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Using Simo's Procedures to Rank Indicators for City Rating System

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ABSTRACT

A city has different interactions in environmental, social and economic activities. The anthropogenic activities in a city represent main source of environmental pollution, ecological damage, and non-renewable resources depletion. Many governmental and non-governmental organizations have indicator systems to evaluate sustainability. This research targets to develop a framework for rating system that counts to sustainability assess developing and developed countries by considering most common indicators that evaluate performances at most cities. This paper illustrates the proposed framework for developing city sustainability rating system. This framework consists of two steps for developing rating system: Identification of indicator system and weighting indicator system. This paper contains detailed procedures to identify final indicator list: structuring framework level of hierarchy, refining indicator system, and preliminary indicator list obtained as a last result of these procedures. A questionnaire survey and statistical factor analysis have been performed to obtain final indicator list. The second main step is weighting final indicator list components. This paper illustrates the procedures for weighting the proposed indicator list. The weighting process uses Simo's Procedures to weight components. The weighting process is performed by using Simo's Procedure which is suitable to react with a lot of indicators within the final list. This weighting process consists of three components: grouping indicator list, collecting information and determining the weight of criteria

Key Words: *Sustainability Assessment, Sustainable City, Simo's Procedure, Weighting Indicators.*

1. INTRODUCTION

Recently, there is an urgent need for a comprehensive assessment of city sustainability and monitoring its dimensions (environment, economic, and social). However, this has faced difficulties because of competing characterizations of sustainability and a lack of hard evidence [1].

Sustainability assessment is vital requirement to view present situation in order to check whether a new policy, decision or technical innovation is making things better or worse. This leads to increase attention of sustainable development indicators by public administration to underpin their sustainable strategies, notably by allowing assessment and monitoring systems for city sustainability status. The use of sustainable indicators remains changeling as it is lacking clear objectives in some developing regions

The research targets to develop rating system that is suited for assessment developing and developed countries by considering most common indicators that evaluate performances at most cities. This paper illustrates the proposed framework for developing city sustainability rating system. This framework consists of two main steps for developing rating system: indicators selection and weighting indicator list. It shows also the detailed procedures to identify preliminary indicator list including data resource management, structuring framework level of hierarchy, refining indicator system, and determining preliminary indicator list. After the preliminary list has been obtained, a questionnaire survey has been conducted to identify final indicator list. The weighting final list components have been performed at the final stage to develop a quantifying rating system.

2. FRAMEWORK DEVELOPING

This paper illustrates the framework for developing city sustainability rating system. The proposed framework consists of two main processes: indicators selection and indicator list weighting.

Indicators selection process is performed taking into consideration previous studies and guidelines which include indicators for sustainability assessment for developing and developed countries. Structuring the hierarchy levels of indicator list consists of three levels: dimension level, category level and indicator level. After structuring the main hierarchy levels of the indicator list, refining procedures to filter these indicators have been performed to obtain the preliminary indicator list. In order to obtain more applicable and reliable indicator list, a questionnaire survey based on the proposed preliminary list has been prepared. Statistical factor analysis is performed on responses available for questionnaire survey. Final indicator list is obtained as a result of statistical factor analysis that consists of four levels of hierarchy: dimension level, category level, indicator level and sub-indicator level.

Weighting indicator list process is used to transmit indicator list from qualitative to quantitative assessment system. The weighting process is performed using Simo's Procedures. Applied Simo's Procedures need to determine relative importance between indicator list components. The relative importance for indicator list component are according to experts opinions which explored by performing a structured interviews. After experts assigned these relative importance degrees, Simo's Procedures using formatted Excel sheets have been performed to obtain the global weight of each indicator, category and dimension.

3. INDICATORS SELECTION PROCESS

Indicator selection process is performed based on reviewing similar current indicator system that proposed as a rating system for city sustainability. After reviewing these indicator systems, two procedures are formulated: structuring the main hierarchy level of indicator system and refining indicator system.

Authors initially compiled studies that apply indicators related to sustainable development to one or more cities covering a broad array of Western, Eastern, and Middle East countries. Covering developing and developed countries to target common system has more attention on environmental issues in developed countries, and on economic issues in developing countries. These studies established by academic firms, governmental organizations, and non-governmental organizations. Many of these selected studies are generated from reviewing and comparing preceding studies.

3.1 Reviewing Similar Studies

The studies related to sustainability development assessment are improving the public concern of sustainability aspects and creating frameworks that covers all constituent components of city/community sustainability [2]. The frameworks attempt to implement theoretical approaches to practical works and to provide the best practice in developing and applying indicators for sustainability assessment.

There are two common approaches used for developing a framework and selecting sustainability development indicators [3]: 1) top-down approach which defines the framework and selects indicators by experts and researchers; 2) bottom-up approach which defines the framework and selecting indicators by different stakeholders.

The following paragraphs illustrate studies and frameworks of cities/communities sustainability that have been used in literature survey. Research activities that have been conducted by both academic and non-academic firms in the field of sustainable development have been extensively reviewed. The considered studies can be divided into qualitative indicator based approach and quantitative indicator based approach.

The US Environmental Protection Agency proposed technical guidelines for evaluating sustainability ecological indicators. The framework consists of 15 guidelines that organized into four evaluation phases: conceptual relevance, feasibility of implementation, response variability and interpretation, and utility [4].

Mediterranean Environmental Reporting, Monitoring and Information System framework represents a pilot regional project involving Mediterranean countries according to a well-defined selection process [5]. This project investigates about 44 municipalities representing three different regions in Lebanon qualified for inclusion in the project with 17 choosing to participate in MED-ERMIS-Lebanon [5]. A total of 110 indicators were generated and grouped into four major categories adopted by the national indicator system: (1) population and socio-economic; (2) economic activities; (3) environment; and (4) sustainable development activities and policies.

Jining City in China's Shandong Province has developed a system of 52 indicators of urban sustainable development that addresses economic growth and efficiency, ecological and infrastructural construction, environmental protection, and social and welfare progress [6]. The authors developed a Full Permutation Polygon Synthetic Indicator method to evaluate the capacity for urban sustainable development at different times during the next two decades.

The Community resilience model consists of four components: economic development, social capital, community competence, and information and communication. This model is measuring community resilience as a set of network adaptive capacity [7]. In 2010, Sherrieb conducted with community resilience model, but he considered two components from the four components mentioned [8].

International Urban Sustainability Indicators List (IUSIL) examines nine different practices and proposes a comparative basis study [9]. The nine examined practices selected from both developing and developed countries and regions in the world, including Melbourne, Hong Kong, Iskandar, Barcelona, Mexico City, Taipei, Singapore, Chandigarh and Pune. Discussions made on the comparative analysis are categorized in four different dimensions: environmental, economic, social and governance. Research results show how comparative basis can lead to knowledge sharing between different practices, which can be used to guide the selection of indicators of sustainable urbanization plans and improve the effective communication of the status of practices [9]. Another comparative study called "Measuring the sustainability of cities: An analysis of the use of local indicators" that analyzes 17 studies of the use of urban sustainable development indicators (SDI) in developed western countries. The analysis reveals a lack of consensus not only on the conceptual framework and the favored approach, but also on the selection and optimal number of indicators [10].

European institutions and research projects developed framework to discuss the constraints and achievements of standardizing sustainable indicator sets. In a second stage, it analyzes a Portuguese initiative that uses common indicators to benchmark sustainable development across cities and municipalities – ECOXXI [11].

Burton in 2015 identified 64 indicators which grouped into six components as follows: social resilience, economic resilience, institutional resilience, infrastructure resilience, community resilience, and environmental resilience [12]. The objective of this study is to measure resilience at sub-country level. Burton takes Hurricane Katrina as a case study in study called "Metric for community resilience to natural hazards".

Although these mentioned attempts, there is a lack of international sustainability assessment systems that is universally accepted. This is because of ambiguity of sustainable development definition and objectives to assess, the confusion of data and methods for measurements, and the plurality of purpose in measuring sustainable development [13]. Since the indicator set should reflect particular culture, political, and institutional context, there is not a common set for use [14].

3.2 Indicator System Hierarchy Level

In this research, the use of sustainability indicator sets for cities in developed and developing countries has been studied. The analysis demonstrates a lack of consensus in several steps to create indicator set that stems from the ambiguity in the definition of sustainable development, objectives for the use of such set, the selection method, and the accessibility of qualitative and quantitative data.

The hierarchy level of any indicator list consists of several sequential levels: level for sustainability dimensions (sectors), level of sustainability categories, level of sustainability sub-categories, level of sustainability indicators and level of sustainability sub-indicators.

According to the frequency use, there are three main sustainability dimensions (environment, social, and economic). These are the most frequent used dimensions. Under these three dimensions, there are thirteen categories that represent the most frequent used categories, namely energy, air quality, transportation, water quality, waste, demographics, education, security, health, wellbeing, economic health, ecological footprint, and land use. Other used dimensions and categories were considered in order to determine whether they can be used in the category list, indicator list or excluded. Figure 1 illustrates the proposed indicator system hierarchy level.

3.3 Refining the Proposed Indicator System

Refining indicator system process was performed by passing the selected indicator list based preceding procedure through three layers of filtration. The three layers of filtrations are SMART selection criteria, removing indicators, and reviewing similar systems.

First filtration layer: using SMART criteria for selecting indicators from a pool of available indicators. Selected indicators should be:

- Specific for measuring certain sustainable criteria,
- Measurable, indicator could be measured by scientific procedures,
- Achievable, indicator could be assessed by known methodology,
- Relevant, indicator is related to city sustainability assessment,
- Timely, indicator has a time scale for assessment.

Second filtration layer, there are many indicator systems have specific application and region. Many studies have similar indicators under different categories and hierarchy. Accordingly, to refine the indicator list, an elimination process has been adopted to remove the following:

- Indicator that is repeated more than one times.
- Indicator that is used to assess specific area (region).
- Indicator that does not assess specific phenomena.
- Indicator that does not have time scale for assessment.
- Indicator that does not have specific method for evaluation.

Third filtration layer, reviewed similar systems such as, LEED Neighborhood, Environment Health and Safety Guidelines (EHS) issued by the World Bank, and Global Sustainability Assessment System (GSAS). After reviewing these mentioned systems, several indicators have been consolidated into more progressive indicator system. In addition, the names of some indicators have been adjusted and refined according to international terminology.

3.4 Preliminary Indicator System

After applying the mentioned procedures, further steps have been conducted to come up with the preliminary indicator system. These steps include: data resource management, structuring framework levels of hierarchy, and refining the indicator system. Hence, the preliminary indicator system consists of:

- Three main sustainable dimensions (environment, social, economic).
- Twenty five categories distributed as follows:
    - Environment includes: Air, Water, Waste, Ecological Footprint, Land Use, Biodiversity, Public Administration and Management Policies and Strategies
    - Social includes: Demographic, Housing, Education, Security, Health, Wellbeing, Natural Catastrophes and Social and Community Services.
    - Economic includes: Energy, Transportation, Economic Health, Tourism and Heritage, Consumption and Production Pattern, Science and Technology.

Two hundred indicators distributed under categories which are divided into 78 environmental indicators, 64 social indicators, and 58 economic indicators.

3.5 Final Indicator System

Based on the preliminary indicator list that explained in the previous section, a complete identification of city rating system list (final indicator list) is obtained according to the following procedures:

- Performing questionnaire survey based on the preliminary indicator list to obtaining reliable, common, and applicable indicator list.
- Engaging stakeholders in questionnaire survey. The selection of the stakeholders was based on area of expertise, and they include Egyptian Environmental Affairs Agency EEAA consultants, academic staff, non-governmental organization, and researchers in sustainability field at Cairo University. The questionnaire survey consists of four parts: introduction, personal data, and indicator description and importance degree. This is in addition to the participant’s comments and suggestions.
- Analyzing the collected data and responses.
- Performing statistical analysis through descriptive statistics and exploratory factor analysis. These analyses performed for selecting and aggregating key factors for city sustainability.

The questionnaire survey is designed for obtaining indicator importance based on a scale that ranges from '1' to '5' which corresponds to 'Very Low Importance' to 'Very High Importance'. The question for each indicator gives indicator description, indicator ID, and importance degree.

The survey was carried out through six months from January 2017 to May 2017. The obtained responses out of 147 invitations to Cairo University, British University in Cairo, American University in Cairo, Social Service Institute, Minister of Housing, EEAA, Cairo Governorate, non-governance organizations (Palm Hills Development, Dorra Development, Enppi, SIAC, and Zaml), are 39 responses, yielding a response rate of 26.53%.

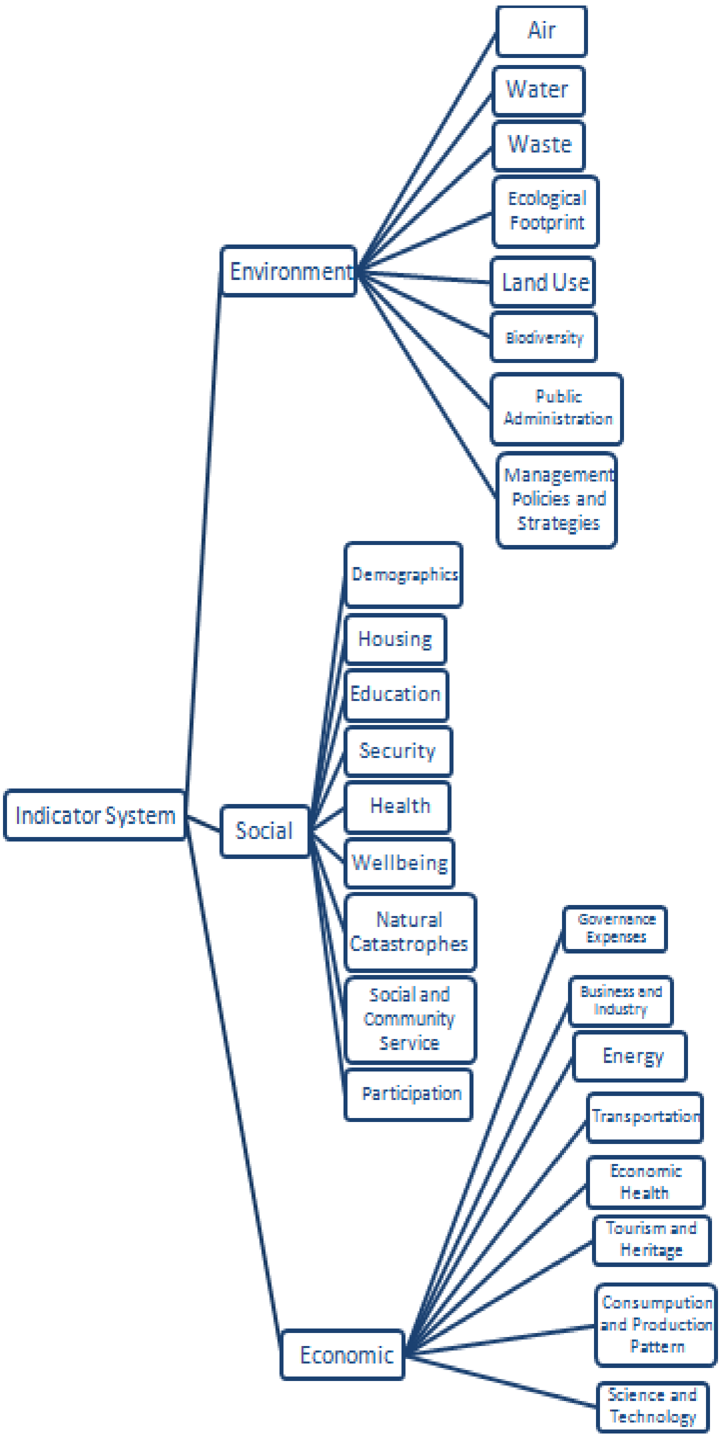
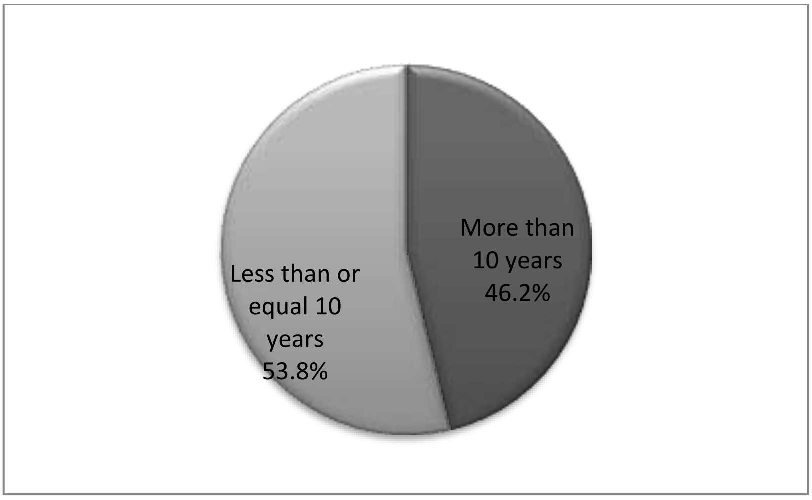


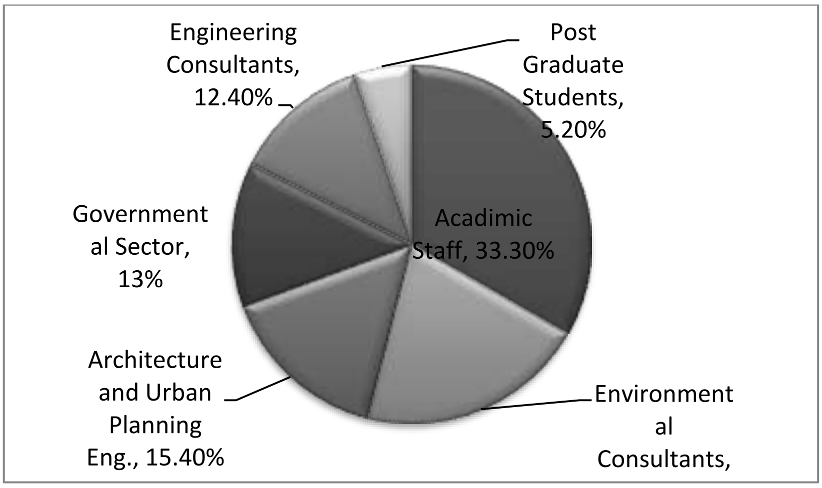
Figure 1: Sustainable Dimensions and Categories for Proposed Indicator System.

The respondents are categorized. One category is based on years of experience. This category shows 53.8% of respondents has less than 10 years of experience and 46.2% has more than or equal to ten years of experience. Another category is based on proficiency where 33.3% are academic staff including lecturer, assistants and professors, 20.7% are environmental consultants accredited by EEAA or consultant firms, 15.4% are architectures and urban planning engineers, 13% are working at the governmental sector (i.e., ministry of housing), 12.4% are engineering consultants for buildings and infrastructure, and 5.2% are post graduate students enrolled at sustainability program at Cairo University (Faculty of Engineering). Figure 2 depicts the respondent's characteristics.

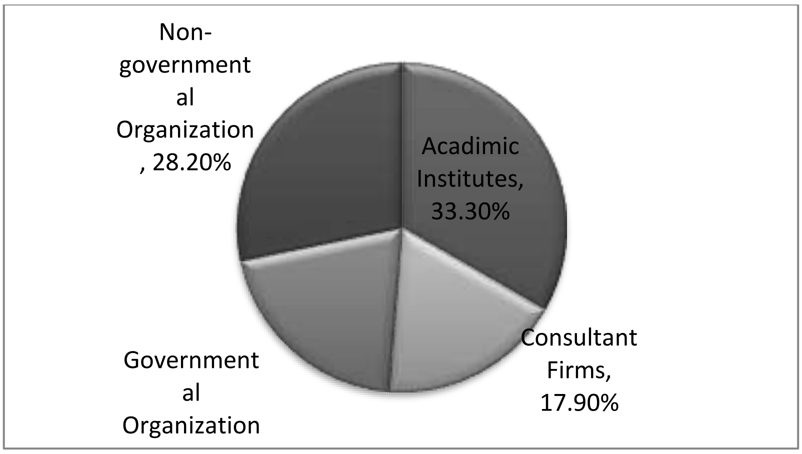
Descriptive statistical factor analysis performed on the collected respondents to exclude low importance indicators and aggregating other indicators that have strong correlations. Statistical factor analysis involves three processes: measuring sampling adequacy, low importance indicator and aggregation.



(a) Years of Experience



(b) Profession



(c) Firm Type

Figure 2: Respondents Characteristics

The factor analysis has been conducted using IBM© SPSS© Statistics version 22 (IBM© Corp., Armonk, NY, USA). Items were tested for the factorability of correlation. All items should be correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Measuring sampling adequacy has been performed using the Kaiser-Meyer-Olkin. The measurement of sampling adequacy must be > 0.5 with significant Bartlett's test of sphericity ($p < 0.05$). These two tests indicate the suitability of the data for structure detection [15]. Low importance indicators are appeared by performing the anti-image correlation matrix. The diagonals of the anti-image correlation matrix should be > 0.5 and those items below this were excluded from analysis and the communalities were considered if above 0.3 to confirm that each item has shared some common variance with other items.

The factor analysis showed that a set of 170 indicators are remained from 200 indicators and this mean that 30 indicators are excluded. The communality analysis suggested aggregating of 170 indicators into 57 factors divides into 20 at environmental dimension, 20 at social dimension, and 17 at economic dimension. The aggregation between indicators is performed according to factor load analysis that based on: correlation between indicators and pattern of responses and the number of responses to the number of indicators to be aggregated. Due to the limited number of responses (39 responses) to the number of indicators under analysis (200 indicators), the aggregation process performed between indicators within each category.

Final indicator list consists of twenty five categories that are divided into nine categories under environmental dimension, nine categories under social dimension and seven categories under economic dimension. For indicator level the final indicator list consists of fifty eight factors that are divided into twenty one factors at environmental, twenty factors at social dimensions and seventeen at economic dimension.

4. WEIGHTING INDICATOR SYSTEM

Indicators need to be weighted toward quantification assessment of city sustainability. Weighting entails attributing multiplier effects to one relative indicator to another, so that the weighted indicators have greater impact in determining overall ranking. Indicator weighting is relevant to policies that have multiple objectives that have different importance.

There are two main arguments against weighting:

- If there are two groups of professions working independently within the same policy, they would not assign the same weighting values to all indicators.
- It is nearly impossible to prove that a weight is scientifically justified because cities are complex systems and data limitations make it impossible to establish weights based on the impact of an indicator.

There are two ways for weighting any indicator list: first is equally division of the total weight through the hierarchy levels and second is by weighting hierarchy levels by using survey which is the most common [16]. The concept of survey is based on the importance degree score to each indicator, category and dimension selected by each participant.

4.1 Simo's Procedures

The main objective to use Simo's method is weighting indicator system for sustainable dimensions, categories, and indicators. The main concept of this approach is made up of correlating a " playing card" with each criterion. The action that the person is being made has to manage the cards in order to rank them, insert the white ones, allow a rather intuitive to understanding the aim of this procedure. There are a number of white cards that depends on the user's needs. The next step is to ask the user to arrange these cards (criteria) from the least important to most important. Therefore, the user arranged in ascending order according to the importance of the criteria. The first criterion in the ranking is the least important and last criterion in the ranking is the most important.

4.2 Implementation of Simo's Procedures

The objective of weighting process of indicator system is obtaining relative importance between indicator list components within dimension level, category level and indicator level. The weighting process is performed by using Simo's Procedure which is suitable to react with a lot of indicators within the final list. This weighting process consists of three components: grouping indicator list, collecting the information, and determining the weight of criteria.

Collecting data belongs to the relative weight of the factors through experts interviews. The experts were asked to rank the indicator of each category in ascending order from the lowest important indicator to the most important one. Table 1 depicts the average relative importance by experts.

4.3. Determining the weight of criteria:

In order to convert the ranks into weights, Simos proposes the following algorithm which consists of five steps:

1- Ranking mentioned cards from the least to the best according to importance.
2- Attributing a position which called weight by Simos to each criterion. The least importance card receives position 1, the next criterion receives 2 and so on.
3- Determining the non-normalized weight (average weight by Simos) by dividing the summation of positions to the total number of criteria.

4- Determining the normalized weight (relative weight by Simos) by dividing the non-normalized weight by the total summation of the position of the criteria.
5- Calculating the global weight of the indicator by multiplying the main indicator normalized weight by category normalized weight by dimension normalized weight. Table 2 illustrates the five steps for obtaining global weight of each indicator list component.

Table 1: Simo's Rank for Indicator List Components

Indicator List Component	Item	Average Relative Weighting (Responses)	Simo's Rank
Dimensions	Environment	2.5	3
	Social	1	1
	Economic	1.5	2
Environment	Air	8.5	8
	Environmental Compliance	6	6
	Water	7.5	7
	Waste	4	4
	Ecological Footprint	5	5
	Land Use	2.5	3
	Biodiversity	6	6
	Public Administration	1	1
	Management Policies and Strategies	1.5	2
Social	Demographics	1.5	1
	Housing	3	3
	Education	4.5	5
	Health	7.5	8
	Wellbeing	6.5	7
	security	5.5	6
	Natural Catastrophes	4	4
	Social and Community Service	3	3
	Participation	2	2
Economic	Energy	6	5
	Transportation	3.5	3
	Economic Index	5	4
	Tourism and Heritage	2.5	2
	Material	5	4
	Governance Expenses	1.5	1
	Science and Technology	1.5	1

Table 2: Global Weight of Indicator List Components

Indicator List Component	Item	No. of Cards	Position	Non-Normalized Weights	Normalized Weight	Weight of Upper Level	Global Weight
Dimensions	Environment	1	3	3	0.5	100%	50%
	Economic	1	2	2	0.33		33%
	Social	1	1	1	0.166		17%
Environment	Air	1	8	8	0.19	50%	9.5%
	Environmental Compliance, Biodiversity	2	6	6	6	.14		7.075%
	Water	1	7	7	0.17		8.5%
	Waste	1	4	4	0.10		5.0%
	Ecological Footprint	1	5	5	0.12		6.0%
	Land Use	1	3	3	0.07		3.50%
	Public Administration	1	1	1	0.02		1.0%
	Management Policies and Strategies	1	2	2	0.047		2.35%
Social	Demographics	1	1	1	0.03	17%	0.44%

	Housing, Social and Community Service	2	3	3	3	.154		2.62%
	Education	1	5		5	0.128		2.18%
	Health	1	8		8	0.205		3.49%
	Wellbeing	1	7		7	0.179		3.04%
	security	1	6		6	0.154		2.62%
	Natural Catastrophes	1	4		4	0.103		1.75%
	Participation	1	2		2	0.051		.85%
Economic	Energy	1	5		5	0.25	33%	8.25%
	Transportation	1	3		3	0.15		4.95%
	Economic Index, Material	2	4	4	4	0.40		13.2%
	Tourism and Heritage	1	2		2	0.10		3.3%
	Governance Expenses, Science and Technology	2	1	1	1	0.10		3.3%

After global weights of dimensions, categories and indicators are performed, then sustainability rating system moves to quantitative system. Detailed assessment is performed for each indicator for measuring and scoring performance of city at each indicator. Finally, aggregating indicators scores for total city score are obtained.

5. CONCLUSION

This paper illustrates a framework for developing city sustainability rating system. The proposed framework is consisted of two main processes: indicators selection and weighting indicator list.

Indicators selection process is performed taking into consideration previous studies and guidelines which includes indicators for sustainability assessment for developing and developed countries. Structure the hierarchy levels of indicator list contains of three levels: dimension level, category level and indicator level. After structuring the main hierarchy levels of indicator list, filtrating indicators is performed to obtain preliminary indicator list. For obtaining more applicable and reliable indicator list, a questionnaire survey based on the preliminary list has been conducted. This questionnaire survey aims at investigating indicators degrees of importance. Statistical factor analysis is performed on the questionnaire survey responses. The statistical factor analysis has three procedures: 1) measuring responses adequacy, 2) eliminating indicators which have low importance and 3) aggregating of indicators. Final indicator list is obtained as a result of this statistical factor analysis.

Weighting indicator list process is used to transmit indicator list from qualitative to quantitative assessment system. The weighting process is performed using Simo's Procedures. Applied Simo's Procedures need to determine relative importance between indicator list components. The relative importance for indicator list component is according to experts opinions. The experts' feedbacks have been collected through a structured interviews with them. After experts assigned these relative importance degrees, Simo's procedures have been applied using formatted Excel sheets to obtain the global weight of each indicator, category and dimension.

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