langat, Hulu Langat and Sepang where the resilience level would then be (2) mapped out (spatial mapping) using the GIS system.



Source: ERI study

Figure 1: Conceptual framework for Environmental Resilience Index study

6. Conclusion

The purpose of this paper is to explain the preliminary studies and methods undertaken to develop the Environmental Resilience Index (ERI) by explaining the concept and interrelation between sustainability and resilience while understanding the importance of urban areas as the driver towards resilience development. The importance, issues, and challenges; as well as environmental degradation of three main land use; namely forest area, coastal area, and built-up area had been identified. Lastly, selected indicators in developing the ERI framework have been listed with an attachment of the conceptual framework which reflects a comprehensive coverage towards the achievement of establishing a workable framework for the ERI study. The generation of the results in a composite ERI spatial mapping is the expected outcome that benefits the relevant stakeholders in planning and managing the development of the nation. The ERI framework can be used as a tool in generating the baseline resilience level.

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