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DEVELOPING SUSTAINABILITY INDEX MEASUREMENT FOR RECLAMATION AREA

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ABSTRACT

Despite its positive and negative impacts to the environment, marine reclamations have been done in many urban areas and countries. It is due to the insistence of the economic development in urban areas. The ability to assess and regulate the sustainability performance of the built and nature area of coastal area have been performed by previous researchers with many indicators. In spite of the fact, the assessment of specific area for reclamation is still lacking. This study is aimed at defining index for reclamation area as a process of appraising and grouping specific index in terms of its sustainability. This paper reviews existing indices for assessing sustainability and evaluates these indices by a range of selection criteria based on literature review and interviews with experts. The analyses of sustainability index can be used to assist planners in assigning reclamation coastal zone development for appropriate uses and help the modeling of reclamation plans to create a suitable environment. This research applies Analytic Hierarchy Process (AHP) to direct the novelty of the research that is to simplify the existing indices into only a few indices that are useable to evaluate the sustainability of reclamation process.

Keywords: Analytic Hierarchy Process (AHP); Reclamation area; Sustainability index

1. INTRODUCTION

The coastal lands are very important boundaries in the natural system, but these areas are under pressure that has threatened their health by short-sighted planning policies. The management options have been focused on economic production and human benefits rather than on the natural systems that guarantee their sustainability . The marine reclamation has led to the environmental and ecological problems with the rapid development of national economy . The ability to assess and regulate the sustainability performance of the built and natural environments, based on measurable criteria at a variety of temporal and spatial scales is critical for sustainable urban development .

The sustainable development of coastal zone does not only meet the increasing demand, but also protects ecology and environment, without prejudice to future generations' access to adequate food security . But the concept of sustainable development still rarely analyze how sustainable the reclamation area is. Planners should study complex social, environmental and economic criteria to suggest sustainable development strategies for planning the future not only in coastal zone as a macro study but also in particular for reclamation. Hence, we have to make a research in order to identify the sustainability index for reclamation area.

From many studies in field of sustainable development analysis, the size of criteria and number of indicators should be limited. Too large number of criteria will confuse

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decision makers. But too few criteria, on the other hand, may be insufficient to provide all the necessary relevant information . Through sustainable development system evaluation, we can judge whether or not a city is placed in the sustainable development process. . To evaluate the developmental sustainability of the area completely and objectively, we have to build up an index system especially for reclamation area that is rarely found nowadays. The purpose of this research is to develop sustainability index to measure the reclamation area.

2. METHODOLOGY

The methodology of this study is to examine the present index for assessing many kinds of urban sustainability which analyzes methods for measuring sustainability index, then explains the five steps of analyses for simplification of index especially for reclamation sustainability index.

2.1. State of the Art, Present Index for Assessing Urban Sustainability

Since sustainable development becomes an analysis priority in a planning progress, a lot of researches have been developed to study the relation of sustainability performance to urban areas. Based on method developed by IUCN (International Union for the Conservation of Nature and Natural Resources) 1990, the so-called Wellbeing Index consists of 87 indicators from three aspects, namely social, economic and environmental aspects. The wellbeing index comprises two concepts that is human wellbeing and ecosystem wellbeing. Indicator of ecosystem wellbeing consists of land, water, waste, biodiversity and resource usage . This research will be used to develop sustainability index especially for reclamation area, which will be explained in later part of this paper.

2.1.1. Sustainable Development System

The process of evaluating the sustainable development system (SDS) is to build up a set of index systems to evaluate present status and condition, the trend of development, potential of regional development using scientific and systematic methods. Determination of the city sustainability status research is expressed by index and status of sustainability. Scale of index system examined has the interval from 0 to 100 with four (4) categories of sustainability status. The value of the index and status of sustainability can be shown in Table 1.

Table 1 Category Index and Status of City Sustainability Index

Value	The Status Of Sustainability
0,00-25,00	Bad (not sustainable)
25,01-50,00	Less (less sustainability
50,01-75,00	Enough (sufficient sustainability)
75,01-100,00	Good (very sustainable)

Source: Renald, 2015

The study is intended to make a developing index to measure the sustainability index special for reclamation area, as shown in Table 2.

Base on Table 2, it can be seen that many study of sustainability focuses only on the assessment of the coastal area and it is not for the reclamation area. So this research will select the assessment index related to the reclamation area, so the research purposes the developing of specific sustainability index that is reclamation area.

2.1.2. Selection of the Indices by Computation

By computing, Yua selected the indexes with bigger values as the components of constructing comprehensive evaluation index system and removed the indexes with little differences of variance, thus making up the comprehensive evaluation function. The good indicators should be easy to be understood, sensitive to changes and relevant among themselves

In this paper, the scholar presented a whole assessment process from three dimensions of environment, economy and society subsystems and chose a coastal city of China-Yantai as a case study). Then the scholars can get comprehensive development levels of subsystems involving positive value and negative value, resulting from data standardized. The negative value does not mean no-sustainable development, but means that the value is below the average value of evaluating stage .

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Table 2 State of the Art Sustainability Index

Model of Sustainable Urban Infrastructure at Coastal Reclamation of North Jakarta	Assessment of Sustainable Development System in Suihua City, China	Integration of spatial suitability analysis for land use planning in coastal areas; case of Kuala Langat District, Selangor, Malaysia	Assessing coastal reclamation suitability based on a fuzzy-AHP comprehensive evaluation framework: A case study of Lianyungang, China	Analytic network process for criteria selection in sustainable coastal land use planning (Malaysia):
• Land use: o Suitability of residence with land use o Availability of open space o Density of building in their area • Transportation o Accessibility of public transport o Availability of public transport o Preference between public and private transport • Building o Livability of their residencies o Density of households occupancies o Maintenance of public building • Open Space o Availability space for social activity o Availability space for water conservation • Infrastructure Network o Adequate service for transporting solid waste o Role of waste segregation in the area o Adequate service for waste water o Adequate road network • Energy o Adequate service for energy supply o Suitability of house hold energy using o Using of energy-efficient appliances o Using of alternative energy	• Environment o Total volume of industrial waste gas emission (100 million m3) o Waste gas emission per 10000 yuan industrial output value (10 thousand m3) o Percentage of waste gas disposal (%) o Volume of industrial waste water discharged (10000t) o Waste water discharged per 10 thousand industrial output value (t) o Percentage of waste water disposal (%) o Volume of industrial solid wastes discharged (10000t) o Volume of industrial solid wastes emission per 10 thousand yuan industrial output value (t) o Percentage of solid wastes disposal (%) o Noise pollution (dB) • Population o Total population (10000 persons) o Annual growth rate (%) o Natural growth rate (‰) o Population density (person/km2) o Student enrollment of regular institutions of higher education (10000 persons) o Student enrollment of secondary school (10000 persons) o Student enrollment of primary school (10000 persons) o Urban population rate (%) • Resources o Per capita coverage of land (ha) o Energy consumption for per 10 thousand yuan of industrial GDP (tons of standard coal) o Forest coverage rate (%) o Per capita coverage of grassland (ha) o Water consumption per 10000 yuan of industrial GDP (t) o Per capita forest area (ha)	• Population density • Access to main road • Access to public health concern • Access to beach • Access to schools • Proximity to life-support system • Proximity to high-value area • Proximity to geo-hazard risk area • Proximity to different industries	**Environmental resources index (A)** • Distance from places of interest (DPI) • Distance from natural coastal scenery tourism (DNS) • Distance from environmentally sensitive estuaries and coastal wetlands (DES) • Distance from nature reserves and ecological reserves (DNR) • Distance from fisheries resources zones (DFR) • Distance from muddy coast (DMC)	• Legal & existing plans • Population structure • Proximity to facilities • Accessibility • Geo-hazard risk areas • Proximity to pollution sources • Life support system • High value areas • Income • Employment • Water quality • Land statues • Physical suitability • Global process

(Source author)

2.1.3. Multi Criteria Analysis

Another method is Multi criteria Analysis method which can help to optimize the power of criteria and indicator approach to have a comprehensive analysis for sustainable coastal land use development, it is the same with Multi-criteria decision (MCD) as a tool based on mathematical models to analyze the large number of attributes and various criteria involved in decision making, consists of some phases. The first phase is to compare the criteria in the whole system to form the matrix, done with pair-wise comparisons by asking “How much importance does a criterion has compared to another criterion with respect to our interests or preferences, using a scale of 1e9 to represent a scale from equal importance to extreme importance.

2.2. Developing Assessment for Sustainability Index

The AHP-Expert Choice evaluation method has been refined into four steps , and their detailed explanation is given below:

2.2.1 Step 1. Determination of Evaluation Index System

The first step is to structure an index system and identify the indices. For this purpose, ‘‘m’’ indices are assumed in the index system, and the index system is given as:

$$U = [U1; U2; \ldots; Um) \qquad (1)$$

The index system is divided into three layers. The topmost layer is the goal of the analysis. Hence, the second layer is divided into three groups: land use, building and infrastructure. Lastly the third layer is the index that will be selected, drawn at Figure 1.

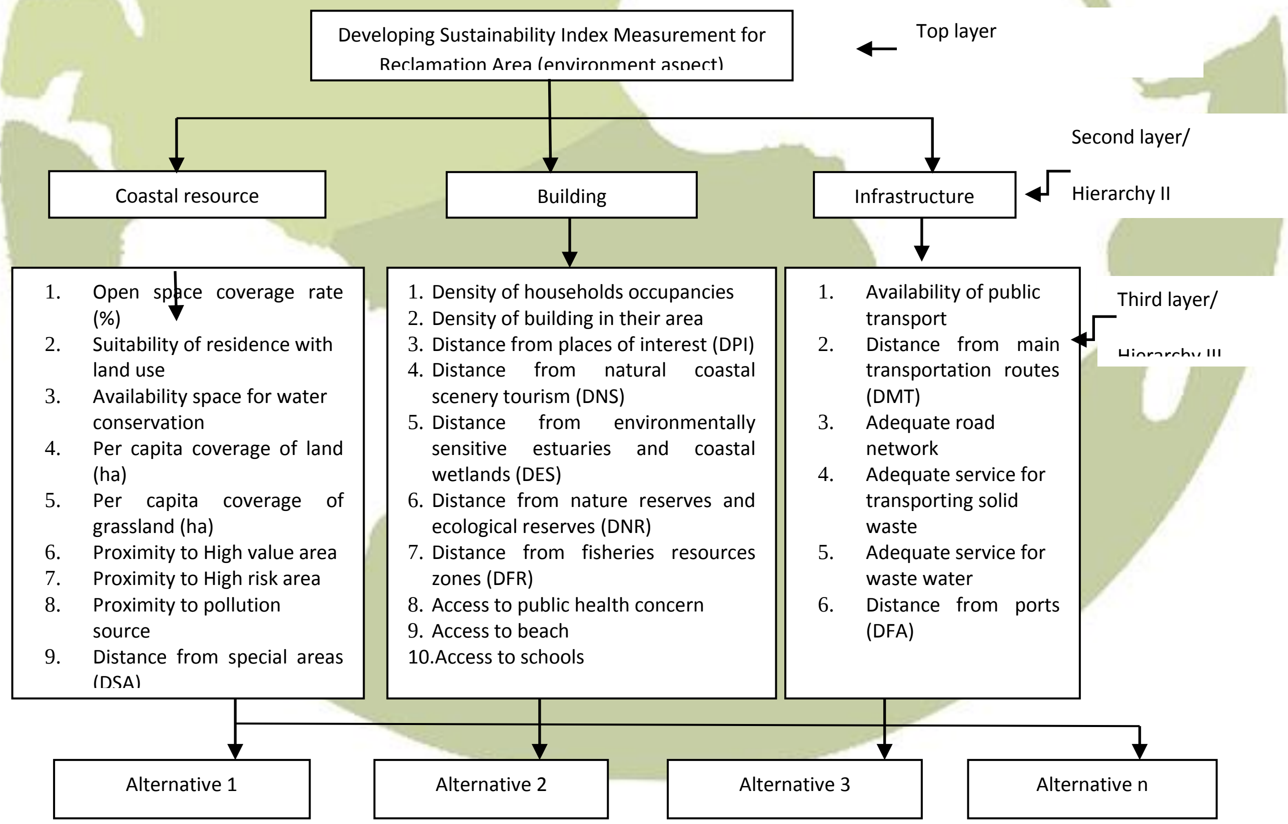

Figure 1 Structure of Analytic Hierarchy Process (AHP)

2.2.2 Step 2: Weighting of Indices

The weights were obtained by AHP method developed by Thomas l, that is determined by experts' choice with compared pair wise. The questionnaire consists of three sections, namely coastal resource, building and infrastructure; each section compares between point 1 and 2, 1 and 3, which one is important and so on until all element has been compared.

2.2.3. Step 3: Arranging Matrix

In the process of weighting or "charging", the next step is to arrange matrix pairs to measure the weight of the importance level of each element in each of their hierarchy. Thus, the analysis is performed by computer. Paired comparisons are intended to obtain a decision as much as:

$$n \times ((n-1)/2) \qquad (2)$$

n = the number of elements that are compared

2.2.3. Step 4: Testing Consistency

After compiling a matrix, the results obtained in the calculation of the table should be tested, so that the consistency is valid, using the formula below.

$$\text{Consistency Index (CI)} = (\lambda\text{max.} - n) / (n-1) \qquad (3)$$

n= matrix measurement

2.2.4. Step 5: Determination of priority

When the process of analysis of the computer has been accomplished, we found the simple indices that are very important.

3. RESULTS, PERFORMANCE MEASUREMENT OF SUSTAINABILITY INDEX

This research can be used as a tool to measure specific areas of reclamation. There were three types of experts who served as respondents to give opinions to be considered and included in the matrix. They were professional fields, government staffs and academics. They choose the most important indicators by pair wise system, using expert choice.

Table 3 Proposed Sustainability Index from Physical Approach

Category	Sub Category	Indices
Coastal resourse	1. Open space coverage rate (%)	1. >30 % of the area: good 2. 10–30 % of the area: poor 3. 0–10% of the area: bad
	2. Suitability of residence with land use	1. Suitable: good 2. less Suitable: poor 3. not Suitable: bad
	3. Availability space for water conservation	1. available: good 2. less available: poor 3. no available : bad
	4. Per capita coverage of land (ha)	Ha
	5. Per capita coverage of grassland (ha)	Ha
	6. Proximity to High value area	1. Within of high-value area 2. 1–500m away from high-value area 3. >500m away from high-value area
	7. Proximity to High risk area	1. >500m away from High risk area 2. 1–500m away from High risk area 3. Within of High risk area
	8. Proximity to pollution source	1. >500m away from pollution source 2. 1–500m away from pollution source 3. Within pollution source

	9. Distance from special areas (DSA)	1. Within special areas 2. 1–500m away from special areas 3. >500m away from special areas
	10. Distance from large beaches suitable for swimming (DLBS)	1. >500m away from DLBS 2. 1–500m away from DLBS 3. Within DLBS
Building	1. Density of households occupancies	1. Suitable: good 2. less Suitable: poor 3. not Suitable: bad
	2. Density of building in their area	1. Suitable: good 2. less Suitable: poor 3. not Suitable: bad
	3. Distance from places of interest (DPI)	1. Within DPI 2. 1–500m away from DPI 3. >500m away from DPI
	4. Distance from natural coastal scenery tourism (DNCT)	1. >500m away from DNCT 2. 1–500m away from DNCT 3. Within DNCT
	5. Distance from environmentally sensitive estuaries and coastal wetlands (DES)	1. >500m away from DES 2. 1–500m away from DES 3. Within DES
	6. Distance from nature reserves and ecological reserves (DNR)	1. >500m away from DNR 2. 1–500m away from DNR 3. Within DNR
	7. Distance from fisheries resources zones (DFR)	1. >500m away from DFR 2. 1–500m away from DFR 3. Within DFR
	8. Access to public health concern	1. 0–15 minutes: good 2. 15–30 min: poor 3. >30 min: bad
	9. Access to beach	1. 0–15 minutes: good 2. 15–30 min: poor 3. >30 min: bad
	10. Access to schools	1. 0–15 min: good 2. 15–30 min: poor 3. >30 min: bad
Infrastructure	1. Availability of public transport	1. available: good 2. less available: poor 3. no available : bad
	2. Distance from main transportation routes (DMT)	1. >500m away from DMT 2. 200–500m away from DMT 3. 100-200 away from DMT
	3. Adequate road network	1. available: good 2. less available: poor 3. no available : bad
	4. Adequate service for transporting solid waste	1. available: good 2. less available: poor 3. no available : bad
	5. Adequate service for waste water	1. available: good 2. less available: poor 3. no available : bad
	6. Distance from ports	1. >500m away from ports 2. 1–500m away from ports 3. Within ports

(Source author)

3.1. The Assessment Criteria on the Level of Resource Indicators

From the interviews with the expert by questionnaire, the answers on a scale/range given on the assessment sheet questionnaire were obtained. The answers of each respondent's perception of "Criteria" were filled in the table. The weighting element retrieved from the E-Vector value expressed in Percentage is as shown in Figure 2:

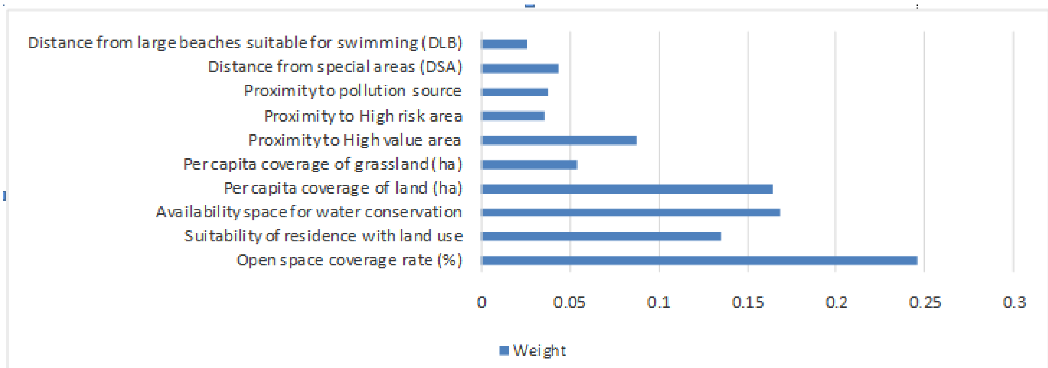

Figure 2 Weighting for Criteria of Coastal Resource Priority Scale
Source: the results of analysis, 2016

The figure 2 shows the assessment of the respondent against some criteria, open space coverage rate (%) has influenced the level of interest with weights 0.245 (24.6%), then followed by space for water conservation which accounts for 0.168 (16.8%), Per capita coverage of land (ha) factor which accounts for 0.164 (16.4%), the last is the distance from large beaches suitable for swimming (DLB) factor which accounts for 0.026 (2.6%).

3.2. The Assessment Criteria of Building Indicators

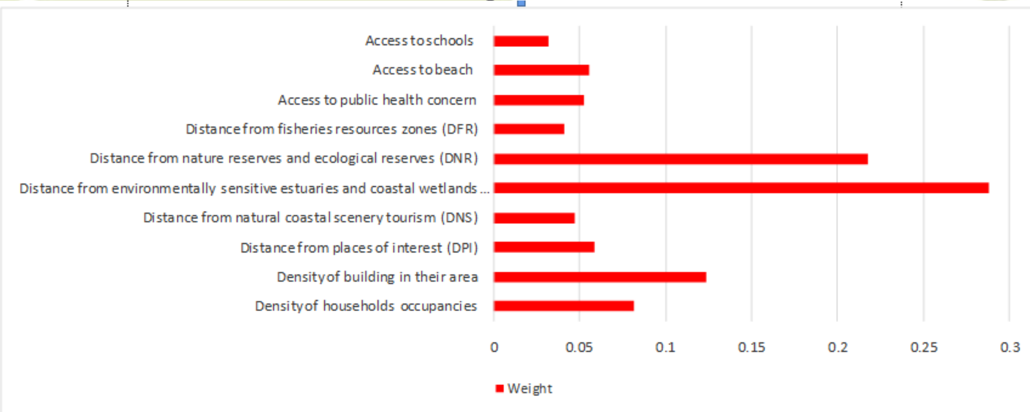

Figure 3 Weighting for Criteria of Building Priority Scale
Source: the results of analysis, 2016

Figure 3, it can be seen that the assessment of the respondents against some criteria showed distance from environmentally sensitive estuaries and coastal wetlands (DES) have influenced importance weights 0.288 (28.8%), then followed by a factor of distance from nature reserves and ecological reserves (DNR) with 0.218 (21.8%), the density of building in their area with weights 0.124 (12.4%), and lastly the factor Access to schools with weights 0.032 (3.2%).

3.2. The Assessment Criteria of Infrastructure Indicators

At figure 4, the respondent's assessment adequate road network factors has importance weights 0.346 (34.6%), followed by availability of public transport with 0.308 (30.8%), distance from main transportation routes (DMT) with 0.164 (16.4%), the last was distance from ports (DFA) with 0.033 (3.3%).

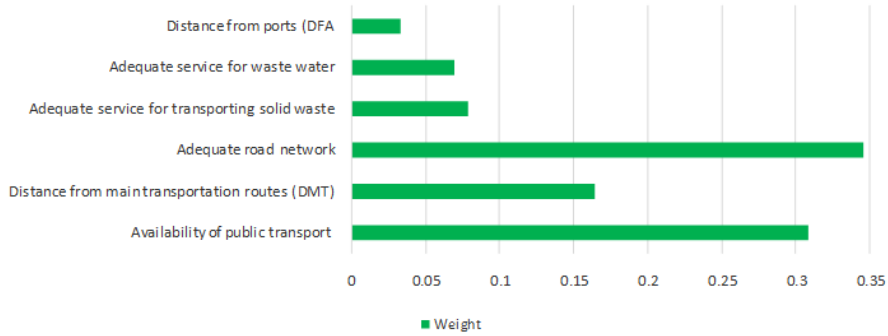

Figure 4 Weight of Priorities Scale Criteria Infrastructure
Source: the results of the analysis, 2016

4. DISCUSSION

The summarized criteria obtained from experts' opinion from 72 criteria disclose 26 indicators applicable, and from AHP, it lists 9 indicators which are most important according to the experts' choice. The experts assess whether an indicator is more important influence than other indicators with a range of assessment 1 – 9, then ranked and graded. Top rank is environment effort rather than manmade, consistent across all interviewees. The result is the most important criteria are ranked as follows:

Table 4 The Most Important Criteria of Sustainability Index Reclamation Area

Category	Sub Category	Indices of sustainability
Coastal resource	Open space coverage rate (%)	3. >30 % of the area: good 2. 10–30 % of the area: poor 1. 0–10% of the area: bad
	Availability Space for water conservation	3 available: good 2. less available: poor 1. no available : bad
	Per capita coverage of land (ha)	Ha
Building	Distance from environmentally sensitive estuaries and coastal wetlands (DES)	3. >500m away from DES :good 2. 1–500m away from DES: poor 1. Within DES: bad
	Distance from nature reserves and ecological reserves (DNR)	3. >500m away from DNR: good 2. 1–500m away from DNR :poor 1. Within DNR: bad
	The Density of building in their area	3. Suitable: good 2. less Suitable: poor 1. not Suitable: bad
Infrastructure	Adequate road network	3. available: good 2. less available: poor 1. no available : bad
	Availability of public transport with weights	3. available: good 2. less available: poor 1. no available : bad
	Distance from main transportation routes (DMT)	3. 100-200 away from DMT : good 2. 200–500m away from DMT : poor 1. >500m away from DMT: bad

Source: yurnita, 2016

5. CONCLUSION

This paper proposed nine indicators which are most important to measure reclamation whether it is sustainable or not. It can be seen that the most indicator indices are related to environment effort first, then community concern and manmade such as housing and recreation area, how to prepare a reclamation area that consists of space green area, and concern for sensitive estuaries and coastal wetlands and distance from nature reserves and ecological reserves. This study is developing measurement tools for sustainability research that can helps the government, private sector and society to develop sustainable reclamation area, so that the environment can be maintained.

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