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Procedia Environmental Sciences 30 (2015) 244 – 249

**Procedia**  
Environmental Sciences

International Conference on Environmental Forensics 2015 (iENFORCE2015)

## Delphi method of developing environmental well-being indicators for the evaluation of urban sustainability in Malaysia

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### Abstract

Urban sustainability is the goal of many cities to improve well-being of urban residents that live in cities. This study sought expert consensus in a 2-round Delphi survey to rate the importance of environmental well-being indicators to assess urban sustainability. A multidisciplinary group of 45 experts rated the importance of 18 indicators with response rates of 75.6% and 91.2% in the rounds. Consensus was reached on 12 indicators with a high level of group agreement (Kendall's  $W=0.522$ ,  $P < 0.001$ ), and high correlation in rounds rankings ( $\rho=0.964$ ,  $p>0.01$ ).

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Peer-review under responsibility of organizing committee of Environmental Forensics Research Centre, Faculty of Environmental Studies, Universiti Putra Malaysia.

**Keywords:** Environmental well-being, sustainability, indicator, urban area, delphi

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### 1. Introduction

Urban environment includes large cities are assuming increasing importance in global environmental health concern[1]. The primary reason is that, more than half population (3.4 billion people) of the world lives in urban areas, and with expected increase (6.3 billion by 2050) into the future [2]. Human population growth has resulted in environmental change in the form of uncontrolled and unplanned urbanization, intensification of agricultural

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production, deforestation, and biodiversity loss [3]. These change impacts the quality of life in the cities; affect human health both directly (air, water pollution) and indirectly (climate change). Cities are faced with environmental health impacts of urban pollution derived from inadequate water, sanitation, solid waste services, poor urban and air pollution (primarily from particulates) cause severe environmental health hazards for urban residents [4,5]. For example, exposure to severe traffic noise in urban environments can cause serious sleep disturbance, hearing impairment, and raised stress levels leading to high blood pressure, related coronary heart disease, stroke, and possibly immune system and birth defects [6]. Also, there are of death from causes related to air pollution in large urban centers each year [7].

Cities are civilization and the engines of economic growth, but the environmental implications of such growth on the well-being of the society are consequential. Rapid urbanization in many developing countries has pressure on the cities and the supporting ecological systems [8]. Thus, there is need for redirection towards sustainability and well-being as an option for further development [9]. Cities are necessary determinants of future sustainability in human health and environmental well-being [10]. Environmental as well as social issues must be addressed in order to move towards sustainability.

The value of linking urban environmental health and wellbeing outcomes is now well recognized [11], but poorly understood not to mention guiding urban environmental planning, policy and governance [12]. The relationships are complex and in many instances; clear and measurable links are not available [13]. Therefore, environmental well-being indicators are required to summaries, understand and monitor the complex relationships to enhance policies on urban sustainability. Many leading democracies and major international institutions around the world are involved in efforts to develop specialized and comprehensive indicator systems to measure societal performance. Indicators are increasingly becoming a useful tool for policy-making and public communication [14]. Different practices use different indicators according to their particular needs, and these have been selected under different methods. The process of urban sustainability require a measurable indicators [15]. Environmental indicators thus, assess the effects of human activities on the environment and the implications for human health, quality of life and the ecosystems. Environmental indicators are usually scientifically based information that describes environmental conditions and trends [16].

Malaysia is currently experiencing rapid economic growth, industrial development, an urbanization process, increasing population and a changing lifestyle [17]. Despite the challenge of urban sustainability practices, the environmental impacts on well-being are yet to be studied. An environmental well-being indicator as a tool can assist in the assessment and monitoring of the impact of sustainable development [18], and transform societies in the direction of environmental sustainability [19]. This study, therefore, develop a valid environmental well-being indicators for urban sustainability in Malaysia, using Delphi consensus.

## 2. Methods

### 2.1. Delphi consensus techniques

Delphi consensus techniques have been used in natural resources and environmental management research to facilitates interaction in investigation of variety of local, regional, and global issues among the stakeholders [20]. However, few researchers have used the methods to develop environmental well-being indicators among expert group. A Delphi traditionally involves an anonymous survey using questionnaires with controlled feedback to allow iteration within a panel of experts [21]. It is also understood as a tool for reaching expert consensus through scientific discourse and helping to solve complex situations in which, while scientific knowledge elements are relatively certain, the relations between variables are very complex [22]. The method is found appropriate for developing indicators [23]. The choice of a specific design and the methodological of a Delphi process dependent on the research question defined by the analyst and vary significantly among studies [24]. The Delphi study presented here was devised in a structured format in order to assess a list of pre-defined environmental indicators drawn from the literatures.

## 2.2. Establishing expert panel

Experts' panel selection is an important component in the Delphi method, as the validity of the results relies on their judgement (25). Donohoe (26) stated that, the decisions regarding panel size, characteristics, and composition should ensure that the expertise represented on the panel is congruent with the research issues in question. Four 'expertise' requirements should be taken into account: knowledge and experience of the field of study; ability and willingness to participate; adequate time to participate; and effective communication skills (27). It is also recommended to involve expert with various expertise and spatial location in the panel (28) to capture on context-specific issue that may be overlooked by participants and thus ensuring a more holistic, objective and positive grounding of the resulting framework (29). In this context, fifty highly informed local expertise's from academia with variety of disciplines, and an in-depth understanding of local and wider issue on sustainable development and environmental well-being domains in Malaysia participated. The purposively sampled experts have at least five years work experiences in sustainable development, and environmental management, intermediate position, a relevant bachelor degree. Purposive sampling was used in other to ensure that the experts meet pre-defined definitions of expertise in the fields [29]. The sample size for the study is considered appropriate and fulfilled a Delphi survey criterion [29]. Literature recognized a minimum appropriate size of seven or eight experts [30], and a ranged from 20 – 60 number of participants [32] for heterogeneous group (expertise from different social or professional groups but on a topic).

## 2.3. Delphi procedure

Invitation letter was sent to nominated participants by email to complete a two round rating process, and were asked to give demographic information. The participants were to rate the importance of each indicator on a 5-point scale (1 = very low important to 5 = very high important). The questionnaire provides the participants to add free text comments. Two-email reminder was sent in each round. At the second round, the experts were presented with feedback results for each indicator rated in first round. Indicators were extracted from the literature reviewed and subjected to iterative consultation about comprehensiveness and subsequently edited in a pilot rating exercise. A set of 18 subjective environmental indicators was established for the expert's consensus initiatives.

## 2.4. Consensus criteria

To assess consensus, three sets of combined criteria measures are used. This includes a median score of  $\geq 4$  ('highly important')[31], the interquartile range (IQR) of 1 or less and the standard deviation below 1.0 [32] on a 5-Likert scale. For test of level of agreement and stability, the stopping criteria have three rules: the Kendall's W should be  $\geq 0.5$ , Spearman's rho between rounds should be  $\geq 0.9$ , and If the criteria aforementioned are not met in the third round, then the study will stop at the end of the fourth round.

## 2.5. Analysis of ratings

After the first round, the aggregate ratings were calculated. Table 1 show the distribution of the median score, IQR and standard deviation of expert's ratings of indicators in both rounds (1&2). We based thresholds for retaining indicator items was based on the combined criteria (median, IQR and standard deviation) and the level of agreement (Kendall's W) among participants as well as the stability between rounds at the second round. Only indicators that satisfied these criteria wholly were considered to have reached consensus. A non-parametric analysis, Spearman rank correlation coefficient was used to test the potential impact of differences between expert groups' ratings.

## 3. Results and discussion

Table 1 and 2 describes the results of the first and second rounds. Fifty participants were invited to the Delphi process, 45 experts gave their consent to participate. Of those numbers, 34 (75.6%) provided ratings at the first round and 31 (91.2%) participants completed rating in second rounds. Descriptive information about the experts

shows that the majority of the experts had at least 5 to 10 years working experience in various aspects of sustainability fields. All experts had 5 or more years of experience (mean = 2.32, SD = 1.07) as full-time professionals in fields, mostly with PhD degree (76.5%), and in senior (76.5%) and associate professors (8.8%) positions.

Table 1 show the panellist consensus on the importance of 18 potential environmental indicators ranked within median scores ranged of 4 to 5, inter-quartile range (IQR) of  $\leq 1$ , and standard deviation  $\leq 1$  on 5-point response scale. Overall, consensus was reached on 12 (66.7%) out of 18 indicators, but 6(33.3%) did not achieve consensus. These include Population growth: Enw10 (IQR = 2.0 > 1.0), Biodiversity: Enw11 (Median = 3.5 > 1.0), Climate change: Enw12 (IQR = 2.0 > 1.0), Sanitation and Hygiene: Enw 14(IQR = 2.0 > 1.0), Landuse: Enw16 (IQR = 2.0 > 1.0), and City growth/sprawl: Enw17 (IQR = 1.3 > 1.0). The Kendall's coefficient of concordance W was calculated to evaluate the level of consensus among expert individual rankings of importance in the round. The result reveals a significant but not enough satisfactory value (Kendall's  $W = 0.262$ ,  $p < 0.001$ ). Suggesting a weak agreement ( $W < 0.3$ ) and low confidence across the expert's ratings of the indicators importance. The panellists suggested combining and rephrasing of six indicators into three indicators; green area and natural environment, waste management for waste generation and disposal, and land use and city growth/sprawl. The experts also suggested one new indicator - Natural Disaster (Environmental well-being).

Table 1 Rating result of the importance for the Delphi first and second round

Indicators	Median	Minimum	Maximum	Interquartile Range	Std. Deviation
<b>1st Delphi Round</b>					
Enw1 Physical/built environment	4.0	2.0	5.0	1.0	0.85
Enw2 Air pollution	5.0	2.0	5.0	1.0	0.59
Enw3 Water pollution	5.0	2.0	5.0	1.0	0.70
Enw4 Noise pollution	4.0	2.0	5.0	1.0	0.77
Enw5 Waste generation/disposal	5.0	2.0	5.0	1.0	0.61
Enw6 Housing/Home environment	4.0	3.0	5.0	1.0	0.65
Enw7 Green areas	4.0	3.0	5.0	1.0	0.65
Enw8 Transport	5.0	3.0	5.0	1.0	0.56
Enw9 Urban design	4.0	3.0	5.0	1.0	0.69
Enw10 Population growth	4.0	2.0	5.0	2.0	0.69
Enw11 Biodiversity	3.5	3.0	5.0	1.0	0.80
Enw12 Climate change	4.0	3.0	5.0	2.0	0.84
Enw13 Water quality and accessibility	5.0	2.0	5.0	1.0	0.66
Enw14 Sanitation and Hygiene	5.0	2.0	5.0	2.0	0.65
Enw15 Waste management	5.0	3.0	5.0	1.0	0.61
Enw16 Landuse	4.0	3.0	5.0	2.0	0.79
Enw17 City growth/sprawl	4.0	2.0	5.0	1.3	0.78
Enw18 Natural environment	5.0	3.0	5.0	1.0	0.74
Number (n)			34		
Kendall's Coefficient of Concordance (W)			0.262		
Level of Significance			0.000		

Similarly, in round two (Table 2), that 12 (75%) potential indicators had gain consensus and retained, while 4(25%) could not reach consensus among the expert panel, thus there were removed. The indicators removed include urban design (Enw7), population growth (Enw8), biodiversity (Enw9), and climate change (EW10). Kendall's coefficient of concordance W for the group agreement reveals a high value ( $W = 0.522$ ,  $p < 0.001$ ). A  $W > 0.5$  indicates a good consensus on the responses in the rounds (Cohen, 1975). Also, Spearman's rank correlation coefficient computed to assess the stability of expert ratings between rounds shows a strong positive correlation at 0.01 level of significant ( $Rho = 0.964$ ,  $p < 0.001$ ), indicating a high degree of stability in the experts' opinion in the study. Therefore, the study identifies 12 indicators which encompassed aspect of environmental well-being assessment associated with sustainable development in urban environment. The findings are comparable to those obtained in other studies (34–33), and provided a clear understanding of the different opinions of experts from diverse disciplines of the importance of environmental well-being indicators in measuring and monitoring urban sustainable development. Accordingly the indicators derived from the consent among the expert panel in this study

are of particular importance in measuring environmental well-being for urban sustainability.

Table 2 Rating result of the importance for the Delphi first and second round

Indicators	Median	Minimum	Maximum	Interquartile Range	Std. Deviation
<b>2nd Delphi Round</b>					
Enw1 Physical/built environment	<b>4.0</b>	3.0	5.0	<b>0.0</b>	<b>0.54</b>
Enw2 Air pollution	<b>5.0</b>	4.0	5.0	<b>0.0</b>	<b>0.37</b>
Enw3 Water pollution	<b>5.0</b>	3.0	5.0	<b>1.0</b>	<b>0.53</b>
Enw4 Noise pollution	<b>4.0</b>	2.0	5.0	<b>1.0</b>	<b>0.80</b>
Enw5 Housing/Home environment	<b>4.0</b>	3.0	5.0	<b>1.0</b>	<b>0.60</b>
Enw6 Transport	<b>4.0</b>	3.0	5.0	<b>1.0</b>	<b>0.66</b>
Enw7 Urban design	3.0	3.0	5.0	<b>1.0</b>	<b>0.68</b>
Enw8 Population growth	3.0	3.0	5.0	<b>1.0</b>	<b>0.56</b>
Enw9 Biodiversity	3.0	2.0	4.0	<b>1.0</b>	<b>0.54</b>
Enw10 Climate change	3.0	2.0	5.0	<b>1.0</b>	<b>0.68</b>
Enw11 Water quality and accessibility	<b>5.0</b>	3.0	5.0	<b>1.0</b>	<b>0.53</b>
Enw12 Sanitation and Hygiene	<b>5.0</b>	4.0	5.0	<b>1.0</b>	<b>0.46</b>
Enw13 Waste management	<b>5.0</b>	4.0	5.0	<b>1.0</b>	<b>0.49</b>
Enw14 Landuse/City growth/sprawl	<b>4.0</b>	2.0	<b>5.0</b>	<b>1.0</b>	<b>0.78</b>
Enw15 Green/Natural environment	<b>5.0</b>	4.0	5.0	<b>1.0</b>	<b>0.51</b>
Enw16 Natural disaster*	<b>4.0</b>	2.0	5.0	<b>0.0</b>	<b>0.68</b>
Number (n)			31		
Kendall's Coefficient of Concordance (W)			0.522		
Level of Significance			0.000		

#### 4. Conclusion

Through a two-round Delphi survey procedure, a set of indices was established that represent a consensus-based environmental well-being indicators for urban sustainability in Malaysia. The panellists brought extensive experience and verse knowledge to the study. The indicators identified are mostly used in the literature and internationally. The study also provides evidence on the local accepted of these indicators for environmental well-being assessment in an urban area in Malaysia. These set of indicators appears sufficiently well defined may help to form the basis for a framework development to assess environmental impact of sustainability on well-being. The most important indicator identified by the expert panel was the air pollution. The other 11 indicators in order of the importance attributed, were sanitation and hygiene, waste generation and management, water pollution, water quality and accessibility, noise pollution, transport, housing/home environment, physical environment, and natural disaster respectively. The twelve environmentally important measures were prioritized by the participants as relevant indicators of environmental well-being. Although, the indicators derived from consensus techniques have face validity, but their metric properties must be tested to ensure their effectiveness for identifying environmental well-being in different settings.

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