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# Enhancing Economic, Social, and Ecological Resilience Through Sustainable Waterfront Development in Penang

Daniel Ying Shin Tan[1*], Suk Wah Woo[2], Yee Chin Wong[1]

[1] Faculty of Built Environment, Tunku Abdul Rahman University of Management and Technology, 53300 Kuala Lumpur, Malaysia
[2] Department of Engineering and Built Environment, Tunku Abdul Rahman University of Management and Technology, 11200 Tanjong Bunga, Penang, Malaysia

* Correspondence: Daniel Ying Shin Tan (danieltan72@gmail.com)

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**Abstract:** The global economic disruption caused by the COVID-19 pandemic has significantly impacted development across various regions, including Penang, where supply chain disruptions, restricted cash flow, and delayed progress have led to reduced economic growth for stakeholders and communities alike. This study aims to explore the interconnected economic, social, and ecological (ESE) systems within the context of sustainable waterfront development in Penang, focusing on how these systems contribute to economic resilience and dynamism. The land and water resources of Penang, strategically situated along vital maritime routes, present substantial potential for economic revitalization. A quantitative research approach was employed, gathering data from questionnaire surveys, revealing a positive correlation between ESE variables. Key attributes such as local authority governance, development scale and impact, business operations, place identity, heritage preservation, and waste management were found to play crucial roles in shaping sustainable waterfront initiatives. The study highlights that Penang's core economic sectors—agriculture, mining and quarrying, manufacturing, construction, and services—have historically driven the local economy, but the growing focus on waterfront development offers new avenues for economic recovery and growth. The results validate the chosen quantitative methodology and underscore the importance of adopting integrated strategies to address land and water management challenges. By aligning with sustainability goals and adopting a holistic approach, Penang's waterfront development can foster resilience, ensuring long-term socio-economic and ecological balance. The insights provided contribute to a broader understanding of sustainable urban development and offer actionable strategies for policymakers and stakeholders involved in Penang's waterfront projects.

**Keywords:** Waterfront; Development; Preservation; Sustainability; Sustainable Development Goals (SDGs); Economic, social, and ecological (ESE)

## 1 Introduction

Bullish and positive economic growth is often construed as a result driven by consumer spending, business investment, tax cuts and rebates, the emergence of new technologies, and many other factors that correlate to monetary flow [1, 2]. The recent COVID-19 pandemic has left its dent for several years that dampened the economy in many ways across the globe, with Penang none the less that experienced its fair share of supply chain disruption, poor market cash flow, and slow development that adversely affected the stakeholders and users of Penang [3, 4]. According to the Department of Statistics Malaysia and the Penang Economic and Development Report for 2017 and 2018, the economic activities in Penang are categorized generally by agriculture, mining and quarry, manufacturing, construction, and services [5]. With the travel and movement restrictions during COVID-19, the global tourism sector with all its sub-sectors was brought to a halt.

While it was suggested that the monetary flowing factors potentially promote economy growth, it is pertinent to note that no single factor can define or build a robust economy. Rather, it is the intricate interplay of several factors, operating in synchrony, that contributes to the resilience of economies. Consumer spending and business investment

in development and construction may experience wealth shifting between home purchases with the building materials industry. Worker wages and employment from job creations are also the contributing factors, while tax cuts, incentives, or rebate approaches return money to businesses or consumers, potentially boosting spending and leading to economic growth. The history of Penang economy began as an entrepot [6] to semiconductor industry resonance [7] and now waterfront development. What may possibly influence the immense waterfront development in Penang is the geographical position as one part island and the other part mainland encircled by water, making it almost inevitable. These waterfront developments serve as the infrastructure or mechanism for enhancing tourism and the meetings, incentives, conventions, and exhibitions (MICE) that contribute to Penang's economic [8–10].

The context of resilience comprehends an understanding of the ecosystem's dynamic handling and evaluating its ability to withstand disruption without undergoing significant changes or deterioration [11, 12]. In urban environment resiliency, it is the urban system's ability to adapt and anticipate the development or changes [11, 12].

Albeit Penang's waterfront development ability to stimulate economic growth, one unneglectable factor is sustainability. The consequences or impact magnitude towards the ESE systems sustainability depends on the development scale. Jobs and business opportunities are expected, from waterfront development for the workforce to building material demand. As results, the spending ability potentially increases for consumer products and may potentially drive the real estate industry [13–16] are intertwined. Concurrently, this also possibly changes the place's identity with the occupants' changes. Unless efforts are offered as part of inclusion measures to retain the initial occupants with the development, a place identity change [17] is bound to take place. Several possible causes vary from affected income source, social environment, or ecological system. Therefore, this study aims to ascertain the ESE systems and their respective constituent attributes inherent with sustainability deriving from Penang's waterfront development in attaining economic dynamism by utilizing the land and water in developing resiliency. Henceforth, a sustainable waterfront development is suggested to align and balance the ESE systems deriving from waterfront development in Penang to develop resiliency and ensure continuity [11, 12, 18]. This study adopts the United Nations (UN)'s 17 Sustainable Development Goals (SDGs) in identifying sustainable waterfront development. From this study, we hope it can help the developer, town planner, and other parties involved in waterfront development to come up with more balanced design and planning by considering the ESE factors. By having good planning, sustainable waterfront development will be inculcated. The subsequent section of the papers will investigate the literature review, methodology of the study, results, and lastly, the conclusion.

## 2 Literature Review

### 2.1 Economics

In economics, supply and demand comprehend each other; however, a city is not just a physical entity but also a place where people live, socialize, and work, making it a symbol or a metaphor [19]. An example led by Odense is where the city puts life before building, ensuring the city built is sustainable and attractive [20]. Using the planning life before building metaphor, the city planning incorporates and connects its harbor with city center to create an attractive waterfront city that is both functional to its canal while providing comfort to its occupants. It is a city model that enables commercial and public utilization synchronously that encourages public activity and interactions [20, 21]. Penang is a state of multicultural and diverse ethnics [6]. Therefore, the land and water usage in attaining ESE system dynamism shall cater to this diversity of users. This encompasses the stakeholder's responsibility in governance sustainable development planning in assessing the current ecosystem's ability towards the anticipated development and changes [12, 18, 21].

The Yangpu waterfront in Shanghai was once an industrial area that houses the Shanghai shipyard and China's first fish market, but today it showcases China's belt and road initiative that revitalized and transformed this industrial era into a smart city. According to the We Build Value digital magazine, it was reported that this revitalization process potentially accommodates 100 foreign companies' headquarters, creating 50,000 jobs, is supported by McKinsey & Company's partners Lv and Wang [15], and projects an average residential real estate price per square meter of $12,000.00, surpassing Dubai's [22]. An attractive and sustainable waterfront development can potentially become a tourism attraction that contributes to the region's socio-economic vitality [21].

### 2.2 International Arrival

Medical, health, meetings, incentives, conferences, conventions, and exhibitions were huge contributions to Penang's economy [23–25]. The travel and movement restrictions during COVID-19 were a huge setback to Penang's economy, but with all these restrictions lifted and normalization coupled with the implementation and completion of several waterfront developments in Penang, we see potential economic growth [23–25]. In 2019, Penang was proclaimed by CNN Travel as one of Asia's best places to visit [8], and George Town was named as one of the most picturesque towns in the region [9]. Figure 1 indicates the total arrivals for both internationals and domestics at Penang International Airport decreased significantly at the start of the pandemic, which has impacted the tourism sector in Penang drastically.

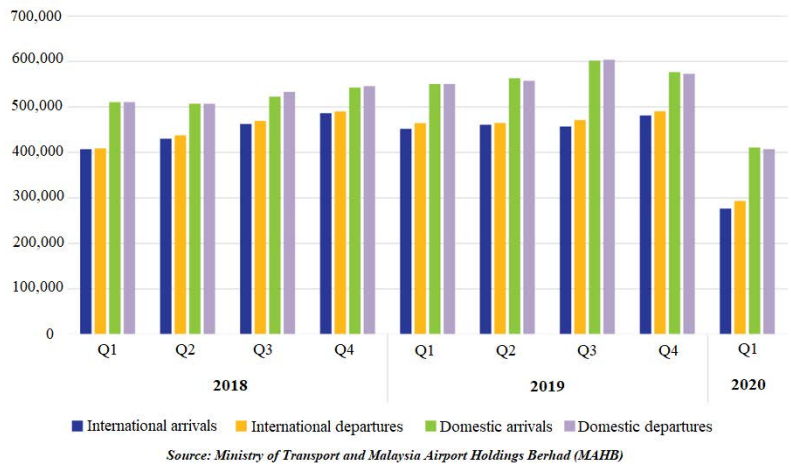


**Figure 1.** Penang International Airport total arrivals and departure, 2018-2019
Source: Ministry of Transport and Malaysia Airport Holdings Berhad (MAHB) [10]

### 2.3 Landmark

The identity of a place can be arguably changed or gradually faded because of physical changes or without preservation with development [17, 21]. One potential effect from waterfront development could also jeopardize the livelihood of occupants at the proposed development area that includes loss of income and sees a shift in wealth distribution at that area of those relying on marine life [26]. Several clan jetties in Penang initial occupants did not survive the tide of time and revitalization that sees a major transformation from a fishing village to a tourism and commercial hub [27]. One part of the jetties was developed into high-rise housing development. These initial occupants moving out and place transformation is one example of identity change.

### 2.4 Settlement

Population increase and economic development are unescapable with new waterfront development and land scarcity. Waste that is not managed efficiently may create a critical environmental issue such as land, water, and air pollution and communities' health issues that may choke economic growth. A case study of Dali Hill in Kano, Nigeria, was subject to erosion with surrounding community encroachment due to lack of proper management and planning [28]. As a result, the escalating encroachments eventually led to slums and makeshift settlements mushrooming with lacking roads, drainage, and sewerage systems. This uncontrolled situation will potentially lead to conflicts, environmental degradation, and possible disease outbreaks [12, 29].

### 2.5 Town Planning and Activities Aligned with UN SDGs

The town planning and management are within the governing authority. The Dubai dump [29] and Jelutong dump in Penang Island [30] are examples of town dumpsters becoming obsolete due to reaching their maximum capacity, and this should not be taken lightly as it has a direct impact on the environment and the city's liveability [27]. Figure 2 shows Penang's waste disposed per day increment at landfills from 2009 to 2019 [23]. The waste disposed at landfills and recycled for Penang Island in 2009 was 277,763 metric tons and 560,602 metric tons on the Seberang Jaya (Mainland), totaling up to 838,365 metric tons per day [23]. This figure was increased to 374,014 metric tons for Penang Island and 1,260,773 metric tons on the Seberang Jaya (Mainland), making it a whopping 1,518,010 metric tons per day [23].

An ideal and liveable built environment encourages humans to interact in a neighborhood. This aspect includes safety, affordability, and social and economic opportunities, among others, that influence a person to socially mix, live, and spend in the neighborhood [20, 21]. The Gurney Wharf, a 131-acre waterfront located at the front of the popular Gurney Drive promenade stretch of local hawkers, commercial complexes, and hotels in the island's North-East district, is a state-owned development comprised of a public park, a promenade, a children's playground, snack kiosks, a picnic area, a bicycle lane, a hawkers' center, casuarina trees, and a mangrove edge, among others (see Figure 3 and Figure 4). It is essential to the public with its vast public access space that promotes social activities [31]. Over at the Southwest district, the Penang South Reclamation (PSR) was boasted to generate about 15,000 job opportunities [32] with 3 human-made islands (see Figure 5) by reclamation. An inclusion effort to incorporate the current occupants with the waterfront development was taken, and they are not being displaced by the development. Financial aid was given with skills enhancement through a cooperative platform. This is to assist

the current occupants relying on marine life income that were affected to acquire new skills and diversify to maintain their businesses and remain in the development.

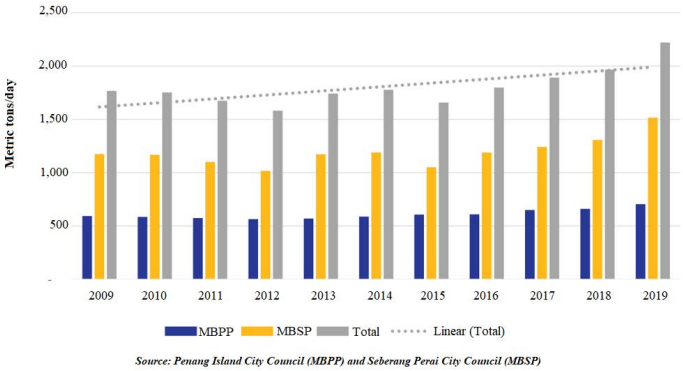


**Figure 2.** Waste disposed at landfill per day in Penang, 2009-2019
Source: Penang Island City Council (MBPP) and Seberang Perai City Council (MBSP) [10]

**Figure 3.** Gurney Wharf reclamation
Source: The Star 2021 [33]


**Figure 4.** The Gurney Wharf masterplan
Source: Penang Property Talk 2019 [34]

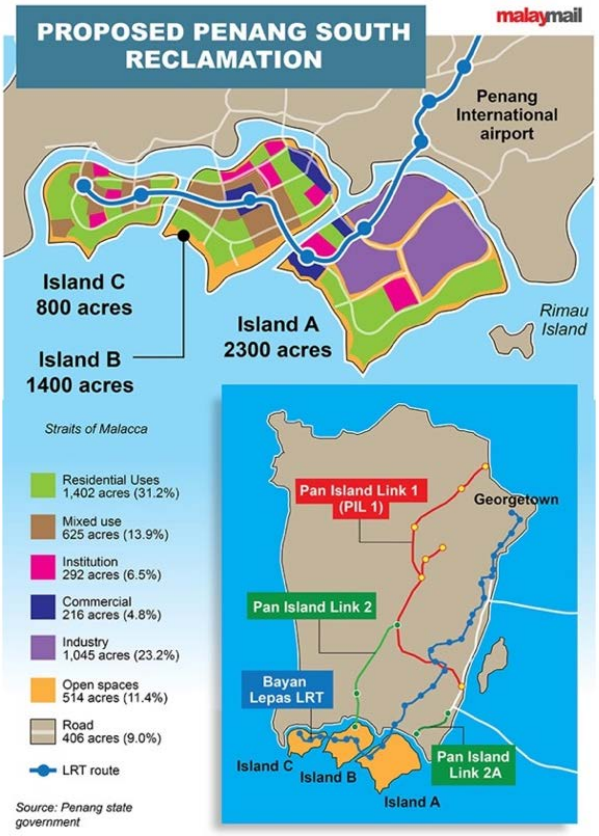


**Figure 5.** PSR waterfront
Source: Penang State Government and Malay Mail 2021 [35]

**Table 1.** The 17 UN SDGs and PSR 11 adoption

| UN SDGs | Description | PSR |
|---|---|---|
| 1 | No poverty | ✓ |
| 2 | Zero hunger | |
| 3 | Good health and well-being | |
| 4 | Quality education | |
| 5 | Gender equality | |
| 6 | Clean water and sanitation | |
| 7 | Affordable and clean energy | |
| 8 | Decent work and economic growth | ✓ |
| 9 | Industry, innovation, and infrastructure | ✓ |
| 10 | Reduce inequalities | ✓ |
| 11 | Sustainable cities and communities | ✓ |
| 12 | Responsible consumption and production | ✓ |
| 13 | Climate action | ✓ |
| 14 | Life below water | ✓ |
| 15 | Life on land | ✓ |
| 16 | Pease, justice, and strong institutions | ✓ |
| 17 | Partnerships | ✓ |

* PSR = Penang South Reclamation
**✓ = PSR adopted UN SDGs
Source: Penang Institute 2020 [23]

As universally defined by the UN back in 2015, "sustainable development" categorizes a total of seventeen (17) SDGs for the people and planet. It aims to maintain at a certain level where the continuity of development does not harm the environment [18, 36, 37], and what defines sustainability can be derived from several perspectives, such as financial viewpoints, natural resources, health, human interactions, and activity relationships that are polarized

into economy, social, and ecological systems. In the economic point of view, business opportunities and wealth distribution are closely related and immediately recognized. However, social interactions related to daily activities of assimilation and placement attachment, human consumption, production and waste generation, marine life effect, and shoreline erosions are intertwined and potentially affect the economy. Sustainable development has been advocated around the globe, from education to governance, and with the appropriate collaboration, transformation and transition proved effective in tackling environment and socio-economic challenges [18].

In focusing people, the PSR development aims to create new economic and opportunities [23] in reducing inequalities and to sustain the local community with the development to avoid the younger generations from migrating. The current PSR surrounding occupants with the absence of a proper sewage filtration system is a localized environmental [23] and hygiene concern that corresponds with 'Clean water and sanitation' (UN SDG 6) and with a holistic development that generates better jobs. Table 1 lists the 17 UN SDGs and their descriptions adopted by PSR development.

## 3 Methodology

This paper aims to identify Penang's economy, social, and ecological systems through sustainable waterfront development and adopted the 17 UN SDGs as the waterfront development sustainability fundamentals. A quantitative approach is a scientific and statistical method that was applied in this paper to collect and analyze the data. Further studies were conducted to determine the attribute interaction with theories and literature reviews explanatory. A group representative sampling method, as illustrated in Figure 6, extracts a sample from the population of Penang, which comprises both stakeholders and users [38]. The targeted stakeholders and users of Penang encompass the authorities, professionals, developers, contractors, and the end-users (public). The total data collected from the respondents was N = 508. With the collection of data from 508 respondents, it shows that the study meets the minimum requirement of valid 30 respondents in order to have significant results in data analysis. The population who participated in the data collection comprises the targeted stakeholders and users of Penang. The respondents are required to fill out the questionnaire survey, which consists of three sections that cover the demographics of the respondents and the findings towards the objectives. In addition, the questionnaire was designed with a 5-point Likert scale in order to know the level of agreement in each of the attributes allocated.

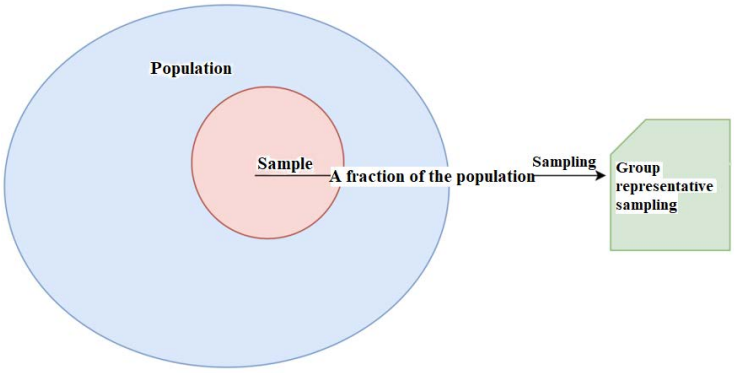


**Figure 6.** Group representative sampling
Source: Adapted from Stockemer 2019

The collected data are ratified by applying the reliability analysis to demonstrate consistency and precision by achieving a value of $\geq 0.700$ to be putative. In determining the data distribution, the quantitative normality test was applied to indicate the Skewness and Kurtosis z-scores indication.

On the contrary, the application of the relative importance index (RII), as set to determine the level of importance among the attributes. This is important in determining the strongest to the weakest contributing attributes. Thus, by using the RII, the following formula Eq. (1) was applied on the Microsoft Excel [39, 40] to establish the degree of importance ranking for the top 3 utmost important or desired sustainable goals for Penang and the ESE systems inherent in Penang's waterfront development. Each of the elements in the formula is explained as below:

$$RII = \frac{\sum W}{A * N} \tag{1}$$

where,

$W$ = respondent's weightage to each factor;
$A$ = highest weightage;
$N$ = total respondents.

Meanwhile, the Pearson correlation was finally applied to analyze the correlations of sustainable goals in waterfront development and the ESE attributes in Penang. The Pearson correlation allowed the analysis of studying the relationship among the attributes. This analysis allowed the evaluation of the strength and their direction between two continuous variables.

## 4 Results and Discussion

In this section, the results are discussed in three scenarios. The first scenario was to ascertain the data collected are consistent, accurate, and reliable by applying the reliability analysis and normality test. Table 2 below shows the sustainable goals in waterfront development with a with a value of 0.920 > 0.700, while the ESE attributes in Penang achieved a value of 0.927 > 0.700. Table 3 shows both the Skewness and Kurtosis absolute statistic range below 2 (Skewness) and 3 (Kurtosis) for sample size above 300 [41]. These results indicate no violation of normality and were reported to be punitive.

**Table 2.** Summarised reliability analysis results

| Variable | No. of Items | Alpha ($\alpha$) |
|---|---|---|
| Sustainable Development Goals (SDGs) | 21 | 0.920 |
| Economic, Social & Ecological (ESEs) | 20 | 0.927 |

**Table 3.** Normality Test's z-Skewness and z-Kurtosis

| | Frequency (N) | Skewness Statistic | Kurtosis Statistic |
|---|---|---|---|
| Sustainable Development Goals (SDGs) | 508 | -0.856 | 1.604 |
| Economic, Social & Ecological (ESEs) | 508 | -0.401 | 0.439 |

**Table 4.** SDG attributes

| Item | Attributes |
|---|---|
| SDG1 | Waterfront development can reduce poverty. |
| SDG2 | Waterfront development can reduce hunger. |
| SDG3 | Good health is important. |
| SDG4 | Quality education is important. |
| SDG5 | Waterfront development can improve gender equality. |
| SDG6 | Everybody deserves a quality living place. |
| SDG7 | Renewable energy must be prioritized. |
| SDG8 | Waterfront development helps economic growth. |
| SDG9 | Green building technology must be incorporated into waterfront development design. |
| SDG10 | Sustainable criteria are important in city planning. |
| SDG11 | Well-being is important in place of living. |
| SDG12 | The population statistic survey must be carried out properly before any waterfront development. |
| SDG13 | Material wastage must be reduced in waterfront development. |
| SDG14 | Climate effect must be considered in development planning. |
| SDG15 | Marine life must be preserved in waterfront development. |
| SDG16 | Environmental Impact Assessment report must be obtained prior to any waterfront development. |
| SDG17 | Environmental Impact Assessment report must be made public prior to any waterfront development. |
| SDG18 | The existing regulations and guidelines are not sufficient to manage waterfront development. |
| SDG19 | The authority should make SDGs compulsory as prerequisite to waterfront development. |
| SDG20 | The UN SDGs are important to transform our world. |
| SDG21 | Implementing SDGs can improve Penang's living environment. |

Note: SDG = Sustainable Development Goal

The second scenario is by using the RII Eq. (1) to determine the attribute importance ranking for sustainable goals in waterfront development and the ESE attributes in Penang. Table 4 lists the SDG attributes, while Table 5 lists the ESE attributes for this paper. These attributes were used to collect data from the respondents using the quantitative approach. Table 6 demonstrated the data collected for the for the most desirable and important attributes by summing the agreement or disagreement to produce attribute SDG3 (Good Health is Important) as the highest. SDG4 (Quality Education) is ranked second, while SDG6 (Everybody Deserves a Quality Living Place) is ranked third. These are persuasive evidence of the relativeness between the respondents and sustainable waterfront development goals. This exhibits the respondent's awareness and agreement that coincides with the life before building metaphor adoption in Odense city planning to prioritize life needs and public space consideration [20, 21].

**Table 5.** ESE attributes

| Item | Attributes |
|---|---|
| ESE1 | New waterfront development generates new income to the local. |
| ESE2 | Revitalizing existing waterfront will benefit the community as a whole (ESE). |
| ESE3 | Waterfront development provides everyone with equal business opportunity. |
| ESE4 | A new waterfront development has direct impact on existing businesses. |
| ESE5 | Existing waterfront redevelopment improves the local economy. |
| ESE6 | Existing community must not be marginalized on waterfront development plans. |
| ESE7 | A waterfront development should include public space. |
| ESE8 | Existing local business should embrace and accept new challenges to stay competitive. |
| ESE9 | Local authority must evaluate new waterfront development scale for its impact on existing business. |
| ESE10 | Local heritage and identity businesses must be preserved. |
| ESE11 | Waterfront development is a sound and practical method to develop an area over inner land. |
| ESE12 | Waterfront development increases population to the area. |
| ESE13 | Higher population increases daily waste. |
| ESE14 | Local authority must re-evaluate daily waste management before approving new waterfront development. |
| ESE15 | Construction work contributes to environmental waste. |
| ESE16 | Waterfront development affects the eco-system. |
| ESE17 | Reclamation project changing natural coastline impacts the environment. |
| ESE18 | The environment and eco-system can heal itself from waterfront development construction works after completion. |
| ESE19 | The local authority must monitor the waterfront development effect on climate. |
| ESE20 | Reclamation works endanger marine life. |

Note: ESE = Economic, Social, and Ecological

In identifying the ESE attributes important through sustainable waterfront development, Table 7 shows that ESE10 (Local heritage and identity businesses must be preserved.) is ranked the highest, followed by ESE14 (Local authority must re-evaluate daily waste management before approving new waterfront development.) and ESE13 (Higher population increases daily waste.). These indications are relative to the SDGs ranking with the respondents where quality living is prioritized. It was demonstrated in Chapter 2 where Dubai [29] and Jelutong on Penang Island [30] dumpsters became obsolete when they reached their maximum capacity. These attributes have a direct environmental impact, living quality, and place attachment case study of identity preservation where the Penang's Clan jetties that was churned into a tourism business hub from the initial heritage fishing village [12, 17, 18, 21, 29]. However, the Yangpu waterfront development has a different perspective from revitalization that gives it a new lease of life. It transforms the industrial area into a tech-savvy business hub, making it a smart city, but also potentially affects its identity, occupants, and ecological systems [20, 21].

Results from Table 8 reveal a positive and significant correlation between the SDGs and ESEs ($r = 0.844$, $p < 0.01$). This shows that an increase in SDGs would lead to higher ESE development in waterfront development. It supports the recent winning proposal of the Penang Bay competition and the PSR project incorporation of the UN SDGs in their design and project theme towards a sustainable waterfront development. This also reflects the life before building metaphor implemented in Odense [20, 21, 32].

The findings in Table 7 contributed to the achievement of objectives of this research by revealing the high emphasis of respondents towards the ecological, followed by social and then economic concern in the development of sustainable waterfront in Penang. Among the top ten attributes in Table 7, ecological attributes had taken seven places. For examples, respondents highly rank the need of local authority to re-evaluate daily waste management before approving new waterfront development and monitor the waterfront development effect on climate (ESE14, ranked 2; ESE19, ranked 4), concern that a higher population in waterfront development will increase daily waste (ESE13, ranked 3), construction works and reclamation works will endanger marine life (ESE 20, ranked 5), contributes to environmental waste (ESE15, ranked 7), changing natural coastline impacts the environment (ESE17, ranked 8) and the overall waterfront development affects the ecosystem (ESE16, ranked 10). In the top ten sustainability attributes, respondents' aspiration for the social aspects was expressed through their call for preserving local heritage and identity businesses (ESE10, ranked 1) and the inclusion of public space in the waterfront development (ESE7, ranked 6). The only economic attribute that makes it to the top ten list is the call for local authority to evaluate new waterfront development scale for its impact on existing business (ESE9, ranked 9).

In general, the findings of this research show that ESE attributes underpin the development of sustainable and resilient waterfront projects in Penang, and these triads are aligned to the SDGs goals. The research further reveals the aspiration of respondents that emphasis falls on ecological aspects, followed by social then economic concern. These collective views from different stakeholders are good sources of strength and direction for policymakers, urban planners, and asset managers to be aware, understand, and further include these attributes in planning, executing,

and operating waterfront development. As this research focuses on an exceptional example of multiracial and multicultural trading and historical town, Penang, the findings show that respondents highly ranked preserving local heritage and identity businesses. This finding shows the importance for stakeholders to understand that attribute ranking is contextual and the narratives of resilience and sustainability efforts are dependent on the interplay of temporal, geographical, and demographical scales. This further illustrates the need for a continuous effort from the policymakers, urban planners, and community so top-down and bottom-up participative approaches are encouraged and celebrated in developing sustainable and resilient waterfront projects.

**Table 6.** SDG attributes RII

| Attributes | Frequency | | | | | | Total | Missing | RII | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | | |
| SDG1 | 62 | 43 | 98 | 154 | 101 | 50 | 508 | 0 | 0.5335 | 19 |
| SDG2 | 62 | 45 | 105 | 158 | 88 | 50 | 508 | 0 | 0.5240 | 21 |
| SDG3 | 1 | 4 | 17 | 50 | 91 | 345 | 508 | 0 | 0.8965 | 1 |
| SDG4 | 0 | 4 | 19 | 51 | 107 | 327 | 508 | 0 | 0.8890 | 2 |
| SDG5 | 59 | 49 | 109 | 150 | 90 | 51 | 508 | 0 | 0.5244 | 20 |
| SDG6 | 2 | 5 | 15 | 77 | 131 | 278 | 508 | 0 | 0.8583 | 3 |
| SDG7 | 2 | 2 | 16 | 90 | 182 | 216 | 508 | 0 | 0.8315 | 11 |
| SDG8 | 14 | 11 | 45 | 146 | 170 | 122 | 508 | 0 | 0.7201 | 18 |
| SDG9 | 3 | 4 | 33 | 99 | 169 | 200 | 508 | 0 | 0.8043 | 14 |
| SDG10 | 1 | 1 | 29 | 71 | 159 | 247 | 508 | 0 | 0.8437 | 6 |
| SDG11 | 3 | 1 | 25 | 78 | 160 | 241 | 508 | 0 | 0.8386 | 8 |
| SDG12 | 3 | 1 | 33 | 79 | 176 | 216 | 508 | 0 | 0.8220 | 12 |
| SDG13 | 4 | 3 | 21 | 83 | 160 | 237 | 508 | 0 | 0.8343 | 10 |
| SDG14 | 2 | 1 | 25 | 78 | 174 | 228 | 508 | 0 | 0.8350 | 9 |
| SDG15 | 3 | 3 | 18 | 85 | 134 | 265 | 508 | 0 | 0.8484 | 5 |
| SDG16 | 0 | 3 | 21 | 80 | 147 | 257 | 508 | 0 | 0.8496 | 4 |
| SDG17 | 2 | 2 | 28 | 78 | 143 | 255 | 508 | 0 | 0.8421 | 7 |
| SDG18 | 4 | 7 | 45 | 159 | 155 | 138 | 508 | 0 | 0.7417 | 17 |
| SDG19 | 0 | 1 | 31 | 112 | 153 | 211 | 508 | 0 | 0.8134 | 13 |
| SDG20 | 3 | 2 | 49 | 133 | 157 | 164 | 508 | 0 | 0.7655 | 16 |
| SDG21 | 3 | 2 | 29 | 107 | 184 | 183 | 508 | 0 | 0.8000 | 15 |

**Table 7.** ESE attributes RII

| Attributes | Frequency | | | | | | Total | Missing | RII | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | | |
| ESE1 | 8 | 15 | 47 | 144 | 176 | 118 | 508 | 0 | 0.7224 | 14 |
| ESE2 | 8 | 10 | 47 | 165 | 179 | 99 | 508 | 0 | 0.7126 | 16 |
| ESE3 | 21 | 25 | 81 | 163 | 142 | 76 | 508 | 0 | 0.6394 | 18 |
| ESE4 | 3 | 10 | 48 | 169 | 172 | 106 | 508 | 0 | 0.7209 | 15 |
| ESE5 | 3 | 8 | 55 | 174 | 170 | 98 | 508 | 0 | 0.7127 | 16 |
| ESE6 | 2 | 13 | 48 | 154 | 161 | 130 | 508 | 0 | 0.7343 | 12 |
| ESE7 | 2 | 6 | 35 | 106 | 158 | 201 | 508 | 0 | 0.7996 | 6 |
| ESE8 | 2 | 9 | 38 | 124 | 207 | 128 | 508 | 0 | 0.7579 | 11 |
| ESE9 | 0 | 6 | 28 | 133 | 175 | 166 | 508 | 0 | 0.7839 | 9 |
| ESE10 | 0 | 5 | 22 | 117 | 148 | 216 | 508 | 0 | 0.8157 | 1 |
| ESE11 | 8 | 16 | 52 | 160 | 163 | 109 | 508 | 0 | 0.7075 | 17 |
| ESE12 | 6 | 9 | 45 | 169 | 157 | 122 | 508 | 0 | 0.7260 | 13 |
| ESE13 | 1 | 5 | 34 | 110 | 142 | 216 | 508 | 0 | 0.8075 | 3 |
| ESE14 | 1 | 4 | 32 | 106 | 158 | 207 | 508 | 0 | 0.8083 | 2 |
| ESE15 | 3 | 4 | 32 | 115 | 164 | 190 | 508 | 0 | 0.7949 | 7 |
| ESE16 | 2 | 9 | 47 | 123 | 152 | 175 | 508 | 0 | 0.7697 | 10 |
| ESE17 | 1 | 7 | 27 | 141 | 148 | 184 | 508 | 0 | 0.7858 | 8 |
| ESE18 | 38 | 45 | 67 | 150 | 129 | 79 | 508 | 0 | 0.6063 | 19 |
| ESE19 | 2 | 4 | 38 | 101 | 154 | 209 | 508 | 0 | 0.8047 | 4 |
| ESE20 | 1 | 2 | 34 | 117 | 157 | 197 | 508 | 0 | 0.8008 | 5 |

Note: ESE is short for Economic, Social and Ecological

This research gathers the views of authorities, professionals, developers, contractors, and end-users (public). While this mix of stakeholders allows collective perspectives from a myriad of backgrounds, the findings would have

been skewed toward the groups that are relatively higher in representation. For future studies, it is recommended that a specific group of population be chosen so that a deeper understanding of the needs and concerns of a particular group can be gained. Besides, while this study explores the various emphasizes of stakeholders in the ecological, social, and economic aspects of waterfront development, it gives insights for future studies to investigate approaches or successful case studies to realize these attributes into reality.

**Table 8.** Correlations table for SDGs and ESEs

| **Correlations** | | | |
|---|---|---|---|
| | | SDGs | ESEs |
| Pearson Correlation | SDGs | 1 | 0.844 |
| | ESEs | 0.844 | 1 |
| Sig. (2-tailed) | SDGs | - | 0.000 |
| | ESEs | 0.000 | - |
| N | SDGs | 508 | 508 |
| | ESEs | 508 | 508 |

Note: SDGs is short for Sustainable Development Goals and ESEs is short for Economic, Social and Ecological

*. Correlation is significant at the 0.01 level (2-tailed)

## 5 Conclusions

This paper has focused on ascertaining the ESE system attributes from sustainable waterfront development in Penang in developing resiliency. It points out some of the relevant key findings that open the gap for future research development. The UN SDGs are an appropriate sustainable development measuring tool that can capture all the parameters deriving from waterfront development. It was revealed that the stakeholders and users of Penang aspire for good health, quality education, and a quality living place from waterfront development.

While waterfront development contributes to economic growth, sustainability is what makes prosperous continuity; thus, a sustainable waterfront development. Consequently, the new economic prospects and wealth shifting were investigated and discussed, with inclusion measures taken as possible inference to remain the existing occupants with the waterfront development as part of a sustainable waterfront development. The correlation between SDGs and ESE systems was positive and significant.

A sustainable waterfront development potentially drives the economy from inception until completion and the operational period. These opportunities drive open job opportunities and building materials that potentially boost the local business economy during the construction period. Temporary residences accommodating the construction personnel may boost the real estate industry and consumer spending in Penang. This is a paradigm of a sustainable waterfront development comprehending local business in progress. The completed sustainable waterfront development promotes a livable city and encourages tourism and MICE to promote economic growth. It may potentially increase the real estate demand. However, the population increase requires the city to possess an efficient waste management system to deal with the increased daily waste.

Attributes concerning the local authority, development scale, and its impact, existing businesses, place identity, heritage perseverance, and waste management were found to be relative and important factors towards a sustainable and livable city. For this reason and due to the limitations of this paper's research, a multidisciplinary and methodological approach is suggested for further research to develop a framework that will set a new benchmark and guideline in developing resilient ESE systems through sustainable waterfront development.

### Author Contributions

"Conceptualization, D.Y.S. Tan; methodology, D.Y.S. Tan, S.W. Woo, and Y.C. Wong; software, D.Y.S. Tan; validation, D.Y.S. Tan, S.W. Woo, and Y.C. Wong; formal analysis, D.Y.S. Tan; investigation, D.Y.S. Tan; resources, D.Y.S. Tan, S.W. Woo, and Y.C. Wong; data curation, D.Y.S. Tan; writing—original draft preparation, D.Y.S. Tan; writing—review and editing, D.Y.S. Tan, S.W. Woo, and Y.C. Wong; visualization, D.Y.S. Tan; supervision, S.W. Woo, and Y.C. Wong; project administration, D.Y.S. Tan. All authors have read and agreed to the published version of the manuscript."

### Data Availability

The data supporting our research results are under privacy or ethical restrictions and are available from [D.Y.S. Tan, danieltan72@gmail.com] for researchers, who meet the criteria for accessing confidential data.

### Conflicts of Interest

The authors declare no conflict of interest.

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