



FINAL REPORT

PENANG GREEN AND SUSTAINABLE STATE INDEX

PeGaSuS

PREPARED BY:



TABLE OF CONTENTS

AUTHORS AND CONTRIBUTING TEAM	i
TABLE OF CONTENTS	ii
LIST OF TABLES	iii
LIST OF FIGURES	iii
1.0 INTRODUCTION	4
1.1 Project Background	4
1.2 Project Scope	5
1.3 Project Objectives	6
2.0 PROJECT METHODOLOGY	7
2.1 Stage 1: Establishment of PeGaSuS Index's Framework	8
2.2 Stage 2: Establishment of Focus Areas and Sustainable Indicators (SIs)	8
2.3 Stage 3: Parameter and Data Verification	18
2.4 Stage 4: Data Collection and Analysis	18
2.5 Stage 5: Proximity-To-Target (PTT) Method	18
2.5.1 Identification of Indicator Type	19
2.5.2 Identification of Target and Low Benchmark	19
2.5.3 Calculation of PTT Score	21
2.6 Stage 6: Weightage Assignment	22
2.7 Stage 7: Calculation of PeGaSuS Index	23
2.8 Stage 8: Penang state's Profiling, Result and Trend	26
3.0 RESULTS INTERPRETATION	27
3.1 Focus Areas	27
3.2 Economy Dimension	30
3.3 Environment Dimension	32
3.4 Social Dimension	34
4.0 CONCLUSION AND PROJECT RECOMMENDATIONS	36
REFERENCE	37

LIST OF TABLES

Table 2.1: Potential List of Focus Areas and Sustainable Indicators of PeGaSuS Index	10
Table 2.2: Common Normalizations and Its Example	18
Table 2.3: Star Rating System with Colour Code	26
Table 3.1: Distribution of PTT Score for Dimensions, Aggregated Dimension Score and PeGaSuS Index Score	27
Table 3.2: Tabulation of PTT Scores for Economy Dimension	30
Table 3.3: Tabulation of PTT Scores for Environment Dimension	32
Table 3.4: Tabulation of PTT Scores for Social Dimension	34

LIST OF FIGURES

Figure 2.1: Flow Chart of Development Stages of PeGaSuS Index	7
Figure 2.2: Hierarchy Structure of PeGaSuS Index Framework	8
Figure 2.3: Characteristics of PeGaSuS Index	9
Figure 2.4: PeGaSuS Finalised Framework	17
Figure 2.5: Concept of Proximity-To-Target (PTT)	19
Figure 2.6: Mathematical Formula for the Calculation of PTT Score	19
Figure 2.7: Sources of Reference in Setting Target and Low Benchmark	20
Figure 2.8: Weightages for Dimension Level of PeGaSuS Index	23
Figure 2.9: Flow Chart of PeGaSuS Index Calculation	24
Figure 3.1: Pie-Radar Diagram on Distribution of PeGaSuS Index among Focus Areas	28
Figure 3.2: Breakdown of PeGaSuS Index on PTT Scores for Focus Areas, Dimensions and Aggregated Dimensions	29
Figure 3.3: PTT Scores Tabulation for Economy Dimension	31
Figure 3.4: PTT Scores Tabulation for Environment Dimension	33
Figure 3.5: PTT Scores Tabulation for Social Dimension	35

1.0 INTRODUCTION

1.1 Project Background

Penang state government has always strived to realise the vision of a “Cleaner, Greener, Safer, Healthier and Happier” Penang. Due to the current threats brought by climate change and continuous evolving paradigm of sustainable development, there is a undeniable need for cities to focus on environmental sustainability. With that in mind, Penang State Economic Planning Unit, Penang Green Council (PGC) and Penang Institute mooted Penang Green Agenda (PGA) in March 2017. PGA is a three-year policy planning project, aimed at formulating strategies and building resilient communities in Penang to meet and adapt to future environmental challenges by 2030. PGA has three (3) objectives, which are:

- To identify the current and future environmental issues that needs to be addressed by referring to the United Nations Sustainable Development Goals (SDGs).
- To propose short term, medium-term, and long-term measures/indicators/targets to be achieved by 2030 by referring to the environmental-related targets listed under SDGs.
- To develop a roadmap for achieving the targets and identify the role of stakeholders in tackling the environmental issues identified to make Penang a green and sustainable state by 2030.

In May 2018, the new Chief Minister agreed on the following shared visions for PGA 2030 and 2050. Penang aspires to be the greenest state in Malaysia driven by a green economy, innovative governance with 4P partnerships (public, private, people, professional) and sustainability-led development agenda by 2030. Through 2050, Penang targeted to be a high income, caring, inclusive, low carbon and resilient state that emphasises the integrity of its people and environment, including enriching and restoring the health of its rich cultural and natural ecosystems.

Furthermore, PGA’s mission is to engage stakeholder groups and the people of Penang in identifying and combating the current and future environmental challenges of the State, proposing feasible solutions, together with reviewing and tightening existing policies and enforcement. With that, Penang Green Agenda (PGA) provides the platform for technical experts and policymakers to look into sustainability aspects of the State of Penang, including developing sustainability indicators.

Utilisation of indicators and index as a tool that would altogether assess and monitor the sustainability performance is preferred, as they not only reflect the current conditions, it can also help to monitor for future trend as well. It is believed that the use of indicators and index in management and policy implementation will help greatly in decision making, and thus,

positively impact governance. A great example that utilised indicators and index to measure performance is Environmental Performance Index (EPI).

EPI has been widely accepted as an important environmental benchmarking system of countries around the world. The index was jointly developed by Yale University and Columbia University and published biennially at the World Economic Forum (WEF) since year 2006. EPI adopted the concept of Proximity-To Target (PTT) into its framework. PTT concept is a method of normalising data by transforming the data of various indicators with different original formats and units, so that they can be easily aggregated into an index (Kraemer and Peichert, 2007; Stepping, 2013).

With that, this project aims to develop an index that access the sustainability performance of Penang state, through aggregation of carefully selected sustainable indicators, namely Penang Green and Sustainable State (PeGaSuS) Index. PeGaSuS index can be utilised by the State Government as assessment tool on the state's performance in environment, social and economy aspects, even as monitoring tool across time to keep an eye on the sustainability performance. Furthermore, PeGaSuS index is able to serve as an early-warning tool, pinpointing hotspot areas that needed immediate attention and actions by the State Government.

1.2 Project Scope

The scope of the PGA has been pre-identified by referring to the targets and goals listed under the United Nation Sustainable Development Goals. In particular, the following eight (8) Sustainable Development Goals (SDGs) will be the primary focus of the Penang Green Agenda (PGA), which are:

- Goal 2: Zero hunger
- Goal 6: Clean water and sanitation
- Goal 7: Affordable and clean energy
- Goal 11: Sustainable cities and communities
- Goal 12: Responsible consumption and production
- Goal 13: Climate action
- Goal 14: Life below water
- Goal 15: Life on land

1.3 Project Objectives

The objectives of this project are: -

- i. To produce a set of sustainability indicators that measure progress towards the 2030 shared vision by incorporating relevant targets listed under Sustainable Development Goals (SDGs) and existing initiatives local authorities have adopted.
- ii. To develop the framework of the sustainability indicators.
- iii. To set the target and benchmark of each sustainability indicators.
- iv. To assign weightage to the produced set of sustainability indicators.
- v. To aggregate the indicator score and compute Penang Green and Sustainable State (PEGASUS) Index value.

2.0 PROJECT METHODOLOGY

The methodology of this project can be divided into eight (8) stages. It starts with establishment of PeGaSuS Index's framework, follow by establishment of focus areas and Sustainable Indicators (SIs) for PeGaSuS Index and parameter and data verification. Then, the project methodology continues to data collection and analysis, SIs' target and low benchmark, Proximity-To-Target (PTT) method, weightage assignment, aggregation of SIs and lastly Penang state's profiling, result and trend. The project methodology is summarised into Figure 2.1.

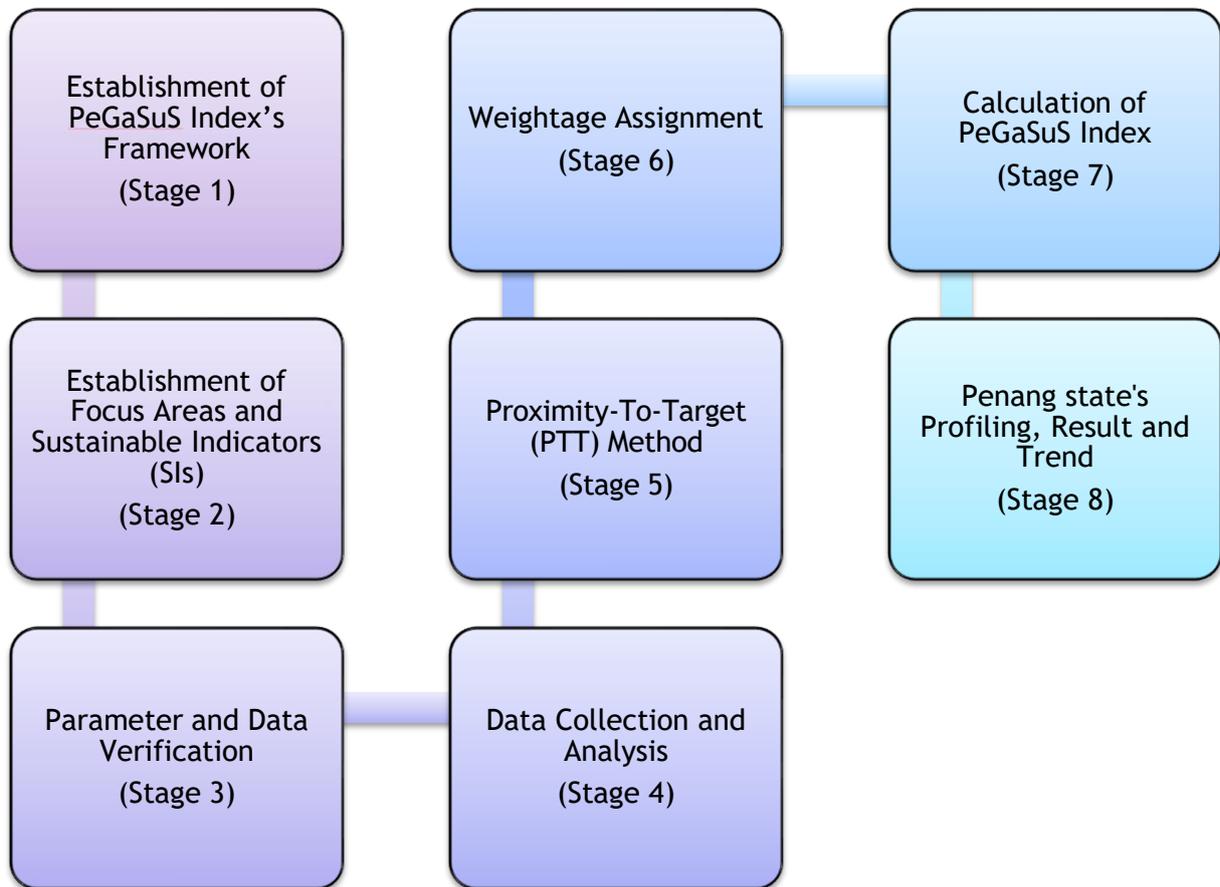


Figure 2.1: Flow Chart of Development Stages of PeGaSuS Index

2.1 Stage 1: Establishment of PeGaSuS Index's Framework

As a starting point in establishing the framework of PeGaSuS Index, it is crucial to return to the objective of PeGaSuS, which is to measure the performance of the SIs under the focus areas that will contribute towards dimensions and the overall index performance. Therefore, the indicators have to be arranged in a way that their performance will affect their respective focus area and dimension, and assuredly the index performance as well. With that, the architecture of the PeGaSuS Index's framework is in the form of hierarchy structure, as shown in Figure 2.2.

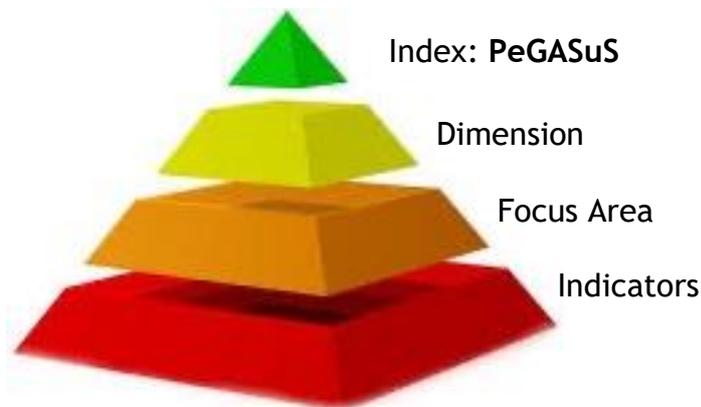


Figure 2.2: Hierarchy Structure of PeGaSuS Index Framework

2.2 Stage 2: Establishment of Focus Areas and Sustainable Indicators (SIs)

Preliminary discussions with Penang Green Council (PGC) were carried out to design the concept and purposes of PeGaSuS Index. It was concluded that there will be three (3) dimensions under the framework of PeGaSuS Index, which are: Environment, Economy and Social. And also, it is crucial that characteristics of PeGaSuS index includes several important themes like: Penang Green Agenda (PGA), Smart City, Green City, Green Economy, Circular Economy, Disaster Management and Disaster Reduction Strategies as illustrated in Figure 2.3.



Figure 2.3: Characteristics of PeGaSuS Index

Consequently, intensive horizontal scanning were conducted to survey and compile SIs that are focused on by the stated themes above. SIs may demonstrate what is happening to the economy, environment or society. However, due to the complexity of the sustainability issues and voluminous amount of sustainability-related data, stringent criteria for selecting data for the SIs are necessary. In this project, SIs with their respective focus areas that are suitable to Malaysia context were gathered. With that, a potential list of SIs and focus areas were compiled. These SIs and their focus areas were then arranged accordingly into the three (3) dimensions. Table 2.1 shows the potential list of focus areas and SIs of PeGaSuS Index.

Table 2.1: Potential List of Focus Areas and Sustainable Indicators of PeGaSuS Index

Index	Dimension(s)	Focus Area(s)	Sustainable Indicator(s)
PeGaSuS (157)	Economy (34)	Economic Performance (11)	Gross Domestic Product (GDP) per capita Labour productivity Growth rate of Real GDP Rate of new business start-ups Income equality: GINI coefficient Gross national disposable income Median disposable annual household income Poverty line income Labour force participation rate Consumer Price Index Trade (% of GDP)
		Industry (2)	Share of industry in GDP Share of industry in employment
		Agriculture (4)	Share of agriculture industry in GDP Changes in agricultural area Irrigation Rate of chemical fertilizers used
		Services (6)	Share of services in GDP Share of services in employment International events organized Tourism intensity International tourism (numbers of arrivals) Inbound tourism expenditure

Index	Dimension(s)	Focus Area(s)	Sustainable Indicator(s)
		Sustainable Resources Management (2)	Material Footprint Resource Productivity
		Green Competitiveness, Innovation and Initiatives (9)	Certification of ISO 14001 Green Public Procurement (GPP) Green jobs Freight movement MyHIJAU Programme Private sector Local banks Secondary raw materials Government Initiatives (qualitative)
	Environment (73)	Energy (4)	Electricity consumption per capita Electricity consumption per unit of GDP Renewable energy Government policies on Green Energy (qualitative)
		Land Use and Planning (4)	Urban green spaces Land use intensity Urban sprawl (qualitative) Government policies on Green Land Use (qualitative)

Index	Dimension(s)	Focus Area(s)	Sustainable Indicator(s)
		Waste Management (8)	Solid waste generation Food waste generation Industrial waste generation Commercial waste generation Recycling Solid waste diversion Scheduled waste collection Government policies on waste reduction
		Water Management (12)	Total water consumption per capita Domestic water consumption per capita Non-domestic water consumption per GDP Non-revenue water Grey and rain water use Drinking water source (urban) Drinking water source (rural) Water Exploitation Index Water Quality Index Government policies on water supply (qualitative) Government policies on water quality (qualitative) Government policies on storm management (qualitative)
		Sanitation (5)	Population with access to improved sanitation Wastewater Treatment Improved sanitation facility (urban) Improved sanitation facility (rural) Sewage treatment

Index	Dimension(s)	Focus Area(s)	Sustainable Indicator(s)
		Air Quality (6)	Particulate matter emissions Fine particulate matter emissions Nitrogen oxides emissions Sulphur dioxide emissions Air Quality Index Government policies on clean air (qualitative)
		GHG Emissions (4)	GHG emissions GHG emissions per capita GHG emissions intensity of GDP CO2 equivalent reduction strategy (qualitative)
		Disaster Management (11)	Death due to natural disaster Exposure to natural disaster Natural disaster related economic loss Vulnerability (Public) Vulnerability (Buildings) Vulnerability (Infrastructure) Resilience (Public) Resilience (Commercial) Capacity development Emergency services response time Expenditures on disaster relief and response
		Noise Exposure (1)	Excessive noise
		River Management (2)	Water catchment areas River Quality
		Marine and Coastal Management (2)	Marine protected areas Natural sites

Index	Dimension(s)	Focus Area(s)	Sustainable Indicator(s)
		Mineral Resource Management (2)	Mineral resources reserves Mineral extraction rates
		Biodiversity and Natural Ecosystem (6)	Green and water spaces Natural forest area Planted forest area Threatened fauna species Fish Catch Expenditure on environment protection (% of GDP)
		Climate Resilience (2)	Climate resilience strategy Urban Heat Island Intensity (UHII)
		Environmental Governance (4)	Green action plan (qualitative) Green management (qualitative) Public participation in green policy (qualitative) Multi-lateral environmental agreements (MEAs) (qualitative)
	Social	Society (12)	State population Urban population Growth rate of urban population Senior population Population density Life expectancy at birth (male) Life expectancy at birth (female) Poverty Extreme poverty Unemployment rate Low-cost housing Net migration

Index	Dimension(s)	Focus Area(s)	Sustainable Indicator(s)
		Health (3)	Health care services Government policies on healthy lifestyle (qualitative) Expenditure on health (% of GDP)
		Transportation (7)	Motorbike/Bicycle route network Public transportation Public transportation availability (qualitative) Congestion Government policies on congestion reduction (qualitative) Green transport promotion (qualitative)
		Accessibility to amenities and facilities (10)	Access to public amenities Access to commercial amenities Flexibility of delivery services (qualitative) Cellular services Public WiFi Network-based services Household access to computer Household access to internet Fixed broadband users Mobile broadband users
		Governance and Institution (4)	Expenditure by the municipalities for a transition towards a Smart City Government policies on Smart City (qualitative) Multilevel government (qualitative) Expenditure on research (% of GDP)

Index	Dimension(s)	Focus Area(s)	Sustainable Indicator(s)
		Social Security and Safety (4)	Crime rate Child protection Cyber security (qualitative) Data privacy (qualitative)
		Community Involvements (2)	Participation in environmental projects Voter participation
		Building Constructions (2)	Green Building Initiatives Adaptive reuse

Round table discussion with experts who were identified beforehand by PGC team to review the suitability of these potential SIs (Table 2.1) to be included into PeGaSuS framework. The group of experts consists of researchers and officers working on both government and private sectors. They were contacted through PGC team through emails mostly. Feedbacks and opinions from the experts and PGC team themselves were gathered and took into account. SIs that are less adequate were filtered out, while the remaining SIs were brought to discussion with Penang Green Council (PGC) team to check their data availability. It should be highlighted that there is one important filtration criteria that have to be met, which is data availability. Only indicators with readily available data remain in the framework. After some back and forth with PGC team, a finalised list of practical SIs with readily available data were concluded and carried forward to next stage. Figure 2.4 shows the finalised PeGaSuS Framework, with its focus areas and SIs.

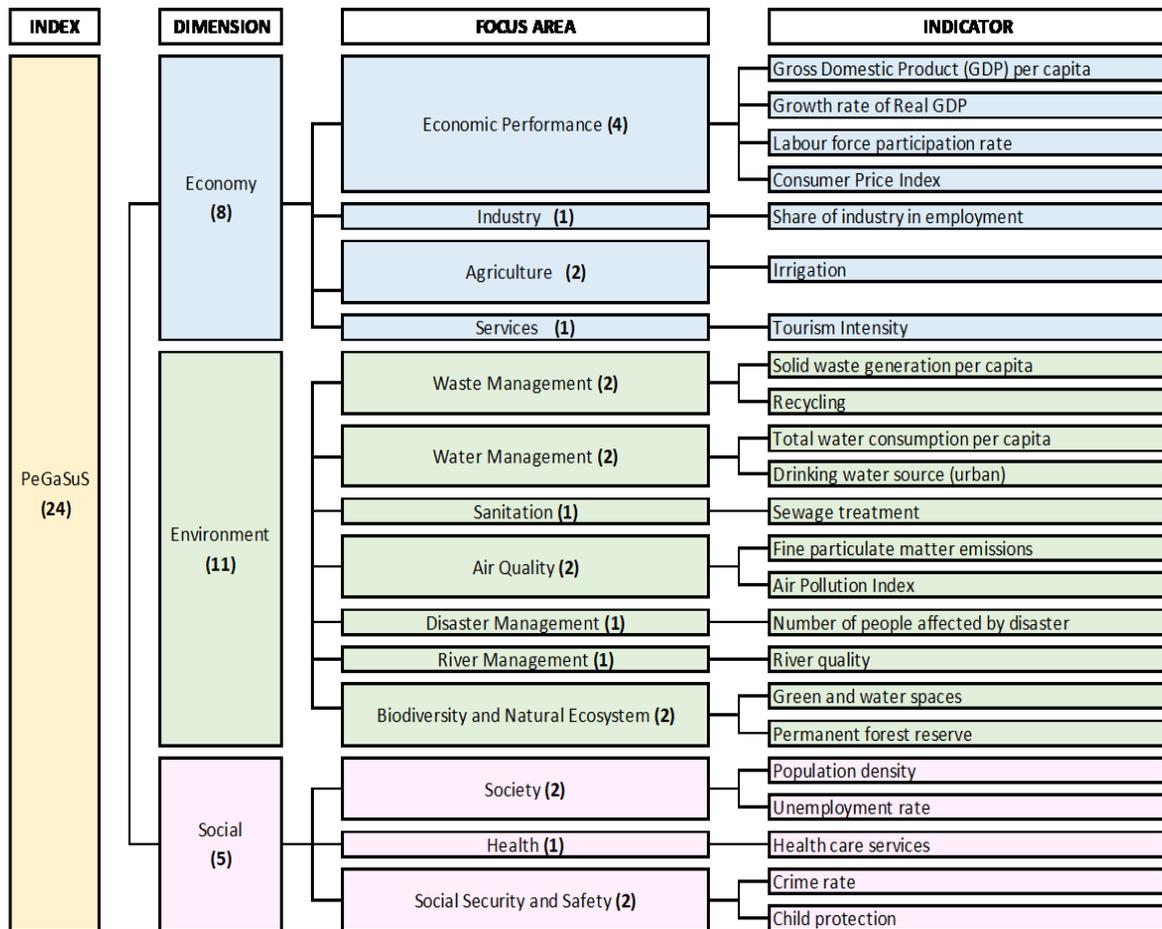


Figure 2.4: PeGaSuS Finalised Framework

2.3 Stage 3: Parameter and Data Verification

Most of the sustainability performance data can be quantified, but the issues of measurability still need to be considered on the matter of data availability. Notably, those related to government policies or actions exist in qualitative form, where expert opinions are preferred. Additional data collection was required to be performed as well, which was through survey questionnaires.

2.4 Stage 4: Data Collection and Analysis

All data that needed to be fed into the finalised SIs were provided by Penang Green Council (PGC). For the qualitative data, additional data collection such as survey questionnaire/expert opinions may be needed. As for weightage assignment, questionnaires are distributed to experts to assign weightage, based on their own perspectives, towards focus areas established in the PeGaSuS framework.

Basic statistical analysis might be used to obtain minimum, mean, average, median and maximum values. For the raw data, such as total emissions, may not be suitable for direct comparison as this would not reflect the different territorial sizes, environmental endowments, demographic and economic contexts of each unit. Therefore, for ranking purposes, such data need to be converted or normalized to be comparable. Table 2.2 summarises several common normalizations that could be found similarly in PeGaSuS Framework.

Table 2.2: Common Normalizations and Its Example

Normalization	Example
Percent change	Rates of deforestation over some time period
Units per economic output	Energy use per GDP
Units per area	Percent territory where water extraction exceeds a certain threshold
Units per population	CO ₂ emissions per capita

2.5 Stage 5: Proximity-To-Target (PTT) Method

As mentioned earlier, the development of PeGaSuS Index adopted similar methodology as Environmental Performance Index, known as Proximity-to-Target (PTT) method. PTT is a concept where data of various established indicators with different measurement units are transformed so that they can be aggregated all together into an index. The indicators' performance of PeGaSuS was primarily expressed as proximity to a predetermined target score. In this manner, the performance of each indicator is measured based on its relative position within a range established by the lowest performance (equivalent to 0 on a 0-100 scale) and the target (equivalent to 100). The concept of PTT is illustrated in Figure 2.5.

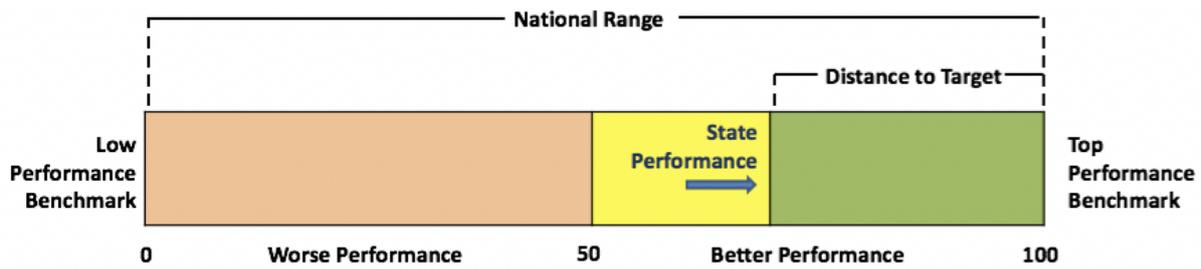


Figure 2.5: Concept of Proximity-To-Target (PTT)
(Source: Emerson et al., 2012)

2.5.1 Identification of Indicator Type

The first step in PTT methodology is to identify the type of indicator based on its nature and purpose. There are two (2) types of indicators: Type A and Type B. Type A indicators are indicators with higher data value means better performance, while Type B indicators are indicators with lower data value means better performance. For example, Gross Domestic Product (GDP) per capita is a Type A indicator, while solid waste generation rate is a Type B indicator. This step is extremely crucial, as the mathematical formulas to calculate PTT score for both types differed significantly. Figure 2.6 shows the mathematical formula used during the calculations of PTT score for the indicator of Type A and Type B.

$PTT = \frac{[(target - min) - (target - Raw\ data)] \times 100}{(target - min)}$	Type A
$PTT = \frac{[(max - target) - (Raw\ data - target)] \times 100}{(max - target)}$	Type B

Figure 2.6: Mathematical Formula for the Calculation of PTT Score
(Source: Emerson et al., 2012)

2.5.2 Identification of Target and Low Benchmark

To set the target and low benchmark for each Sis , there are three (3) major sources that are used and referred. Those major sources are: Best Performance, State Government Policy Document, Federal Government Policy Document.

State government policy documents are the most favourable source to be referred, as the targets are specific to Penang state and set based on the Penang state’s scenario. Policy documents that are published by Federal Government are the second favourable sources, as

targets set by Federal Government for the nation can be referred as guidance. The least favourable source is best performances, where the target is set based on state data trends. To ensure the accountability and credibility of the data trend, data trends published by state government statistics agencies are preferred. Figure 2.7 illustrates the preferences of references sources used in setting the target and low benchmarks of the SIs.

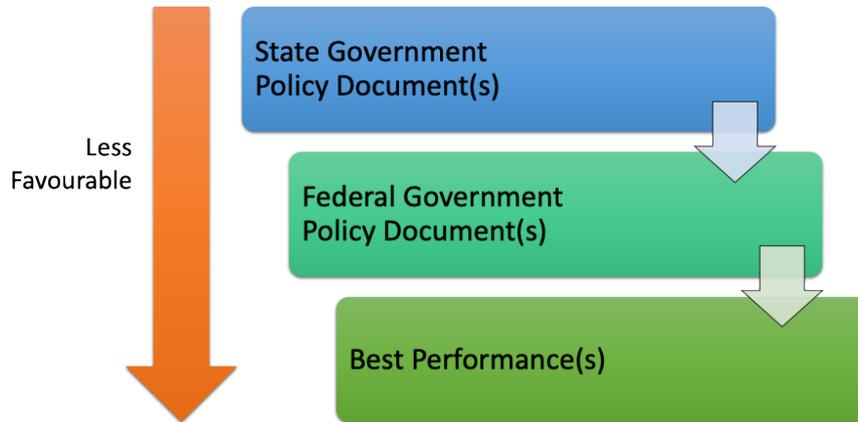


Figure 2.7: Sources of Reference in Setting Target and Low Benchmark

Aside from that, data trends are crucial for setting the low benchmarks of the SIs as well. Generally in setting target and low benchmark for an indicator by using best performances (data trend), if the indicator is Type A, the target usually is the maximum value and low benchmark is the minimum value, and vice versa for Type B. Examples of setting target and low benchmark for Type A and Type B indicator are as follows:

Example of setting target and low benchmark for Type A Indicator

Indicator name: River Quality
 Indicator code: En6-2
 Unit of measurement: %
 Type: A (higher value equates to better performance)
 Raw data provided by PGC:

Year	%
2007	62.740
2008	64.340
2009	66.288
2010	63.860
2011	67.705
2012	69.329
2013	71.624
2014	69.340
2015	72.705
2016	69.717

Since it is Type A indicator,
 Target = Maximum value
 = 72.705
 Low Benchmark = Minimum value
 = 62.740

Example of setting target and low benchmark for Type B Indicator

Indicator name: Child Protection

Indicator code: So6-2

Unit of measurement: pax

Type: B (lower value equates to better performance)

Raw data provided by PGC:

Year	Male	Female	Total
2009	73	119	192
2010	29	50	79
2011	89	133	222
2012	67	120	187
2013	78	116	194
2014	78	105	183
2015	74	114	188
2016	91	156	247
2017	129	159	288

Since it is Type B indicator,

Target = Minimum value
= 79

Low Benchmark = Maximum value
= 288

Furthermore, most indicators' targets in PeGaSuS framework were of target to be achieved by year 2020 set by Penang State. PGC team have done extensive reviews on previous published governmental documentations. Meanwhile the remaining indicators' targets were set by best performances. In short, the targets and low benchmarks were firstly suggested and showed to PGC team. Discussions were comprehensively carried out, and more suitable targets were provided by PGC team.

2.5.3 Calculation of PTT Score

Once the type of indicator, target and low benchmark had been set, together with readily-provided data, the PTT score of the indicators were then computed by using the mathematical formulas given in Figure 2.6. Samples of PTT score calculation for Type A and Type B indicator are as follows:

Sample Calculation: Type A Indicator

Indicator name: Gross Domestic Product (GCP) per capita

Indicator code: Ec1-1

Unit of measurement: RM/capita

Type: A (higher value equates to better performance)

Target: RM 50,000/capita

Low Benchmark: RM 26,833/capita

Raw Data: RM 49,873/capita

$$\begin{aligned}
 PTT_{Ec1-1} &= \frac{[(target - min) - (target - raw\ data)] \times 100}{(target - min)} \\
 &= \frac{[(50,000 - 26,833) - (50,000 - 49,873)] \times 100}{(50,000 - 26,833)} \\
 &= \frac{(23,167 - 127) \times 100}{(23,167)} \\
 &= 99.45
 \end{aligned}$$

Sample Calculation: Type B Indicator

Indicator name: Particulate Matter Emissions

Indicator code: En4-1

Unit of measurement: $\mu\text{g}/\text{m}^3$

Type: B (lower value equates to better performance)

Target: $40.00 \mu\text{g}/\text{m}^3$

Low Benchmark: $119.96 \mu\text{g}/\text{m}^3$

Raw Data: $45.65 \mu\text{g}/\text{m}^3$

$$\begin{aligned}
 PTT_{En4-1} &= \frac{[(max - target) - (raw\ data - target)] \times 100}{(max - target)} \\
 &= \frac{[(119.96 - 40.00) - (45.65 - 40.00)] \times 100}{(119.96 - 40.00)} \\
 &= \frac{(79.96 - 5.65) \times 100}{(79.96)} \\
 &= 99.93
 \end{aligned}$$

2.6 Stage 6: Weightage Assignment

There are four levels in the framework of PeGaSuS: indicator, focus area, dimensions and lastly, index. Each levels have weightage assigned to them, as to show the level of importance within and among one another. At the indicator level, all indicators carry equal weight. This would ease future addition of new indicators into the framework. As for the focus area level, the weights of each focus areas were assigned based on experts' opinions via survey questionnaires. Online survey form was set up through Google Form, and survey questionnaires were disseminated through emails to the same group of experts as before. They were shown the finalised focus areas in PeGaSuS framework, and asked to rate the level

of importance through Likert Scale (Level 1: Not important - Level 5: Very Important). Their responses were collected and analysis to calculate the weightage were carried out. Rating results of all the focus areas were then aggregated into weightages for dimension level. It showed that Environment Dimension had the highest weightage of 38%, followed by Social (32%) and Economy (30%). In other words, it was rated that Environment Dimension is the most important compared with the others. The weightages for dimension level are shown in Figure 2.8.

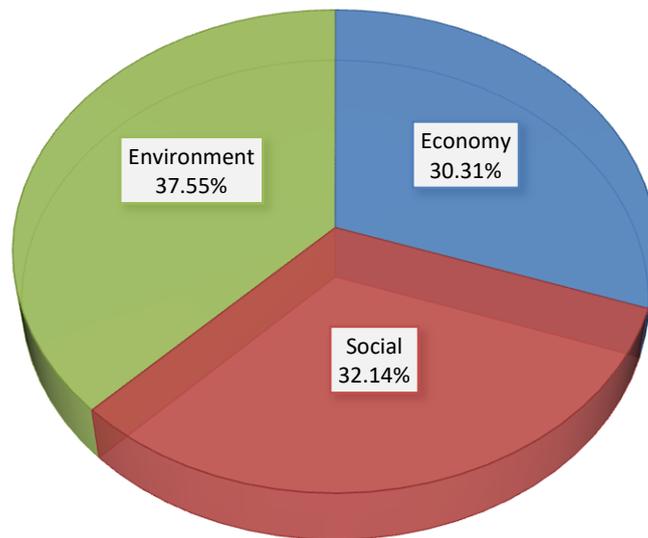


Figure 2.8: Weightages for Dimension Level of PeGaSuS Index

2.7 Stage 7: Calculation of PeGaSuS Index

To calculate the PeGaSuS Index, it starts with calculation of focus area PTT scores by aggregating the indicator PTT scores into focus area PTT scores. All indicators PTT scores were summed up and then divided by the total number of indicators under the respective focus area. After the calculation of focus area PTT scores are complete, the PTT score for each dimension can be done.

Similar process with determining the focus area PTT scores, the PTT score for each dimension is the aggregation of focus area PTT scores. All the focus areas PTT scores are summed up and then divided by the number of focus areas under the respective dimension. Once all dimension PTT scores are completed, PeGaSuS Index is then calculated by summing up all aggregated dimension PTT scores. Aggregated dimension PTT score is computed by multiplying certain dimension PTT score with the assigned weightage. Figure 2.9 summarises the steps of PeGaSuS Index calculation from raw data to index score, while sample calculations for Focus Area PTT Score, Dimension PTT Score, Aggregated Dimension PTT Score and PeGaSuS Index are shown respectively.

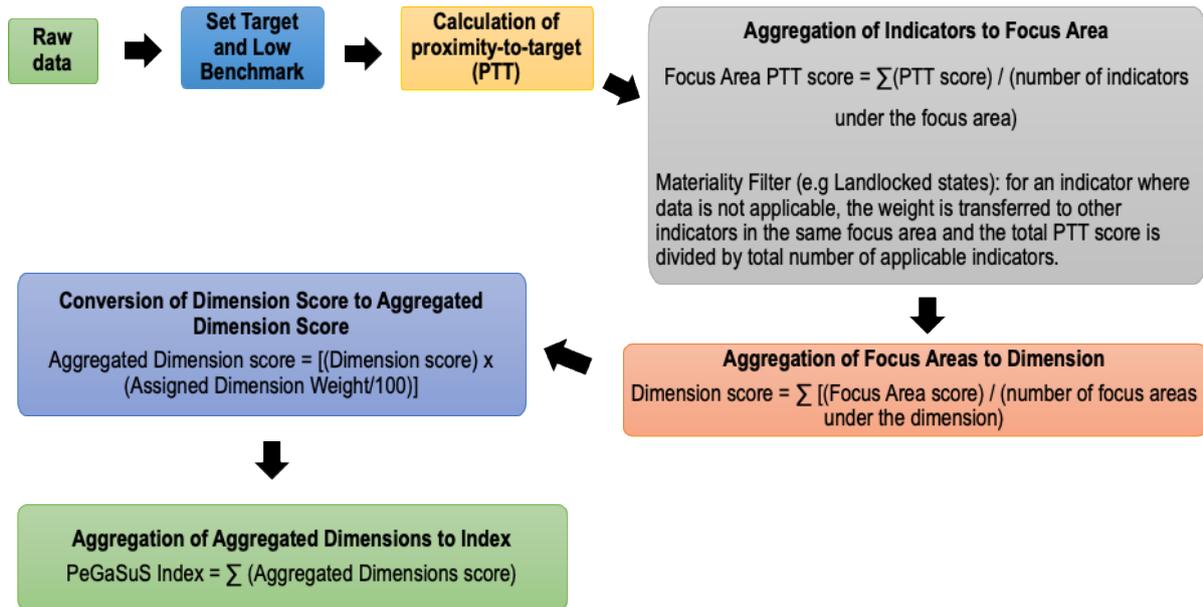


Figure 2.9: Flow Chart of PeGaSuS Index Calculation

Sample Calculation of Focus Area PTT Score

Focus Area: Economic Performance
 Focus Area Code: Ec1
 Number of indicators under focus area: 4
 PTT scores of all 4 indicators:

Indicator	Indicator Code	Unit Measurement	PTT Score (Indicator)
Gross Domestic Product (GDP) per capita	Ec1-1	RM/capita	99.45
Growth rate of Real GDP	Ec1-3	%	100.00
Labour force participation rate	Ec1-5	%	79.25
Consumer Price Index	Ec1-6	Index	100.00

$$\begin{aligned}
 \text{PTT Score}_{\text{Economic Performance}} &= \frac{\text{Sum of all indicators PTT Scores}}{\text{Number of Indicators under the Focus Area}} \\
 &= \frac{99.45 + 100.00 + 79.25 + 100.00}{4} \\
 &= \frac{378.70}{4} \\
 &= 94.68
 \end{aligned}$$

∴ With that, the Focus Area PTT Score for Economic Performance is 94.68.

Sample Calculation of Dimension PTT Score

Dimension: Economy

Dimension Code: Ec

Number of focus areas under dimension: 4

PTT scores of all 4 focus areas:

Focus Areas	Focus Area Code	PTT Score (Focus Area)
Economic Performance	Ec1	94.68
Industry	Ec2	100.00
Agriculture	Ec3	100.00
Services	Ec4	56.62

$$\begin{aligned}
 PTT\ Score_{Economy} &= \frac{\text{Sum of all focus areas PTT Scores}}{\text{Number of Focus Areas under the Dimension}} \\
 &= \frac{94.68 + 100.00 + 100.00 + 56.62}{4} \\
 &= \frac{351.3}{4} \\
 &= 87.82
 \end{aligned}$$

∴ With that, the Dimension PTT Score for Economy is 87.82.

Sample Calculation of Aggregated Dimension PTT Score

Dimension: Economy

Dimension Code: Ec

Weightage assigned (%): 30.31

Aggregated Dimension PTT Score:

$$\begin{aligned}
 \text{Aggregated PTT Score}_{Economy} &= PTT\ Score_{Economy} \times \text{Weightage assigned} \\
 &= 87.82 \times 30.31\% \\
 &= 26.62
 \end{aligned}$$

∴ With that, the Aggregated Dimension PTT Score for Economy is 26.62

Sample Calculation of PeGaSuS Index

$$\begin{aligned}
 \text{PeGaSuS Index} &= \sum \text{Aggregated Dimension Scores} \\
 &= 26.619 + 23.918 + 21.385 \\
 &= 71.923
 \end{aligned}$$

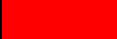
∴ With that, the PeGaSuS Index is 71.923

2.8 Stage 8: Penang state's Profiling, Result and Trend

Once the PeGaSuS index is calculated, pie-radar diagrams and bar charts were used as illustrations for better highlights of hotspots that require improvements, which also known as profiling. Star rating system were adopted to better interpretation of results. Star rating system were chosen, as it is an effective standard used to judge the quality of goods or services (Sobh, 2010). There are five (5) levels in the star rating system, where the highest level was of five (5) stars and the lowest level was of one (1) star. Since the PTT score ranged from 0 to 100, the scores were equally distributed among the five (5) level where each level carried twenty (20) scores respectively. The equal distribution of PTT score among the five (5) levels was approved and accepted by PGC team.

Each of the star rating levels are assigned with a colour code. Red colour is chosen as the colour for lowest star rating level, while blue colour is chosen as the colour for the highest star rating level. This is to highlight the indicator with very poor performance that need immediate attention and improvements, Table 2.3 summarise the star rating system adopted in this project.

Table 2.3: Star Rating System with Colour Code

PTT or Aggregation Score Values	Star Rating	Colour	Status
$81.0 \leq \text{PTT} \leq 100.00$	5		Excellent
$61.0 \leq \text{PTT} \leq 80.00$	4		Good
$41.0 \leq \text{PTT} \leq 60.00$	3		Fair
$21.0 \leq \text{PTT} \leq 40.00$	2		Poor
$0.0 \leq \text{PTT} \leq 20.00$	1		Very Poor

Interpretation of PTT Scores

It is crucial to understand the concept of PTT in interpreting the PTT Scores. PTT concept transforms raw data of the indicator into a score range of zero (0) to a hundred (100), where the PTT score indicates the distance of the most recent year available raw data from the set target, with the highest or lowest raw data value as benchmark (depending on the type of indicator, as explained in Section ...).

A PTT score of a hundred (100) signifies that the indicator has achieved its set target, or in some cases the indicator has surpassed the set target. On the other hand, PTT score of zero (0) signifies that the raw data of the most recent year is at the highest or lowest point of the raw data trend, sharing similar value with the set benchmark. Consequently, when plugging in the raw data into the formula (as showed in Figure 2.6), the PTT score automatically will become zero (0). It can also indicates that the raw data of the most recent year may be higher or lower than the set benchmark, hence resulting a PTT score of zero (0) as well. Therefore, it should be noted that indicators with PTT Score of zero (0) does not indicate that the indicator has zero (0) performance or raw data of the indicator is zero (0).

3.0 RESULTS INTERPRETATION

Overall, PeGaSuS Index score is 71.92, with Economy Dimension PTT Score of 87.82, Environment Dimension PTT Score of 63.70 and Social Dimension PTT Score of 66.54, as summarised in Table 3.1. In other words, looking at the PTT score alone, Economy Dimension had done the best among the others. This is very interesting, as referring back to Section 2.6, Environment Dimension had been rated as the most important. However, the indicators under Economy Dimension performed better therefore resulting Economy Dimension had a better score. Nonetheless, more in-depth discussions on dimensions, together with their respective focus areas and indicators, are carried out under respective sub-sections.

Table 3.1: Distribution of PTT Score for Dimensions, Aggregated Dimension Score and PeGaSuS Index Score

Dimension	PTT Score (Dimension)	Weightage Assigned (%)	Aggregated Dimension Score
Economy	87.82	30.31	26.619
Environment	63.70	37.55	23.918
Social	66.54	32.14	21.385
PeGaSuS Index:			71.923

3.1 Focus Areas

There are a total of fourteen (14) focus areas finalised in this study. Under the Economy dimension, there are four (4) focus areas finalised, which are: Economic Performance, Industry, Agriculture and Services. Meanwhile there are seven (7) focus areas finalised, which are: Waste Management, Water Management, Sanitation, Air Quality, Disaster Management, River Management and Biodiversity. Lastly, under the Social dimension, there are three (3) focus areas finalised, which are: Society, Health and Social Security. The tabulation of PTT scores under each focus areas are shown in Figure 3.1.

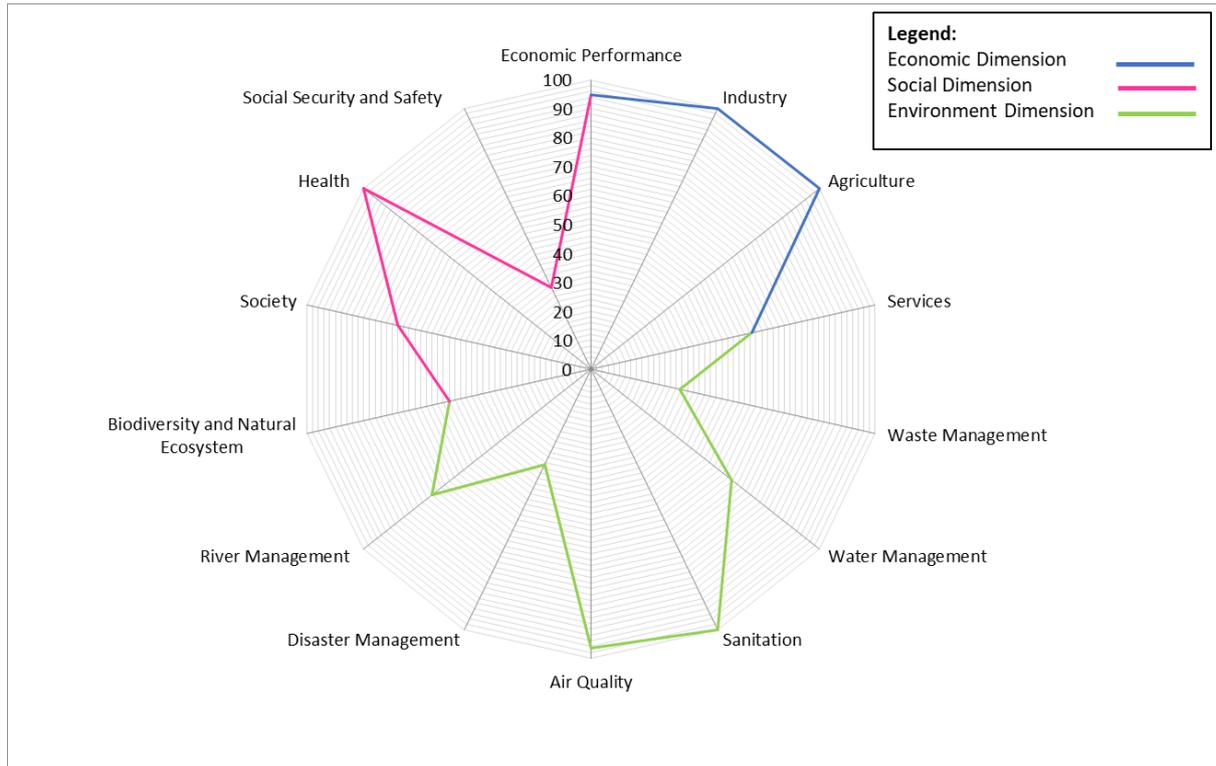


Figure 3.1: Pie-Radar Diagram on Distribution of PeGaSuS Index among Focus Areas

From Figure 3.1, the PTT scores are tabulated in colour coding as depicted in the Legend, to ease the discussion. Among all focus areas, Waste Management (31.06), Social Security (31.41) and Disaster Management (36.67) are the three (3) focus areas that scored lowest. Both Waste Management and Social Security are focus areas categorised under Economy Dimension, while Disaster Management is categorized under Social Dimension. On the other hand, there are four (4) focus areas that obtained PTT score of 100 from each dimensions, which are: Industry, Agriculture, Sewage Treatment and Health Care Services. Industry is categorised under Economy Dimension, Sewage Treatment is under Environment Dimension and lastly, Health Care Services.

Breakdown of the PeGaSuS Index on PTT Scores for Focus Areas, Dimensions and Aggregated Dimensions is shown in Figure 3.2. Further discussions on each dimensions are carried out under respective sub-sections.

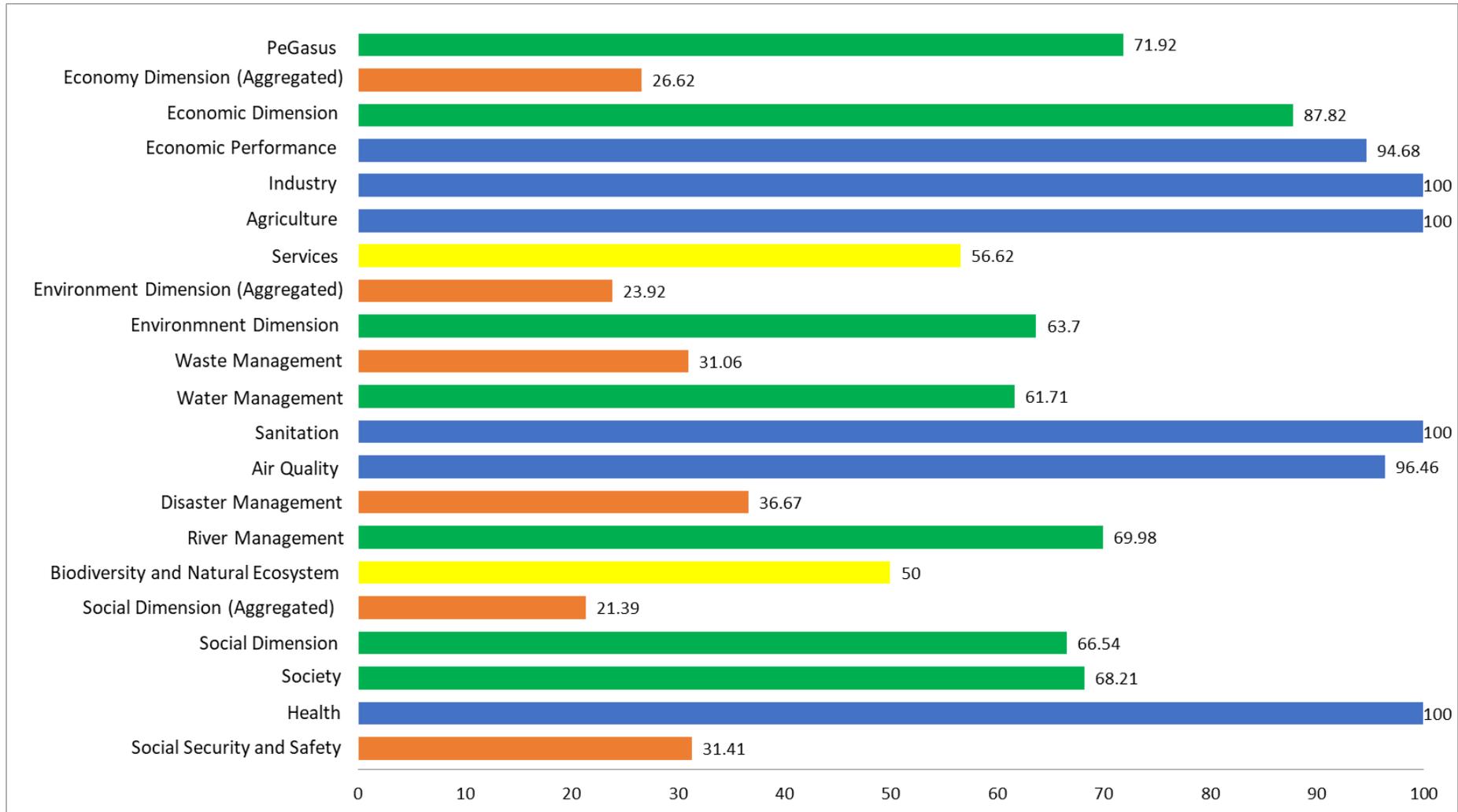


Figure 3.2 Breakdown of PeGaSuS Index on PTT Scores for Focus Areas, Dimensions and Aggregated Dimensions

3.2 Economy Dimension

Economy Dimension consists of four (4) focus areas and seven (7) sustainable indicators in total, as shown in Table 3.2.

Table 3.2: Tabulation of PTT Scores for Economy Dimension

Focus Area(s)	Sustainable Indicator(s)	Unit Measurement	PTT Score (Indicator)	PTT Score (Focus Area)	PTT Score (Dimension)
Economy Performance	Gross Domestic Product (GDP) per capita	RM/cap	99.45	94.68	87.82
	Growth rate of Real GDP	%	100.00		
	Labour force participation rate	%	79.25		
	Consumer Price Index	Index	100.00		
Industry	Share of industry in employment	%	100.00	100.00	
Agriculture	Irrigation	%	100.00	100.00	
Services	Tourist arrivals	pax	56.62	56.62	

Looking at Table 3.2, it can be seen that focus areas of Industry (100.00), Economy Performance (94.68) and Agriculture (100.00) performed excellently. However, focus areas of Services performed fairly, with its PTT Focus Area Score of 56.62. As under Services focus area consist only one sustainable indicator (i.e.: tourist arrivals), improving its performance is much easier. The sustainable indicator “tourist arrivals” is described as the annual number of tourists coming to Penang state, with a measuring unit of pax. Therefore, better marketing strategies to attract more tourists, both local and international, need to be considered and planned carefully.

Under the focus area of Agriculture, there is one (1) sustainable indicator known as irrigation. The sustainable indicator “irrigation” has a PTT Score of 100, in other words achieved the desired target. Figure 3.3 illustrates PTT scores tabulation for Environment Dimension.

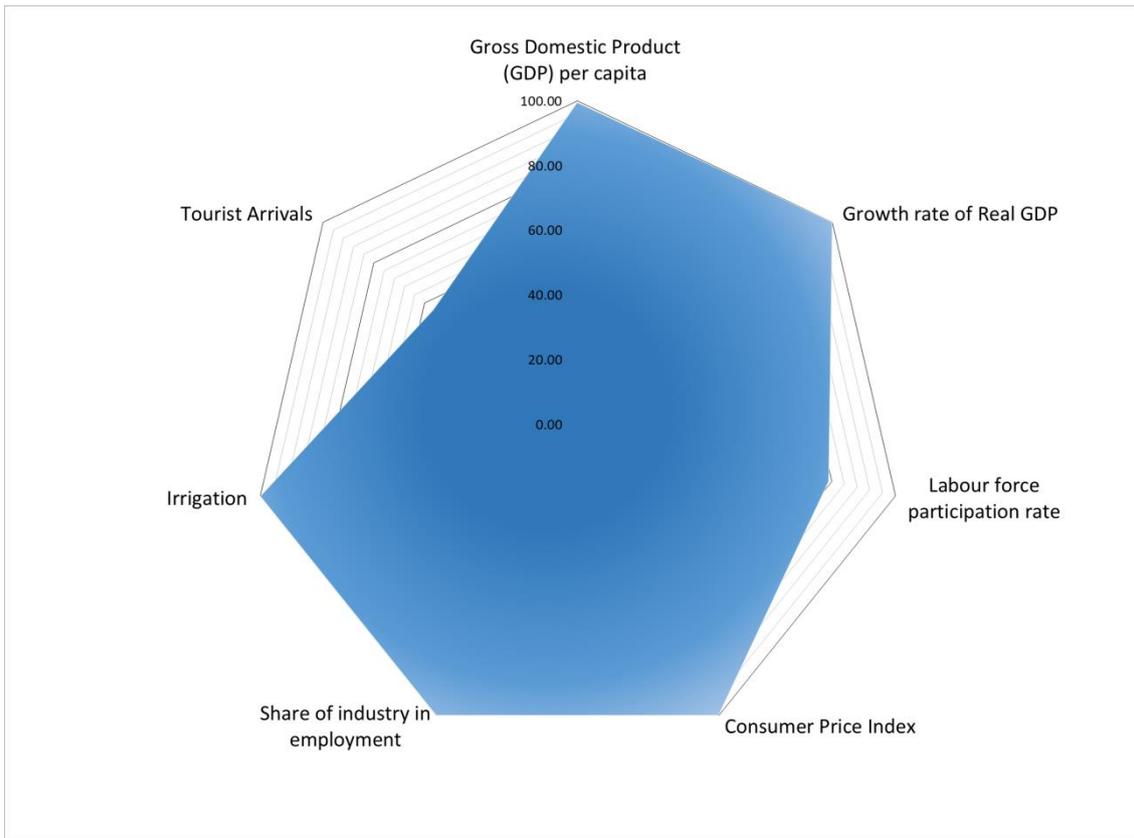


Figure 3.3: PTT Scores Tabulation for Economy Dimension

3.3 Environment Dimension

Environment Dimension consists of seven (7) focus areas and eleven (11) sustainable indicators in total, as shown in Table 3.3.

Table 3.3: Tabulation of PTT Scores for Environment Dimension

Focus Area(s)	Sustainable Indicator(s)	Unit Measurement	PTT Score (Indicator)	PTT Score (Focus Area)	PTT Score (Dimension)
Waste Management	Solid waste generation per capita	kg/capita/year	0.00	31.06	63.70
	Recycling	tonnes/year	62.12		
Water Management	Total water consumption per capita	L/capita/day	23.42	61.71	
	Drinking water source (urban)	%	100.00		
Sanitation	Sewage treatment	%	100.00	100.00	
Air Quality	Fine particulate matter emissions	µg/m ³	92.93	96.46	
	Air Quality Index	Index	99.99		
Disaster Management	Number of people affected by disaster	pax	36.67	36.67	
River Management	River quality	%	69.98	69.98	
Biodiversity and Natural Ecosystems	Green and water spaces	%	0.00	50.00	
	Forest reserves	%	100.00		

Referring to Table 3.3, it can be seen that most focus areas performed good and excellently, which are: Sanitation (100.00), Air Quality (96.46), River Management (69.98) and Water Management (61.71). However, Waste Management (31.06) and Disaster Management (36.67) are the focus areas that performed poorly under Environment Dimension. Focus area of Disaster Management has only one sustainable indicator, which is number of people affected by disaster. The sustainable indicator “number of people affected by disaster” is described as annual number of people successfully get financial aid from Tabung Bantuan Tuan Yang Terutama (T.Y.T) Negeri Pulau Pinang, with unit measurement of pax. To improve the performance of this indicator, better disaster prevention and management strategies for Penang state need to be implemented in order to reduce the number of people affected by disaster.

As for focus area of Waste Management, there are two (2) sustainable indicators that are: recycling and solid waste generation per capita. Sustainable indicator “recycling” has good performance, however sustainable indicator “solid waste generation per capita” performed poorly. The sustainable indicator “solid waste generation per capita” measures the annual solid waste generation rate per capita in Penang state, with unit measurement of kg/capita/day. The awareness of Penang community to generate lesser waste needs to be increase, in order to improve the performance of this indicator.

Meanwhile, there is another sustainable indicator under Environment Dimension that performed very poorly, which is: green and water spaces. This sustainable indicator is under focus area of Biodiversity and Natural Ecosystems. The sustainable indicator “green and water spaces” is described as the proportion of green and water spaces to the total land area in Penang state, with the unit measurement of percent (%). More proportion of green and water spaces need to be allocated in order to improve indicator performance. Figure 3.4 illustrates the PTT scores tabulation for Environment Dimension.

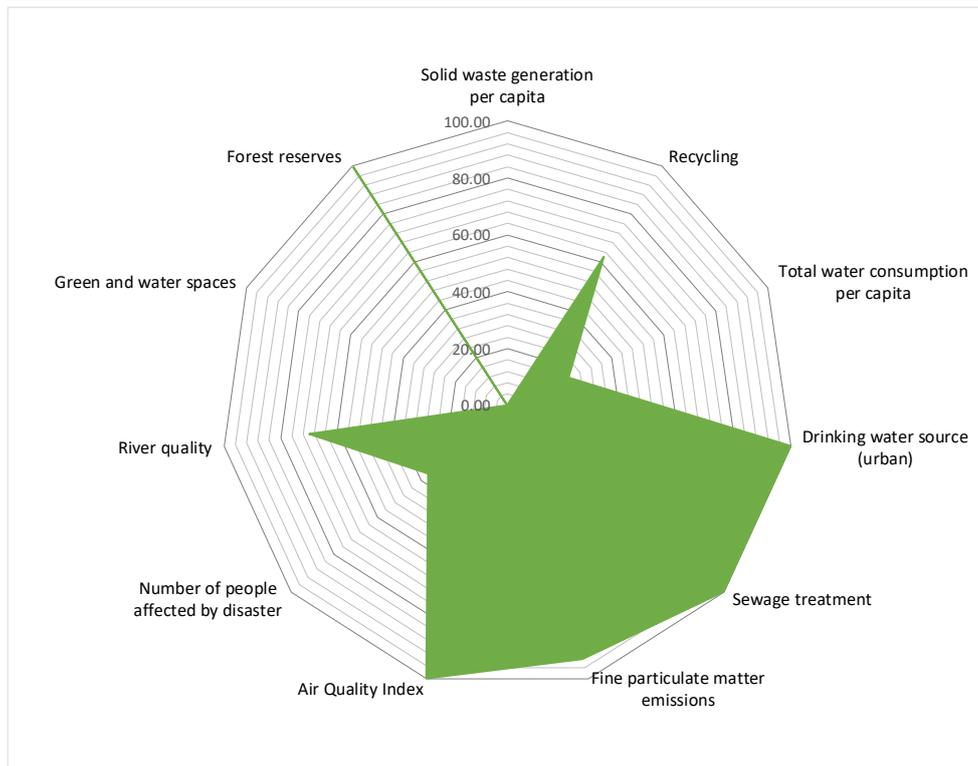


Figure 3.4: PTT Scores Tabulation for Environment Dimension

3.4 Social Dimension

Social Dimension consists of three (3) focus areas and five (5) sustainable indicators in total, as shown in Table 3.4.

Table 3.4: Tabulation of PTT Scores for Social Dimension

Focus Area(s)	Sustainable Indicator(s)	Unit Measurement	PTT Score (Indicator)	PTT Score (Focus Area)	PTT Score (Dimension)
Society	Population density	pax/km ²	36.42	68.21	66.54
	Unemployment rate	%	100.00		
Health	Health care services	%	100.00	100.00	
Social Security	Crime rate	#/100,000 pax	62.81	31.41	
	Child protection	pax	0.00		

Referring to Table 3.4, focus area of Social Security performed poorly compared with the others under Social Dimension, with PTT score of 31.41. There are two sustainable indicators under this focus area, which are: crime rate and child protection. The sustainable indicator “crime rate” had a good performance, where it measures the number of violence, annoyances and crimes reported in a year, per 100,000 inhabitants, at Penang state. On the other hand, the sustainable indicator “child protection” performed very poorly. It measures the annual amount of children that are in need of care and protection in Penang state. Better children protection services and policy need to be put in practice, as well as awareness among Penang community to protect and provide adequate care and attention to children in need to be improved. With that, it can reduce the number of children ended up in child protection, and hence improving the performance of this sustainable indicator. Figure 3.5 illustrates the PTT scores tabulation for Social Dimension.

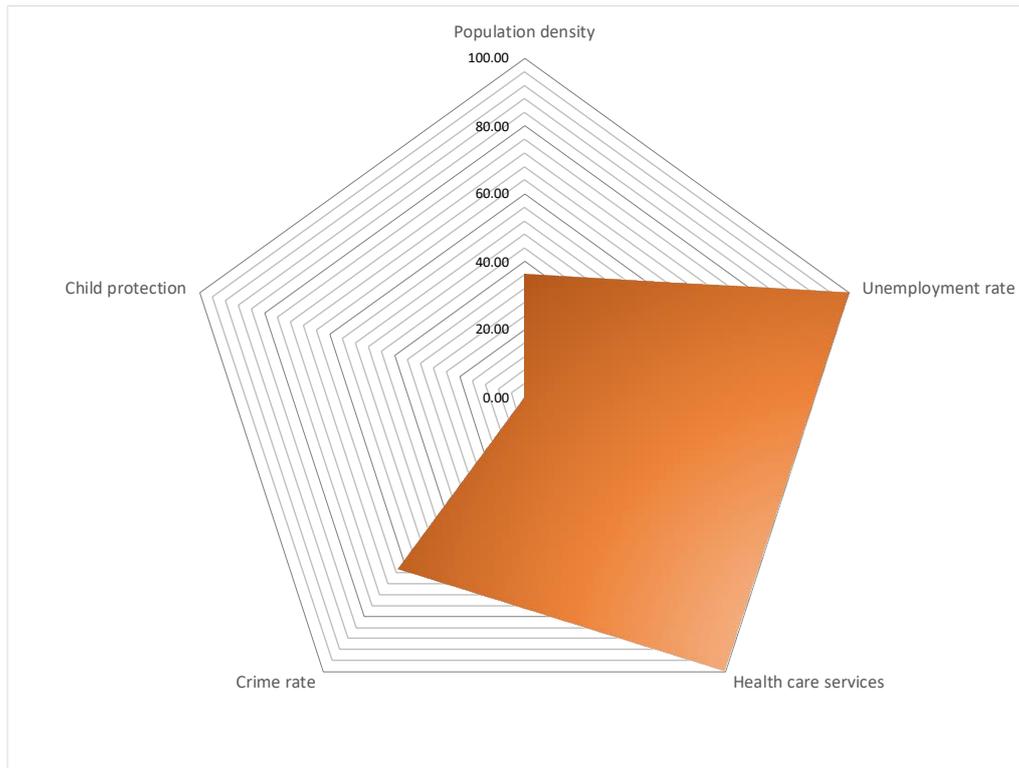


Figure 3.5: PTT Scores Tabulation for Social Dimension

4.0 CONCLUSION AND PROJECT RECOMMENDATIONS

In conclusion, Penang state has scored 71.92 for PeGaSuS Index after utilising all data of most recent year available. Looking at PTT Dimension Scores, all three (3) dimensions have good performances. Economy Dimension had the best performance, with the highest PTT score of 87.82. It is followed by Social Dimension (66.54) and lastly, Environment Dimension (63.70). In addition, after taking into account the weightage assigned by experts, Aggregated Dimensions Scores are also computed. The aggregation process is necessary as it is crucial to incorporate the expert opinions into the PeGaSuS framework, as well as normalising all the PTT Dimension Scores into 0-100 scoring system. Therefore, looking at the Aggregated Dimension Scores, Economy Dimension had the highest aggregated dimension score of 26.62. It is then followed by Environment Dimension (23.92) and lastly Social Dimension (21.38). All these three aggregated dimensions scores are then summed up into PeGaSuS Index, resulting an index score of 71.92.

Recommendations

It is recommended to revisit and review the PeGaSuS framework every two (2) years. This is crucial as new data for the potential indicators listed out at Table 2.1 might be available in future. This will improve the comprehensiveness of PeGaSuS Index in measuring the sustainability performance of Penang state. Furthermore, there might be better sustainable indicators to be considered inserting into the PeGaSuS framework in future. The targets and low benchmark set for each indicator in the PeGaSuS framework need to be revised as well. Most importantly, it is crucial for the State Government to understand the importance of raw data. It is highly recommended that State Government to organise regular data collection so that more potential indicators that listed out at Table 2.1 can be included into PeGaSuS Index framework. This then further improve the extensiveness and inclusiveness of PeGaSuS Index.

REFERENCES

- Kraemer, R., and Peichert, H. (2007). Analysis of the Yale Environmental Performance Index (EPI). Retrieved on June 20, 2020, from http://ecologic.eu/sites/files/publication/2015/kraemer_08_analysis_of_the_e_pi.pdf
- Stepping, K. M. K. (2013). Challenges in Measuring the State of the Environment in Developing Countries. Retrieved on June 20, 2020, from https://www.die-gdi.de/uploads/media/DP_25.2013.pdf
- Wendling, Z.A., Emerson, J.W., de Sherbinin, A., Esty, D.C., et al. (2020). 2020 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu
- Emerson, J. W., Hsu, A., Levy, M. A., de Sherbinin, A., Mara, V., Esty, D. C., & Jaiteh, M. (2012). 2012 Environmental Performance Index and Pilot Trend Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy.