Spatial-Based Sustainability Assessment of Urban Neighbourhoods: A Case Study of Johor Bahru City Council, Malaysia

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Abstract Rapid population growth has caused expansion of many major cities. Cities begin to expand into new areas as the demand for housing increases, thus, contributing to demand for a variety of natural and man-made resources for urban communities. However, it is our responsibility to sustain these resources so that their usage can be prolonged to the next generation. With sustainability as a goal, the use of indicators for urban monitoring and regulation is becoming more in demand. There are many non-spatial indicators in the form of words and statistics developed by local authorities for assessing urban development sustainability. This chapter proposes the use of spatial indicators for the same purpose. The indicators are derived from the Malaysian Urban Indicators Network (MurniNet) and are then developed using Analytical Hierarchy Process (AHP) comprising spatial elements

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of points, lines, and polygons. The AHP is used to determine the ranking of sustainability of urban areas. This study selects Johor Bahru City Council (JBCC) administrative area as a case. The result shows that spatial indicators can contribute to a better visualisation of sustainability via the production of sustainability map.

1 Introduction

Urban development can be defined as the expansion of urban areas into natural and rural areas such as deserts, swamps, and forests (Black et al. 2002). As population grows, socioeconomic needs arise. In particular, population growth in major cities requires city boundary's expansion while developers look into the neighbouring areas to build more housing, recreational, and other facilities. Consequently, demand for a variety of natural and man-made resources for urban communities increases.

The process of urban expansion requires that planners work closely with other parties to ensure environmental protection. In this context, sustainable development seeks to establish a balance between human needs and environmental preservation. Therefore, urban planners need to consider maintaining sustainable development while expanding and renovating urban areas. Especially important, much care needs to be taken to integrate the wilderness with the developing city when an urban area expands into wildlife regions (Litman 2007). Besides, sustainable urban development should function to curtail city pollution, to increase the availability of recycling facilities, and to encourage efficient use of alternative sources of energy.

Urban sustainability needs to be considered from ecological viewpoint and, thus, it needs to adopt the concepts of footprint, emissions, and energy (Broekhof and van Marwijk 2012). Further, to achieve a sustainable city, there are several elements to be considered (Fig. 1).

Figure 1 shows that urban sustainability should be considered from environmental, economic, and social dimensions. Since they are very complex and have different degrees of importance, an approach is needed to rank them accordingly before they can be used as indicators for urban development sustainability assessment (Fig. 1).

In 2004, the Malaysian government has taken an initiative, based on the Eight Malaysia Plan, to develop a set of indicators that can be used to measure sustainable urban development, called Malaysian Urban Indicators Network (Murn-iNet) (Marzukhi et al. 2011). However, these indicators, extracted from several planning sectors, are non-spatial indicators although they can be used for evaluating urban development. We propose the use of spatial indicators for the same purpose. Spatial indicators with sufficient spatial information and geographic visualisation can be useful for local sustainable planning, supporting decision-making in the planning process, and helping policy makers to identify

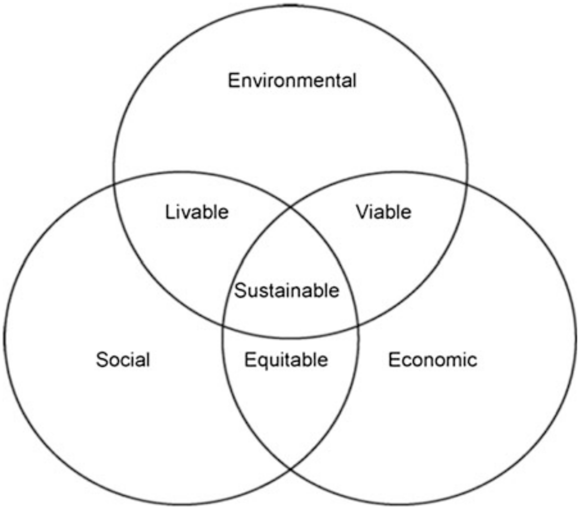


Fig. 1 The classic dimensions of sustainable development (*source* Tanguay et al. 2010)

'unsustainable' actions in the planning areas (Broekhof and van Marwijk 2012). As a result, areas of urban development can be mapped as sustainable, semi-sustainable, or non-sustainable.

Geographic visualization plays an important role in any spatial rating to ensure reliable and consistent outcome. Rating using non-spatial indicators usually results in statistics that can only be viewed as words and numbers; its usefulness in the spatial context is quite limited. On the other hand, spatial indicators can be a more meaningful way of generating spatial information thus assisting users on decision making and enhancing policy by perfect viewing of sustainable urban development with multi-layered information included at one time. Broekhof and van Marwijk (2012) have argued that maps can give valuable information to develop sustainable policies at the local scale.

This study attempts to improve the approach to assessing sustainable urban development adopted by MurniNet. In particular, this study attempts to demonstrate how spatial information can be generated to assess urban development sustainability. In all, this study proposes the incorporation of spatial indicators to help the local authority and policy makers to assess urban development sustainability in a more visualized manner.

2 Assessment of Sustainable Urban Development Sustainability

The literature on through-time urban sustainability assessment techniques conducted using built-environment quality evaluation framework (BEQUEST) reveals several methods available for sustainability assessment of urban activities (Deakin et al. 2001; Ugwu and Haupt 2005). Three of them are Environmental in General (EIG), Life Cycle Assessment (LCA), and Sustainability Indicator Assessment (SIA) methods. Out of these three, the SIA method is most widely used by local authorities around the world. This is because the SIA method seeks to achieve integration of all issues of sustainability compared to the other two which focus solely on environment and socioeconomic aspects, respectively. In general, SIA method employs a wide range of indicators to characterize the different dimensions or aspects of urban development. Therefore, the assessment of sustainability is actually considered as an assessment of indicators by which people can track their progress towards sustainability.

2.1 The Study Area

The study area, Johor Bahru City Council (JBCC), covers an administrative region of 220 km^2 with a total population of 552,026 people. JBCC is divided into 16 planning blocks according to the Johor Bahru Local Plan for 2020 as shown in Fig. 2. These are Daerah Sentral, Tasek Utara/Teluk Danga, Pelangi, Pasir Pelangi, Tampoi, Larkin, Majidee, Teluk Tebrau, Permas Jaya, Rinting, Kempas, Kangkar Tebrau, Pandan/Taman Molek, Bandar Dato' Onn/Setia Tropika, Mount Austin/Taman Daya and Tebrau.

2.2 Sustainability Indicator Assessment Method

An indicator is a measurement to be met, an effect obtained via a gauge of quality or a context variable (European Commission 2008). An indicator produces measured information with a purpose to help researchers concerned with public interventions to communicate, negotiate, or make decisions. In the process of urban sustainability assessment, there is a need for measureable indicators and several approaches of assessment based on these indicators have been developed (Shen et al. 2011).

However, assembling information for all-embracing indicators is not what urban sustainability assessment is all about. Rather, a selective analysis of indicators which are more fundamental in essence and more likely to produce the most accurate information about the status of practice should be focused (Shen et al. 2011). The United Nations Statistical Institute for Asia and Pacific (2007) stated that an indicator must be SMART (i.e. Specific, Measureable, Achievable, Relevant, and Time-related). This can help in effective data management and avoiding data exaggeration of irrelevant selected indicators and, thus, contribute to cost-effective assessment of urban development sustainability.

Sustainability indicators are essential in the overall assessment of progress towards sustainable development. They are useful for measuring and monitoring

Fig. 2 16 Zones in MBJB

the state of the environment by considering a manageable number of variables or characteristics (McLaren and Simonovic 1999). Several studies at the urban, regional, and national levels have compiled extensive lists of sustainability indicators (Foxon et al. 2002; Hellström et al. 2000; Alberti 1996; Maclaren 1996). Based on these indicators, a number of assessment methods have been developed which attempt to simplify the holistic assessment of urban sustainability. These methods rely on key interactions and feedback mechanisms between infrastructure and the surrounding environmental, economic, and social systems and use sustainability criteria and indicators to understand and quantify the resulting interacting effects. From a methodological standpoint, SIA method is recognised as a useful integrative approach to evaluating a multi-dimensional situation and assessment outcome.

2.3 Sustainable Urban Development Indicators

In Malaysia, the Department of Town and Country Planning, Ministry of Housing and Local Government Malaysia has developed a system for assessing the sustainability of a city and region called MurniNet. The goal of this system is to assess the sustainability of Malaysian cities according to Malaysian Urban Indicators. There are eight dimensions with 21 themes that are further subdivided into 36 urban indicators and are used as overall sustainability indicators of a city. These indicators can be re-grouped into three categories, namely non-spatial, spatial, and mixed indicators.

3 Determination of Spatial Indicators

The selection of spatial indicators is based on several criteria including their reliability and effectiveness in providing sufficient information. These criteria must include three pillars of sustainability, namely economy, environment, and social (see Fig. 1). As mentioned earlier, the indicators must be "SMART". However, in this study, these indicators are filtered by selecting only those that contain spatial elements and mapable data.

There were nine spatial indicators selected to be used in this study. The first three indicators are selected from the economic sustainability dimension. The first indicator represents public transportation terminals and stations. The second indicator represents attraction areas and recreational centres and the last indicator from this dimension represents grade 'A' business. All the indicators are represented as points.

Environmental sustainability is the next dimension in assessing urban development sustainability and it is made up of three indicators. All of these indicators are represented in polygons where the first indicator represents flood prone areas. The second indicator represents provision of public open spaces and the last indicator represents residential areas getting centralized sewerage services.

The last dimension is social sustainability whose first indicator is accessibility to community facilities represented in points and polygons. The next indicator is happiness index that indicates population's satisfaction about their daily life and surroundings. The last indicator is related to demography, in particular, the total population of each zone.

3.1 The Scoring System

The urban sustainability assessment scoring system is extracted the MurniNet system itself. The system uses various weightage scores for each dimension and theme according to the predetermined specification. The spatial indicators scoring system shown in Table 1 is adopted in this study to determine the sustainability of the JBCC's planning blocks.

Table 1 Spatial indicators formula

	Standards	Score
Terminals and stations for public transportation (*TS*)		
A = Numbers of integrated public transportation terminals	>3	3
	2–3	2
	<1	1
Tourism attraction area and recreation centres (*TR*)		
A = Numbers of attraction area and recreational centres	>5	3
	2–5	2
	<2	1
Area prone to flooding (*FA*)		
Score = (A/B) × 100	<10 %	3
A = Total population live in the area prone to flooding	10–20 %	2
B = Total population of the research area	>20 %	1
Grade A business premises (*GA*)		
Score = (A/B) × 100	>70 %	3
A = Numbers of grade A food business premises in research area	30–70 %	2
B = Numbers of food business premises assessed in research area	<30 %	1
Provision to public open space (*OS*)		
Score = (1,000/B) × A	>1.5 ha	3
A = Total area of open space (hectares) in research area	1–1.5 ha	2
B = Total population in research area	<1 ha	1
Centralized sewerage (*CS*)		
Score = (A/B) × 100	>80 %	3
A = Numbers of residential area getting centralized sewerage service	60–80 %	2
B = numbers of residential area	<60 %	1
Accessibility of community to public facilities (*AF*)		
Score = (A/B) × 100	>80 %	3
A = Total area of research zone	50–80 %	2
B = Total area of residential within 400 meter radius of public facilities	<50 %	1
Happiness Index (*HI*)		
Score = (A/B) × 100	>80 %	3
A = Total number of respondents satisfied with daily live and surrounding	40–80 %	2
B = Total number of respondents in study area	<40	1

3.2 Analytical Hierarchy Process for Sustainability Assessment

Analytical hierarchy process (AHP) is a multi-criteria decision-making (MCDM) technique. Underlying MCDM principle is that a decision has to be made by means of analyzing a set of criteria. Saaty (1980) has developed AHP which models a hierarchical decision problem framework consisting of multi-level criteria having unidirectional relationships. AHP works with such a hierarchy that can combine both subjective (intangible) and objective (tangible) criteria.

After finalizing the selected spatial indicators, the hierarchical decision model is then developed. The decision model of this study is broken up into three major levels, namely goal, objective, and design criteria. Goal is the topmost level which describes the decision problem. This study attempts to work out the most sustainable urban development and therefore, the topmost level is to "select the most sustainable area". The objectives of sustainability assessment comprise three aspects: economic, environmental, and social. In order to identify the priorities of three sustainable development objectives in the second level, and the relative importance of different design criteria in the third level, a series of pairwise comparisons have to be performed. The elements in both levels are then weighted.

By using pairwise comparisons, the relative importance of one criterion over another can be expressed by ranking them using AHP's nine-point scale of importance as shown in Tables 2, 3, 4, 5, 6, 7, 8, and 9.

The fractions are converted into decimals to acquire pairwise matrix. A short computational way to obtain the ranking is to raise the pairwise matrix to powers that are successively squared each time. The row sums are then calculated and normalized.

$$[\mathrm{AB}]_{i,j} = A_{i,1}B_{1,j} + A_{i,2}B_{2,j} + \cdots + A_{i,n}B_{n,j} = \sum_{r=1}^{n} A_{i,r}B_{r,j} \qquad (1)$$

From the computed eigenvector, the relative criteria are ranked as follows:

EcS	0.3761	The most important criterion
EnS	0.3341	The second most important criterion
ScS	0.2898	The least important criterion

The steps were then implemented for the next level which is design criteria level where it includes all the spatial indicators from environment, economic and social dimensions. Then, the criteria are ranked in a descending order from most important to least important.

Economic sustainability indicators are represented by the numbers of integrated terminals and stations for public transportations (TS), numbers of attraction areas and recreational centres (TR) and percentage of grade 'A' business premises (GA).

TS	0.2380	The second most important criterion
TR	0.6254	The most important criterion
GA	0.1366	The least important criterion

Environmental sustainability indicators are represented by the percentage of population living in areas prone to flooding (FA), provision of public open space ratio compared to 1,000 population (OS) and percentage of centralized sewerage (CS) (Tables 10, 11).

Table 2 Scale of importance

AHP scale of importance for pairwise comparison	Numeric rating
Extreme importance	9
Very strong to extremely	8
Very strong importance	7
Strongly to very strong	6
Strong importance	5
Moderately to strong	4
Moderate importance	3
Equally to moderately	2
Equal importance	1

Table 3 Pairwise comparison

	EcS	EnS	ScS
EcS	1/1	3/1	1/2
EnS	1/3	1/2	3/1
ScS	2/1	1/3	1/1

Table 4 Pairwise matrix

	EcS	EnS	ScS
EcS	1	3	0.5
EnS	0.3	1	3
ScS	2	0.3	1

Social sustainability indicators are represented by the percentage of residential areas within 400 meters from community facilities (AF), happiness index (HI), and demography (DM) (Tables 12, 13).

AF	0.6149	The most important criterion
HI	0.1171	The least important criterion
DM	0.2680	The second most important criterion

The finalised AHP decision model is as shown in Fig. 3.

3.3 Sustainability Map

Sustainability maps are produced for each indicator based on the formula prescribed in MurniNet. These maps represent the sustainability of each planning block according to spatial indicators. There are three sustainability scores:

Table 5 The first eigenvector

	EcS	EnS	ScS	Normalized	Eigenvector
EcS	2.9999	6.16665	10	19.16655	0.3929
EnS	6.6666	2.9998	6.16665	15.83305	0.3246
ScS	4.111089	6.6666	2.9999	13.77759	0.2825
Total				48.77719	1

Table 6 Pairwise comparison of objectives level

	EcS	EnS	ScS	Normalized	Eigenvector
EcS	91.2155	103.6585	98.0166	292.8906	0.3761
EnS	65.3433	91.2200	103.6641	260.2273	0.3341
ScS	69.1056	65.3493	91.2209	225.6757	0.2898
Total				778.7935	1

Table 7 Eigenvector of the objectives level

Objectives	Eigenvector
Economic sustainability (EcS)	0.3761
Environmental sustainability (EnS)	0.3341
Social sustainability (ScS)	0.2898

Table 8 Pairwise comparison of economic sustainability

	TS	TR	GA
TS	1	1/3	2
TR	3	1	4
GA	1/2	1/4	1

1 = 'not-sustainable'; 2 = 'semi-sustainable'; and 3 = 'sustainable'. The production of the maps is important to assist users in interpreting the information correctly. The maps are used in the analysis while graphs and tables created are shown alongside the attributes. With the use of ArcToolbox in ArcGIS 10.0, proximity analysis is performed for the measurement of various data.

4 Results and Discussion

This section discusses the results from the data analysis. The purpose is to spatially visualize the assessed sustainability of each JBCC's planning block. Besides spatial indicators, the usage of non-spatial indicators is also shown in this section.

Table 9 Iterated eigenvector solution

	TS	TR	GA	Normalized	Eigen vector
TS	27.5301	10.4746	48.1068	86.1115	0.2380
TR	72.34	27.5301	126.42	226.2901	0.6254
GA	15.8025	6.0134	27.62	49.4359	0.1366
Total				361.8375	1

Table 10 Pairwise comparison of environmental sustainability

	FA	OS	CS
FA	1	4	3
OS	0.25	1	3
CS	1/3	1/3	1

Table 11 Iterated eigenvector solution

	FA	OS	CS	Normalized	Eigen vector
FA	35.7488	89.4002	168.1425	293.2915	0.6218
OS	13.9403	35.7002	67.1175	116.758	0.2476
CS	7.399	18.52	35.659	61.578	0.1306
Total				471.6275	1

Table 12 Pairwise comparison of social sustainability

	AF	HI	DM
AF	1	4	3
HI	1/4	1	1/3
DM	1/3	3	1

Table 13 Iterated eigenvector solution

	AF	HI	DM	Normalized	Eigen vector
AF	29.6126	155.2424	67.6704	252.5254	0.6149
HI	5.6293	29.6126	12.8749	48.1168	0.1171
DM	12.8748	67.6704	29.5228	110.0680	0.2680
Total				410.7102	1

4.1 Sustainability Based on Economic Indicators

Map 1 shows that out of 16 planning blocks only four are classified as sustainable according to MurniNet standard. These are Teluk Danga, Daerah Sentral, Pelangi and Larkin. Two planning blocks—Tampoi and Pasir Pelangi—have the score of ‘2’ which means semi-sustainable while the rest of the planning blocks are

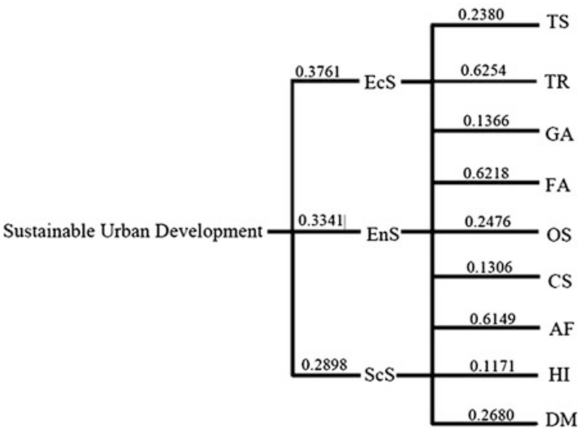


Fig. 3 Finalised AHP decision model

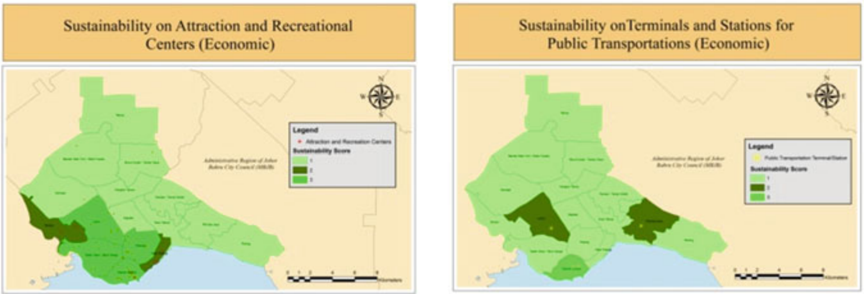
considered not sustainable. Map 2 shows that only Daerah Sentral is considered sustainable. Larkin and Permas Jaya are categorized as semi-sustainable. Overall, the results show that the southern region of the study area is economically sustainable (Fig. 4).

4.2 Sustainability Based on Environmental Indicators

Figure 5 shows that all the planning blocks are sustainable. Map 3 shows that the highest percentage of flood-prone area—Kangkar Tebrau—is only five percent, followed by Teluk Danga (0.28 %) and Teluk Tebrau (0.07 %). Map 4 shows the planning blocks that achieve sustainability on the public open space ratio, namely Tebrau, Bandar Dato' Onn/Setia Tropika, Mount Austin/Taman Daya, Pandan/Taman Molek, Tampoi and Tasek Utara/Teluk Danga. Each of them has more than 1.5 ha of public open space. Rinting, Pasir Pelangi, Permas Jaya and Kempas are categorized as semi-sustainable planning blocks while the rest of the planning blocks are not sustainable. Six areas are classified as environmentally sustainable by achieving the highest score on both indicators. These are Bandar Dato' Onn/Setia Tropika, Mount Austin/Taman Daya, Pandan/Taman Molek, Tampoi and Tasek Utara/Teluk Danga.

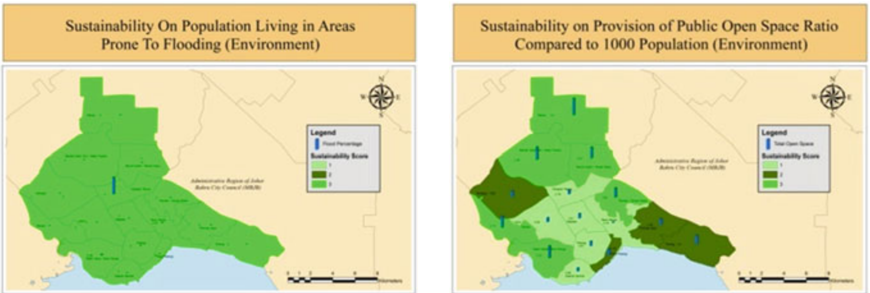
4.3 Sustainability Based on Social Indicators

In Fig. 6, Map 5 shows the population of JBCC with a total of 555,026 people. The most populated area with a total of 70,141 people is Tebrau followed by Bandar Dato' Onn and Setia Tropika with a total of 60,279 people. Pasir Pelangi is



Map 1 Map 2

Fig. 4 Attraction and recreational centres (Map 1) and Terminals and stations for public transportations sustainability (Map 2)

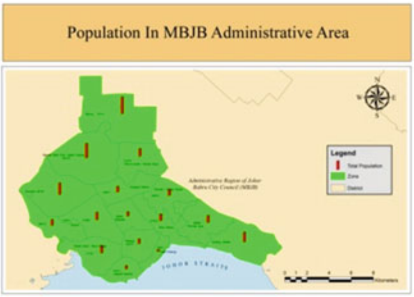


Map 3 Map 4

Fig. 5 Population living in areas prone to flooding sustainability (Map 3) and Provision of public open space ratio compared to 1,000 population sustainability (Map 4)

the least populated area with only 7,852 people. The map also shows that Tebrau is the largest area with a total size 27.24 km^2.

The accessibility from residential areas to community facilities is determined by proximity analysis. Map 6 shows that Majidee is the only sustainable planning block with 81 % accessibility. Kempas, Tampoi, Larkin, Daerah Sentral, Pelangi, and Mount Austin/Taman Daya are categorized as semi-sustainable planning blocks with 50–80 % accessibility to community facilities. Other planning blocks are classified as not sustainable. Map 7 shows that the majority of respondents are satisfied with their daily life and the surroundings. Respondents in Teluk Tebrau, Mount Austin/Taman Daya, and Tebrau feel that they are partially satisfied with the surroundings. Both maps show that the most socially sustainable area is Majidee which achieves the highest score for both indicators. Kempas, Tampoi, Larkin, Pelangi, and Daerah Sentral are classified as semi-sustainable with the highest and second highest scores for both indicators.



Map 5

Map 6

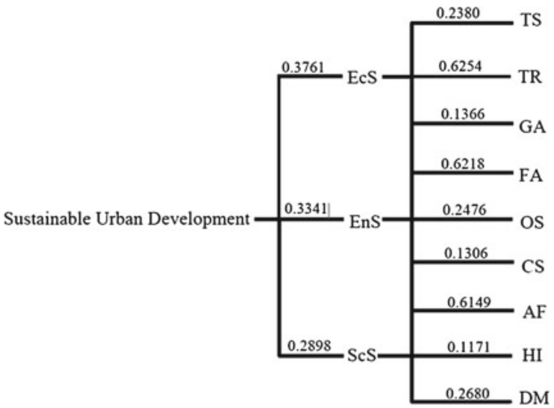
Map 7

Fig. 6 Population in MBJB, Accessibility from residential areas to community facilities, and Happiness index sustainability map

4.4 Sustainability Map Using AHP

The eigenvector is calculated to decide on the importance ranking of sustainability indicators as explained earlier. Each planning block has its own score of sustainability from each indicator through the index prescribed in the MurniNet. Importance ranking is then used to assess the sustainability of urban development of the planning blocks within the JBCC. Based on the indicators' eigenvalues, economic sustainability is the most important dimension to determine sustainability of an area followed by environmental sustainability and social sustainability (Fig. 7).

Figures 8 and 9 show that Daerah Sentral, Tasek Utara/Teluk Danga, Pelangi and Rinting have the highest score on the most important indicators. For the second most important indicator, all planning blocks achieved the highest score. Majidee is the only area that has the highest score for the third highest ranked indicator. For the fourth indicator, all planning blocks obtained the highest score while for the next highest ranked indicator shows that Tasek Utara/Teluk Danga, Tampoi, Pandan/Taman Molek, Bandar Dato' Onn/Setia Tropika, Mount Austin/ Taman Daya and Tebrau are sustainable planning blocks. The indicator of



Indicators	Ranking
TR	1st
FA	2nd
AF	3rd
DM	4th
OS	5th
TS	6th
GA	7th
CS	8th
HI	9th

Fig. 7 Finalised AHP decision model

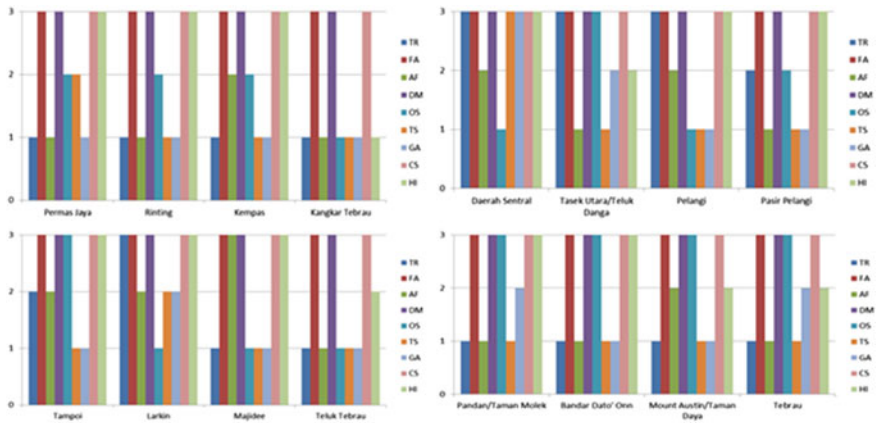


Fig. 8 Graph of overall sustainability score

Fig. 9 Sustainable urban development map

integrated terminals and stations for public transportation is ranked sixth with Daerah Sentral having the highest sustainability score. The next indicator is the premises that are awarded grade 'A' status. This indicator shows that only Daerah Sentral is sustainable compared to other planning blocks. It also indicates that business premises in JBCC, especially the restaurants, do not achieve the standards specified by the Department of Health JBCC. Figure 8 also shows that all the planning blocks are sustainable on the basis of existence of centralized sewerage services. This indicator shows that 82.05 % of the residential areas in JBCC are enjoying sufficient level of centralized sewerage services. The last ranked indicator is the happiness index whereby all planning blocks, except for Kangkar Tebrau, are categorized as sustainable. [Happiness index stipulates that majority of the respondents must be satisfied with their daily life and surroundings.] Kangkar Tebrau, in particular, is found to be not sustainable.

5 Conclusion

Sustainability is a broad concept that encompasses many aspects of the social, economic and environment. The study demonstrates how suitable indicators can be used for the assessment of sustainable urban development. Proper selections of SMART indicators are very important. The use of spatial indicators, with sufficient spatial content provided, can contribute to a better implementation of assessment of areal sustainability. It can also give more understanding and interpretation of spatial information by producing to-be-seen map.

From the overall assessment, we can see that the majority of planning blocks located near city centres such as Daerah Sentral, Pelangi, Teluk Danga, Larkin, Majidee and Tampoi are sustainable because these planning blocks are areas of people's attraction. This study also shows how placement of business premises, recreational areas, community facilities and roads are important to maintain urban sustainability.

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References

Black JA, Paez A, Suthanaya PA (2002) Sustainable urban transportation: performance indicators and some analytical approaches. J Urban Plan Dev 128:184–209

Broekhof S, Van Marwijk R (2012) The role of spatial information for planning sustainable cities. In: Paper presented at the proceedings of FIG working week 2012 on knowing to manage the territory, protect the environment, evaluate the cultural heritage. Rome, Italy, 6–10 May 2012