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IDENTIFICATION OF SUSTAINABLE INDICATORS IN CITIES

Ahmed Hamdy[1], Mohamed El zayat[2] and Mohamed Marzouk[3]

[1]Assistant Lecturer, Structural Engineering Department, Faculty of Engineering, Cairo University, Egypt

[2]Instructor, Integrated Engineering Design Management Program, Faculty of Engineering, Cairo University, Egypt

[3]Professor of Construction Engineering and Management, Structural Engineering Department, Faculty of Engineering, Cairo University, Egypt

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. Due to the diversity of these indicator systems, it is difficult to identify an international best sustainability practice or standard to follow. Each indicator of sustainable assessment systems demonstrates certain goals, target values, and principals. There are many developed frameworks for selecting indicators as well extended assessment criteria for certain areas and municipalities. However, these attempts are unsuitable for any areas or municipalities. The target of this research paper is to develop a more comprehensive framework for sustainability assessment system for cities. This framework describes how to select indicators and set up rating system that suites both developed and developing countries.

Key Words: Sustainable cities indicators, rating systems, sustainability assessment, indicator selection, indicator-based assessment.

1. Introduction

Recently, a need for a comprehensive sustainability assessment of a city and monitoring its dimensions (environment, economic, and social) has emerged. However, it has demonstrated difficulty in order to integrate various sustainable characterizations as well as a lack of hard evidences [1]. Sustainability assessment is required to check how a new policy, decision or technical innovation will better develop current scenarios. Thus, policies and strategies are

performed to meet the sustainable development goals (SDGs) which assist in developing a sustainable manner [2]. Sustainable city theories encompass multiple objectives:

- Improving air, water, and soil quality by reducing the resources and energy consumed in construction, operation, and deconstruction of buildings and infrastructure.
- Developing social and physical structures that improve inhabitant health, comfort, and personal fulfilment.
- Minimizing waste by managing consumer behavior and providing a proper waste management system.
- Encouraging sustainable livelihoods and/or economic growth that results in equity and social harmony.

There are three main criteria for identifying indicators at any rating system [3]; Sustainable development policies and strategies are often established at the regional level, and hence comparing sustainability indicators are important because they allow cities of the same size to have a common grid to share and apply successful tools and measures.

There are attempts to establish standardized indicators for cities by United Nations and other governmental and non-governmental firms. United Nations prepared studies such as the Global Urban Observatory to assess and compare urban indicators and evaluate urban policies [4]. In September 2015, the United Nations declared the Sustainable Development Goals (SDGs) which are a set of goals to end poverty and protect the planet. The SDGs consist of 17 goals that are considered important sustainable policies guidelines. Each goal of The SDGs has a specific target to be accomplished and met within 15 years [5].

The World Bank group developed "World Development Indicators" as a result of partnership among numerous international agencies over 200 national statistical offices. The World Development Indicators are to evaluate global development goals and achievements at community and country. In 2013, Yigitcanlar and Loennqvist [6] argued that there are several international ranking of cities based on several criteria such as cost of living, city branding, innovation economy, and personal safety.

This paper identifies the adopted methodology to identify comprehensive rating system indicators for sustainable cities. The methodology consists mainly of the following: 1) Investigating different rating systems in order to obtain the most common indicators; 2) Refining preliminary indicator list by reviewing other similar systems; 3) Proposing a comprehensive rating system for sustainable cities that can be easily applied.

1. Proposed Framework

Many concepts of sustainable city, green city, and eco-city, are exist. Accordingly, an abroad investigation for indicator systems, focusing on sustainable city, green city, eco-city, sustainability indicators, and sustainable development goals has been carried out. The following criteria are followed in order to identify a proper and suitable indicator system: 1) High level reference related to sustainability of cities, 2) Measurements at sub-national levels, 3) Clarity of criteria and methodology, and 4) Clarity in indicator definition. The proposed framework is carried out in four steps: 1) Investigating current Systems Indicators, 2) Identifying Preliminary Indicators List, 3) Identification of Final Indicators List, and 4) Investigating Indicators Importance: Questionnaire and Data analysis.

Investigating current Systems Indicators

There are many criteria for selecting indicators such as; scientific validity, relevance to users' needs, reliance on accurate accessible data/time series data, representativeness of responsiveness to change, comparability with other indicators, cost- effectiveness of collection and lack of ambiguity [7]. 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 focused on environmental, economic, and social issues. Many studies started from category level, and another started with objectives. A sample consisted of 11 studies has been analyzed covering cities or municipalities of various sizes in US, Canada, Europe, China, Malaysia, Taiwan, and Lebanon. The main characteristics of the studies are described in Table 1. By investigating the mentioned 11 studies above, the followings have been concluded: the studies have different hierarchy (sector, category, subcategory, and indicator) and they are varied in the number and type of used sectors, categories, and indicators.

For the eleven examined studies, the number of indicators varies between 14 and 110. Indicators related to environmental components exceed that in other components. This variation is due to the classification process that articulates the indicator set in a given system. There are many differences between practices suggested by scientists and those proposed by municipal administrations. A less conceptual structure comprising fewer indicators has intended to achieve simple and quantifiable objectives. Scientists prefer a minimum aggregation and, if possible, simplification, in order to adhere to the main concepts of sustainability [8]. Determining the optimal choice and number of indicators inevitably require that selected criteria should be defined. Many of the selected criteria in the 11 investigated studies are based on the usage frequency while others are not.

Table 1: Summary of the Eleven Selected Studies

No.	Reference	Description	No. of Indicators
1	Dizdaroglu [9]	Propose a set of key micro-level urban ecosystem indicators	23
2	Michael et al. [10]	Examines and compares the processes, methodologies and resulting sets of indicators for urban sustainability carried out in three of Asia's developing countries; Malaysia, Taiwan and China.	21 at Malaysia set 21 at China set 87 at Taiwan set
3	Ibrahim et al. [11]	Review the theoretical framework of sustainable city indicator implemented by Malaysian local authority (MURNInet).	55
4	Liu et al. [12]	Measurement indicators and an evaluation approach for assessing urban sustainable development: A case study for China Jining City.	52
5	Nader et al. [13]	Environment and sustainable development indicators in Lebanon: A practical municipal level approach	110
6	Pires et al. [14]	Analyzes a Portuguese initiative that uses common indicators to benchmark sustainable development across cities and municipalities – ECOXX.	21
7	Shen et al. [15]	Examines 9 different practices and proposes a comparative basis, namely, International Urban Sustainability Indicators List (IUSIL)	37
8	Tanguay et al. [8]	Analyze 17 studies of the use of urban sustainable development indicators in developed western countries	61
9	Hak et al. [16]	A method to assess the relevance of sustainability indicators: Application to the indicator set of the Czech Republic's Sustainable Development Strategy	14
10	Zen et al. [17]	Sustainability, Energy and Development: A Proposal of Indicators	26
11	Zhou et al. [18]	Developed the eco and low carbon indicator tool for evaluating cities (ELITE)	33

By assessing the mentioned studies there are many indicator systems have specific application and region. Many studies have similar indicators under different categories and hierarchy. To refine this indicator list, two approaches have been taken. The first approach is to remove indicators that are: repeated more than one time, used for assessing specific area (region) not having time scale for assessment and not having specific method for evaluation. Second approach is to adding indicators by reviewing similar and accredited international indicator systems. These indicators are significant to assess sustainable criteria inside the city borders. The reviewed systems are interlaid, Measuring the Eco., Sustainable, or Green City, Environment,

Health, and Safety Guidelines EHS, and Global Sustainability Assessment System (GSAS) that are used as guidelines or rating systems to assess sustainability.

Identifying Preliminary Indicators List

After refining the system indicators based on the aforementioned approach, the use of sustainability indicator sets for cities in developed and developing countries have been proposed as a preliminary indicator list. The analysis of the systems indicator list in order to come out with a preliminary list demonstrates a lack of consensus to precisely create system indicators. As a consequence and in order to achieve common sectors and categories, a comparison among the 11 studies at each level separately has been conducted. At sector (dimension) level ten sustainable dimensions have been obtained which are: environment, social, economic, institutional, ecological and infrastructure, political, territorial, land use, governance, and resource usage. There are three main sustainable dimensions (environment, social, and economic) that are considered the most frequently used sectors. Accordingly, the most frequently used sectors have been proposed for the proposed comprehensive indicator system, namely environmental, economic, and social. By analyzing the other seven dimensions, it has been observed that institutional, land use, infrastructure, resource usage, governance are part of the social, environment, and economic dimensions in many studies.

At category level, thirty nine categories are used in the selected eleven studies. Based on the frequently used categories and their repetition in the investigated studies, they can be divide into two sets. The first set for categories of six repetitions or more and the second set of categories with less than six times repetition. There are 34% of the categories are used more than more than six times. This set includes 13 categories which are: energy, air quality, transportation, water quality, waste, demographics, education, security, health, wellbeing, economic health, ecological footprint, and land use. By analyzing the less frequently used categories that represent 66% of the mentioned categories, the following has been concluded: noise pollution inserted as a category for 5 times, and inserted as an indicator under Transportation category, so it is recommended to use it as an indicator under Transportation. Green space, ecosystems and heritage have been repeated 3 times and stated as indicator 5 times [11]-[9]-[10]-[3]- [15]-[13], so it is recommended to list them as indicators under Land Use category. Housing presented as a category 4 times and has detailed indicators [11]. In other studies housing appeared briefly. Thus, it is suggested to list Housing as a category with detailed measuring indicators.

Expenses and Public Administration, Business and Industry, Science and Technology, Participation, Management and Policies, and Social Community Services are used as categories to present Economic and Social sector. As mentioned above, the proposed indicator list consists of three level hierarchy sector, category, and indicator level. The sector level has three components (dimensions) environment, social, economic. Then it is subdivided to 25 categories as shows in Figure 1.

Environmental sector consists of eight categories; air, water, waste, ecological footprint, land use, biodiversity, public administration, and management policies and strategy. Social sector consists of nine categories; demographics, housing, education, security, health, wellbeing,

natural catastrophes, social and community service, and participation. Economic sector consists of eight categories; energy, transport, economic health, tourism and heritage, consumption and production pattern, governance expenses, business and industry, and science and technology. The preliminary indicator list consists of 200 indicators divided into 78 indicators for environmental dimension, 64 indicators for social dimension and 58 indicators for economic dimension.

Identification of Final Indicators List

Giving the fact that the preliminary indicator list shows 200 indicators under the different categories, a more comprehensive and concise indicator list should be obtained. The identification of rating system indicator (final indicator list) has been performed following the below procedures;

- Performing a questionnaire survey on the preliminary indicator list in order to obtain reliable, common, and applicable indicator list.

- Engaging stakeholders with different experiences in the field of sustainability in the questionnaire survey. Participants include environmental experts accredited by the Egyptian Environmental Affairs Agency (EEAA), academic staff, non- governmental organizations, and researchers in the field of sustainability at Cairo University.

- Analyzing collected data and responses from the survey participants.

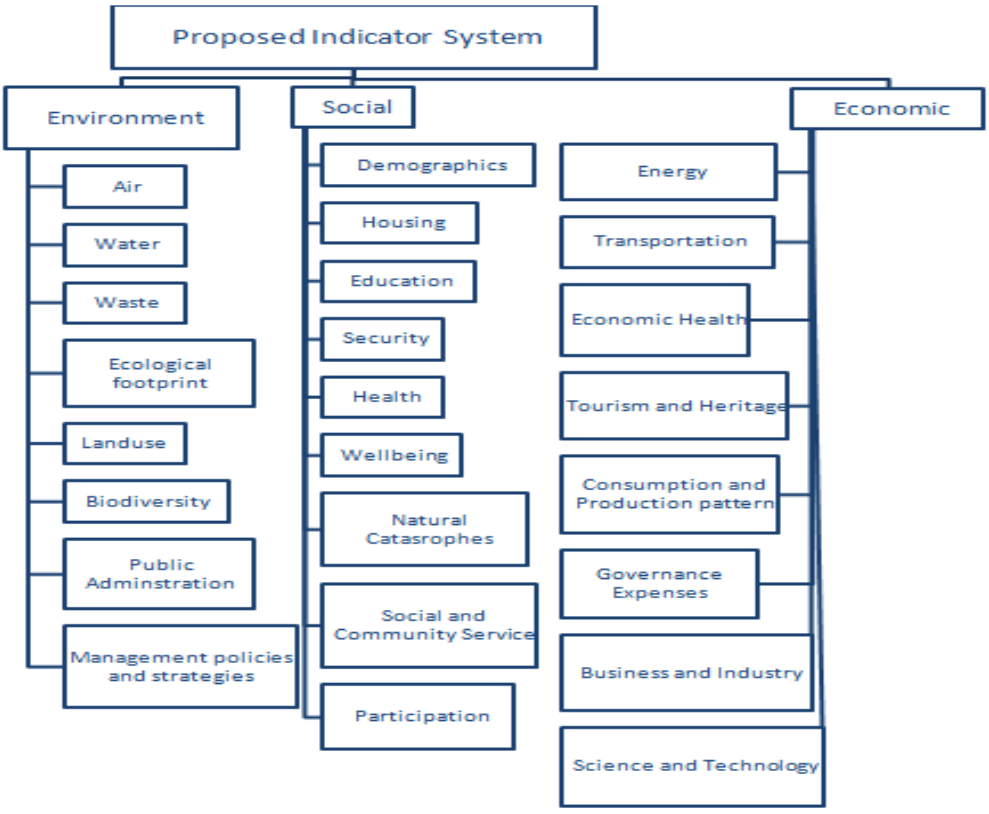


Figure 1: Sustainable Dimensions and Categories for the Proposed City Rating System

Investigating Indicators Importance: Questionnaire and Data analysis

The survey-based research was selected for investigating the importance of the indicators extracted from the literature review. These indicators are listed in preliminary indicator list that obtained after refining different system indicators. The questionnaire is not confined for certain group of specialists as the city sustainability issues are of a concern of a wide range of specialists working at different fields. This questionnaire proposes the most existing indicators in defining the sustainable city. The data extracted from this questionnaire will be used in the development of more reliable indicator system for assessing sustainable cities.

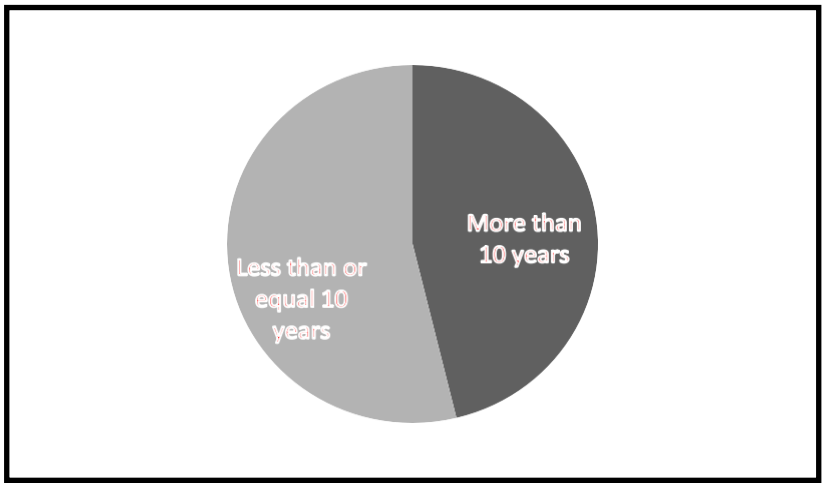
Survey research fits the cases in which author wishes to answer questions regarding the distribution of the variables or the relationships among characteristics of people or groups allowing generalization for a broader population [19]. The questionnaire has two ways for presentation paper survey and electronic survey. Google form techniques are used to design, launch and manage the survey as well as gathering response data. The question design 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 provides indicator description, indicator ID, and selection role for importance degree.

The questionnaire survey is divided into five sections; Section 1 is General Information, Section 2 is Definition of Selected Factors & Degree of Importance for Environmental Factors, Section 3 is Definition of Selected Factors & Degree of Importance for Social Factors, Section 4 is Definition of Selected Factors & Degree of Importance for Economic Factors and Section 5 is the respondents comments and suggestions to improve the questionnaire.

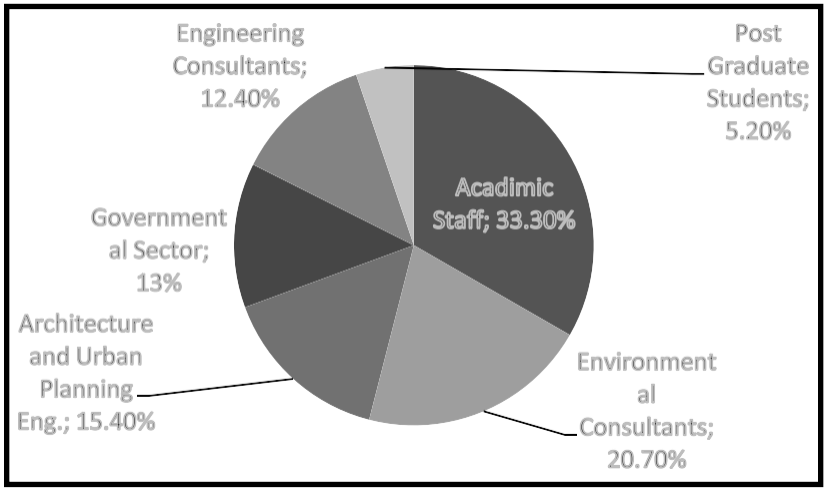
The questionnaire has been designed to be in both paper and electronic based. The responses are then collected at Excel file. The Excel file illustrates each respondent personal data, degree of importance assigned to each indicator, and participants' suggestions. The Excel file is divided into three spread sheets in correspondence with the three sustainable dimensions, namely environmental, social, and economic. The survey was carried out through six months from January 2017 to May 2017. The targeted respondents for city rating system survey are member of governmental organizations like minister of housing members, EEAA (Egyptian Environment Affairs Agency) registered consultants, academic staff who have researches related to sustainability, post graduate students who registered at sustainability topics courses, specialists at non-governmental organizations, and environmental consultants.

The response rate of 147 invitations to Cairo University, British University in Cairo, American University in Cairo, Social Service Institute, Ministry of Housing, EEAA, Cairo Governorate, non-governmental organizations (i.e., private sector), 39 responses were obtained, yielding a response rate of 26.53%.

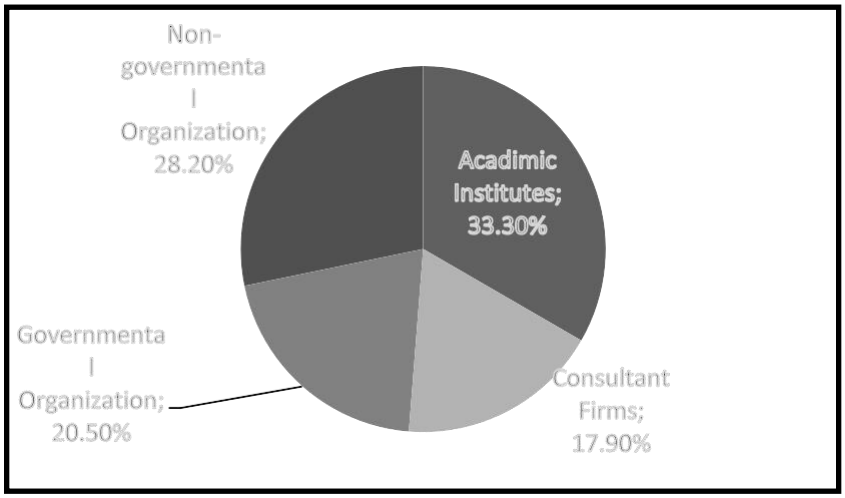
According to years of experience, 53.8% of respondents have less than 10 years of experience and 46.2% have more than or equal to ten years of experience. Regarding the professions of the respondents; 33.3% are academic staff including lecturer, assistants and professors, 20.7% are environmental consultants 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 developments buildings and other infrastructure, and 5.2% are post graduate students enrolled at sustainability program at Cairo University (Faculty of Engineering). While according to firm type, 33.3% are working at academic institutes, 17.9% are from consultant firms, 20.5% are from governmental organizations and about 28.2% from non-governmental organizations. Figure 2 shows stakeholder characteristics according to years of experience, profession and firm type respectively.



a) Years of Experience



b) Profession

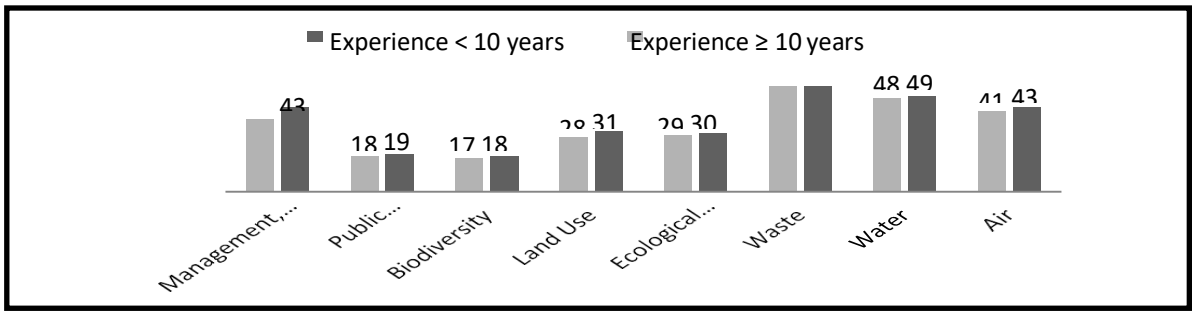


c) Firm Type

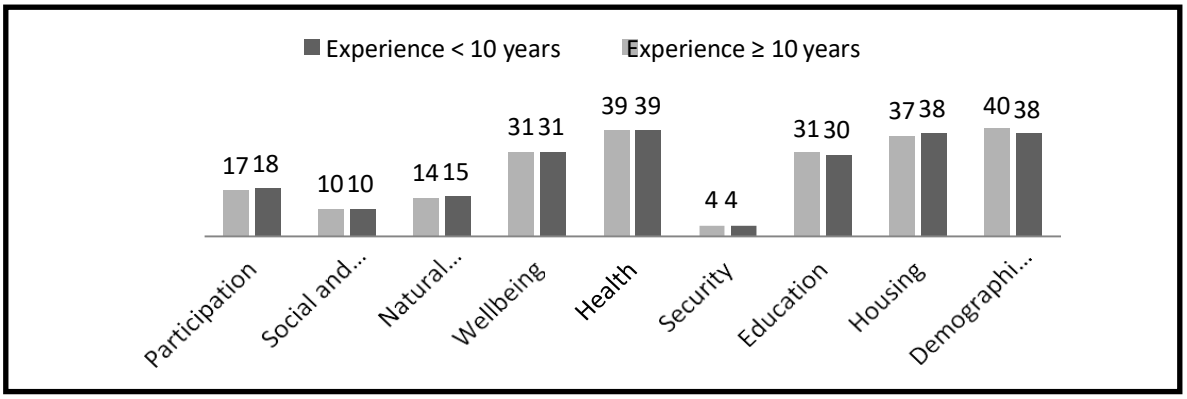
Figure 2: Stakeholder Characteristics

Statistical analysis was done to check the differences in respondents scoring for dimensions and corresponding categories based on their years of experience and firm type. This statistical analysis was done by using IBM© SPSS© Statistics version 22 (IBM© Corp., Armonk, NY, USA). Numerical data were expressed as median and range as since these data represent scores. The characteristics of the respondents' replies were performed by comparing respondents' scores according to their years of experience. Respondents were divided into two groups: first group of ten years or more of working experience, second group of less than ten years of experience.

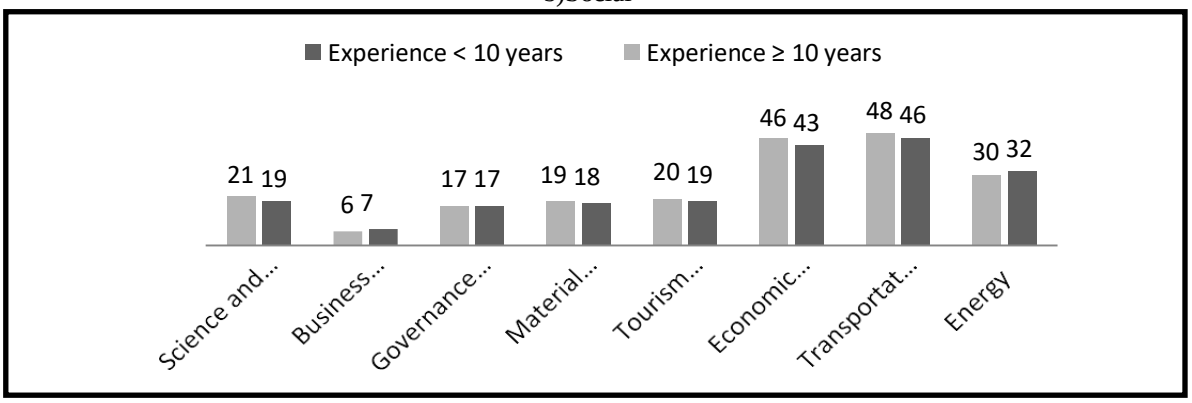
The comparison between these mentioned two groups was carried out using Mann-Whitney test (non parametric t-test) and P- Value < 0.05 was considered significant. Figure 3 (a,b and c) shows median values for each category for both groups. Second comparison between respondents scores according to firm type. Respondents are divided into four groups: academic institute, consultant firms, governmental organizations, and non-governmental organizations. The comparison among these different groups was carried out using Kruskal-Wallis test (non-parametric ANOVA) and P-Value < 0.05 was considered significant. Figure 4 (a,b and c) depicts median values for categories according to firm type for environmental, social and economic respectively.



a)Environmental

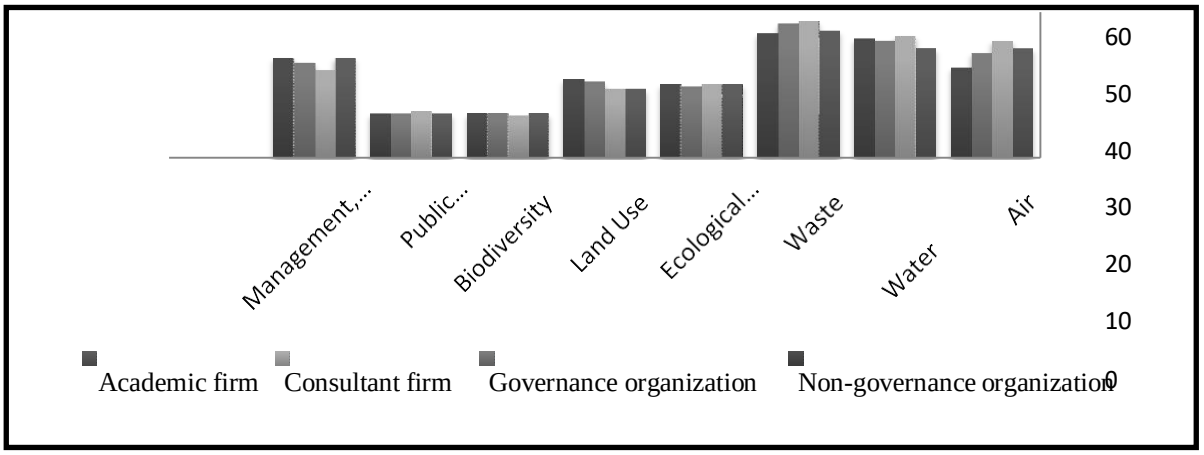


b)Social

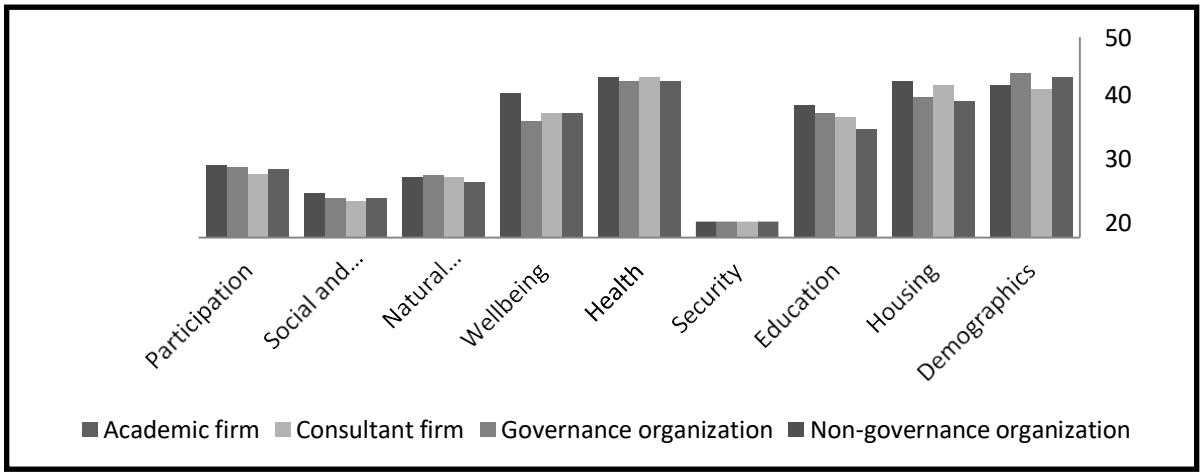


c) Economic

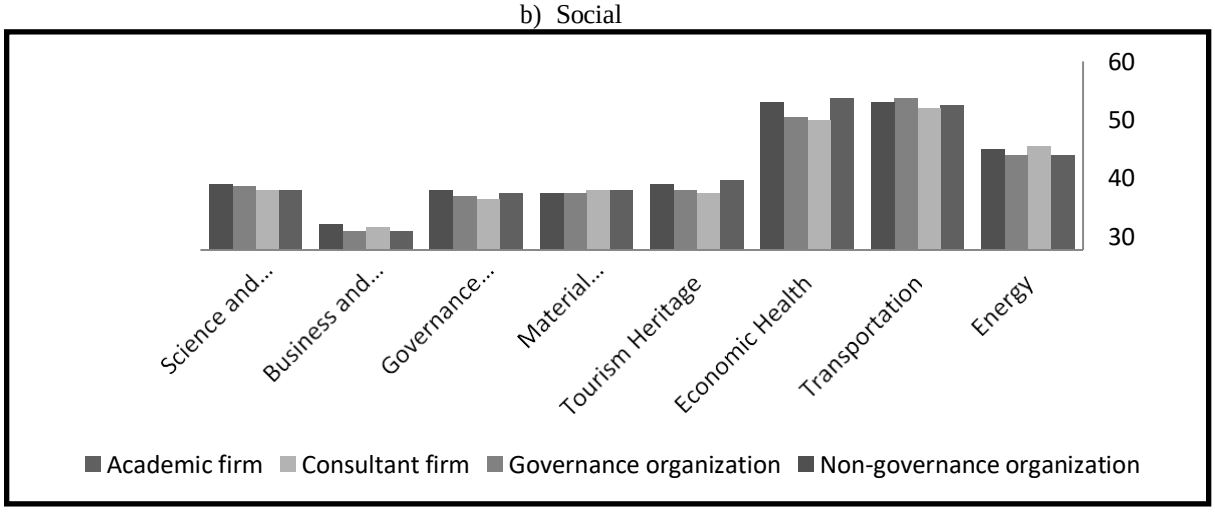
Figure 3: Median Values for Categories according to the Years of Experience



a) Environmental



b) Social



c) Economic

Figure 4: Median Values for Categories according to the Firm Type

Third comparison is performed between importance of sustainable dimension (environment, social, and economic) and corresponding categories according to respondents. This comparison is based on percentage of responses above 50% of importance degree. The environmental dimension receives more attention than social and economic dimensions. At the level of categories the ten more important categories are air, water, waste, management policies and strategies, demographics, housing, security, health, participation and transportation.

The statistical analysis shows that there are no significant difference between scores assigned by respondents according to their working experience and working type classification. These statistical results were generated according to 39 valid responses but the results may be improved in case of more responses have been obtained.

3. Conclusion

This research presented a framework for selecting most common and reliable indicators to perform city rating system suitable for developed and developing countries. The development of the framework through many procedures divides into two parts. The first one to obtain preliminary indicator list based on literature review for recent published studies for indicator systems related to developing and developed countries, performed high level structure of indicator system and refining indicators included this system. The second part target to obtain final indicator list that called city rating system through procedures; developed a questionnaire survey to select more reliable and importance indicators, statistical analysis for respondents and statistical factor analysis is performed to excluding low importance indicators and then aggregating indicators that have strong correlation.

References

[1] C. Böhringer, & P. E. Jochem, "Measuring the immeasurable—A survey of sustainability indices," Ecological economics, 63(1), pp. 1-8, 2007.

[2] K.R. Gustavson, S.C. Lonergan, & H.J. Ruitenbeek, "Selection and modeling of sustainable development indicators: a case study of the Fraser River Basin, British Columbia," Ecological Economics, 28(1), pp. 117-132, 1999.

[3] N. Zhou, "An International Review of Eco-City Theory, Indicators, and Case Studies," Lawrence Berkeley National Laboratory, California, USA, 2014.

[4] J. Flood, "Urban and housing indicators," Urban Studies, 34, pp. 1635 –1666, 1997.

[5] United Nation,"The Sustainable Development Agenda.", Available at http://www.un.org/sustainabledevelopment/development-agenda/, 2016.

[6] T. Yigitcanlar, & A. Loennqvist, "Benchmarking knowledge-based urban development performance: Results from the international comparison of Helsinki," Cities, 31, pp. 357-369, 2013.

[7] V.W. Maclaren, "Urban sustainability reporting," Journal of the American planning association, 62(2), pp. 184-202, 1996.

[8] G.A. Tanguay, J. Rajaonson, J.F. Lefebvre, & P. Lanoie, "Measuring the sustainability of cities: An analysis of the use of local indicators," Ecological Indicators, 10(2), pp. 407-418, 2010.

[9] D. Dizdaroglu, "Developing micro-level urban ecosystem indicators for sustainability assessment.", Environmental Impact Assessment Review, 54, pp. 119-124, 2015.

[10] F.L. Michael, Z.Z. Noor, & M.J. Figueroa, "Review of urban sustainability indicators assessment– Case study between Asian countries," Habitat International, 44, pp. 491-500, 2014.

[11] F. I. Ibrahim, D. Omar, & N. H. N. Mohamad, "Theoretical Review on Sustainable City Indicators in Malaysia," Procedia-Social and Behavioral Sciences, 202, pp. 322-329, 2015.

[12] X. Liu, D. Hu, R. Wang, W. Yang, & D. Zhao, "Measurement indicators and an evaluation approach for assessing urban sustainable development: A case study for China's Jining City," Landscape and Urban Planning, 90(3), pp. 134-142, 2009.

[13] M.R. Nader, B.A. Salloum, & N. Karam, "Environment and sustainable development indicators in Lebanon: a practical municipal level approach," Ecological indicators, 8(5), pp. 771-777, 2008.

[14] S.M. Pires, T. Fidélis, & T.B. Ramos, "Measuring and comparing local sustainable development through common indicators: Constraints and achievements in practice," Cities, 39, pp. 1-9, 2014.

[15] L.Y. Shen, J.J. Ochoa, M.N. Shah, & X. Zhang, "The application of urban sustainability indicators–A comparison between various practices," Habitat International, 35(1), pp. 17-29, 2011.

[16] T. Hak, J. Kovanda, & J. Weinzettel, "A method to assess the relevance of sustainability indicators: Application to the indicator set of the Czech Republic's Sustainable Development Strategy," Ecological Indicators, 17, pp. 46-57, 2012.

[17] A.C. Zen, A. Lima, A.L. Brianchi, & L. Babot, "Sustainability, energy and development: a proposal of indicators," International Journal for Infonomics, 5, pp. 537-41, 2012.

[18] N. Zhou, C. Williams, & D. Fridley, "ELITE cities: a low-carbon eco-city evaluation tool for China," Ecological Indicators, 48, pp. 448-456, 2015.

[19] C. Forza, "Survey research in operations management: a process-based perspective," International Journal Operation Production and Management, 22 (2), pp. 152–194, 2002.