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Urban sustainability assessment framework development: The ranking and weighting of Iraqi indicators using analytic hierarchy process (AHP)

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Abstract

The consideration of local contexts in urban sustainability assessment is important for developing countries because of the varying stakeholder needs and priorities. Using Iraq as a case study, a stakeholder-driven structured methodology is presented which identifies and ranks context-relevant indicators and assigns weights for aggregating indicator scores by applying analytic hierarchy process (AHP). Results indicate that the identified factors and their weights and priorities for Iraq were markedly different from the widely-used tools — suggesting that global tools are not directly applicable in developing countries. In contrast with the 'ecological' focus in the global assessment frameworks, economic and infrastructural aspects of urban development are of greater importance in developing countries. Decades of political instability and the resulting deterioration of infrastructures in Iraq are manifested in the related indicators being rated highly important by the stakeholders, and their corresponding high weighting in the developed Iraqi urban sustainability assessment framework (IUSAF). 'Water', 'safety', and 'transportation and infrastructure' indicators were awarded high weighting scores of 8.5%, 7.9% and 7.8%, in the IUSAF, respectively. IUSAF is envisaged to play a key role in the promotion of built environment sustainability in Iraq by stimulating market demand for sustainable buildings, cities and conurbations.

Keywords: *Urban sustainability assessment; sustainable development; urban development indicators; ranking and weighting; analytic hierarchy process (AHP); Iraq; IUSAF*

1 Introduction

Cities are responsible for 70% of global CO_2 emissions (UN-Habitat 2016), resulting from the use of resources such as fuels, minerals and metals, as well as food, soil, water, air, biomass and ecosystems (European Environment Agency 2015). The development and use of urban sustainability assessment frameworks (USAFs) are considered essential to tackle the severe depletion of natural resources, and increased energy use and associated greenhouse gas emissions from cities and conurbations. They are an effective means to assess, benchmark and communicate urban sustainability performance while encouraging active involvement and engagement of a broad spectrum of stakeholders. Because of their formalised nature, urban sustainability assessment tools have the potential to contribute to evidence–based decision–making (Turcu 2013). Consequently, the global adoption and use of USAFs have expanded rapidly (Yang et al. 2016). They have become a yardstick for sustainable urban development, considering primarily the need to achieve a long-term balance between environmental and socio-economic factors. USAFs also provide the opportunity to decrease undesirable impacts on the built environment and its inhabitants, and to improve the quality of life and economic competitiveness of the urban area (Ameen and Mourshed 2016; Munda 2016).

USAFs share their evolutionary roots with building sustainability assessment methods, the development of which started a few decades ago to stimulate market demand for sustainable buildings. Resource efficiency (i.e. the lifecycle uses of materials and energy) and enhanced environmental performance were typically prioritised over other dimensions (Lee and Burnett 2006; Bragança et al. 2010) – as evidenced by the high weightings[1] of the environmental factors in the building sustainability assessment schemes. The environmental legacy of building sustainability assessment tools is evident in the existing urban sustainability assessment methods, which are found to be biased more towards the environmental than the social and economic dimensions of sustainability (Ameen et al. 2015). However, the priorities of urban challenges vary between cities, regions and countries, especially in developing countries (Cohen 2006) where socio-economic and cultural factors may feature highly in stakeholders' agenda. The lack of consideration of the disparity in priorities may reduce the effectiveness of well-known assessment methods in promoting urban sustainability in different regions around the world (Haapio 2012).

[1] For example, BREEAM (BRE Environmental Assessment Method) was developed in the 1990s. Its indicators and weighting were revised over the past decades. The weighting for indicators related to the use of resources under the categories: "energy", "water" and "materials" accounted for 37.5% of the total in 2008 version (BRE 2010), which increased to 38% of the total in 2018 (draft) version (BRE 2018).

Most urban sustainability assessment methods are designed by first determining a list of urban factors, which are then translated into a weighting–based decision tool (Ali and Al Nsairat 2009). Evidence suggests that the urban indicators and weighting systems in well-known methods such BREEAM Community[2], LEED–ND[3], and CASBEE–UD[4] have originally been designed for their country/region of origin (Ameen et al., 2015). Despite their adoption in both developed and developing countries such as Malaysia, China, and Saudi Arabia, their international applicability and the universality of the selection of their urban indicators have been questioned.

Therefore, the adoption of sustainability assessment strategies in developing countries should be preceded by the determination of local urban challenges as these are different to those of developed countries. The issue is especially important for high-density cities facing changing urban challenges both at present and the future. These include air pollution, water availability and quality, the lack of security systems, the depletion of natural resources, the scarcity of renewable energy, the lack of waste recycling, housing deficits, poor infrastructure services, transportation and economic growth deficiencies (Barbosa et al. 2012; Ameen and Mourshed 2016). The scale of the challenges has prompted some researchers to label them unpredictable and uncontrollable (Freire 2006; Rana 2010).

Developing countries that underwent periods of political instability face further challenges. As an example, Iraqi cities have suffered deterioration and destruction due to successive wars and political instability for more than four decades — causing extensive damage to the environment, public services and infrastructure. Major problems include insufficient water supply systems for significant sections of the population; water pollution, a severe lack of sanitation systems; accumulated waste, diseases, the spread of dangerous materials and emissions into the air, soil, groundwater and vegetation (HRW 2013; MOE 2013). Since the political regime change in 2003 (CSO 2013), the new phase of economic prosperity has resulted in an increase in the construction of new, and the rebuilding, regeneration and rehabilitation of existing cities to improve the quality of life and meet the growing demand for housing and infrastructure. There is, therefore, an urgent need to develop an effective and locally–relevant urban sustainability assessment framework.

This paper presents the final stage of the research on the development of the Iraqi Urban Sustainability Assessment Framework (IUSAF), aimed at the ranking of the identified local urban sustainability indicators and translating them into an appropriate weighting system

[2] BREEAM Community: BRE Environmental Assessment Method.
[3] LEED–ND: Leadership in Energy and Environmental Design — Neighborhood Development.
[4] CASBEE–UD: Comprehensive Assessment System for Built Environment Efficiency for Urban Development.

using analytic hierarchy process (AHP), a structured technique for organising and analysing a complex set of decision criteria.

The rest of the paper is structured as follows. The next section contextualises the reported research with the rest of the larger work on the development of the IUSAF, and discusses the methods adopted in the study. Outcomes of AHP analysis and how they are translated to the proposed IUSAF are presented next in Section 3. The section deliberates on the allocation of weights and credits, the process of identifying mandatory factors, and the development of rating and certification systems. Section 4 discusses the relevance of the IUSAF weighting system, as well as the urban indicators in the Iraqi context. Concluding remarks and the significance of the work is presented at the end of the paper.

2 Methodology

A consensus-based approach is best suited for developing a rating-based assessment framework (Chew and Das 2008), especially where multiple dimensions need to be considered (Wong and Abe 2014) — as it is the case for urban sustainability assessment. A reliable weighting system based on the experts' consensus on the priority of factors is typically utilised to aggregate scores against multiple dimensions into one quantity (Chang et al. 2007). Analytic hierarchy process (AHP), a structured method for organising and analysing complex decision criteria (Saaty 1990) is considered the most appropriate technique to achieve a weighting system for prioritising relevant factors in an assessment framework (Ding 2008). AHP has been employed in many areas, such as healthcare, innovation management, education and the built environment (Ali and Al Nsairat 2009). The effectiveness of AHP in developing an appropriate weighting system for sustainability assessment has been demonstrated by Ying et al. (2007); Wong and Li (2008); Zheng et al. (2009); and Kamaruzzaman et al. (2016). Considering the reported effectiveness of the method, this study employs AHP to identify contextually appropriate weightings of the identified IUSAF urban factors.

2.1 Research process flow

The research reported in this study is part of a larger work on the development of an urban sustainability assessment framework for the Iraqi context. It involves different theoretical and empirical investigations in four key stages, as shown in Figure 1. Stages 1–3 have already been published in various outlets. Only stage four is presented in this article to avoid repetition. The overall research process and how the previous stages contribute to this paper are discussed as follows.

- **Stage one — State–of–the–art review**: Related published literature and technical documentation of existing sustainability assessment frameworks, tools and methods were reviewed to identify similar works, define the research problem and determine the scope of the study from a developing context. Also, six widely–used urban sustainability assessment tools[5] were reviewed in detail to identify, compare and contrast the aim, structure, assessment methodology, scoring, weighting and suitability for application in different geographical contexts. Their similarities and differences, as well as the convergence and divergence in consideration of urban design dimensions were critically analysed. As suggested by Cole (2005), the review enabled the identification and consolidation of urban sustainability indicators relevant to the developing context — to act as a starting point for the Iraqi urban sustainability assessment framework. The results are well documented in Ameen et al. (2014, 2015).

- **Stage two — Stakeholders' perception of local urban challenges**: The identified urban development challenges from the state–of–the–art review were utilised to conduct a nationwide questionnaire to investigate stakeholders' perception of local environmental, social and economic urban challenges in Iraqi cities. Public participation through the questionnaire enabled the elicitation of their priorities of local urban challenges. Questionnaire results are discussed in Ameen and Mourshed (2016, 2017).
- **Stage three — Consultation with experts**: A consultation involving a panel of experts is crucial to filtering the factors identified through the state–of–the–art review and the stakeholder consultation on their local relevance. A panel of experts was assembled representing key stakeholder groups such as academia, government, and the private sector. Delphi technique was used to build consensus on the importance of the identified urban factors among the experts. The effectiveness of the Delphi technique in building consensus, especially in the field of urban sustainability is well documented (Chew and Das 2008).
- **Stage four — Identify appropriate weightings**: The final step in the development of an assessment framework is to identify the appropriate weightings of the urban indicators based on local relevance and priorities. AHP is used to organise and prioritise the indicators in a structured way to develop the IUSAF weighting system. The ranking and weighting of Iraqi urban sustainability factors using AHP are presented in this study.

<Insert Figure 1 about here>

[5] The reviewed tools are: Comprehensive Assessment System for Built Environment (CASBEE), Leadership in Energy and Environmental Design for Neighbourhood Development (LEED-ND), Estiadma Pearl Community Rating System (PCRS), BRE Environmental Assessment Method for Communities (BREEAM Communities), Sustainable Building Tool in Portugal for Urban Projects (SBTool^{PT}–UP), and Global/Qatar Sustainability Assessment System (GSAS/QSAS).

2.2 The selection of the expert panel

The IUSAF expert panel comprised professionals and informed experts, who had local and international experience in sustainable urban development. The composition of the panel was guided by the following factors: specialisation/expertise, government and industry leadership, decision-making responsibilities, experience in the field of construction and built environment, and sufficient knowledge about sustainable urban development. An initial list of experts was drawn from the previous consultation stages; i.e. the questionnaire and Delphi. Prominent urban development experts were then consulted to obtain feedback on the relevance and distribution of the experts and to solicit names of experts that might have been missed. The updated list was then assessed by the authors for relevance (local and topic specific) and distribution of expertise, educational background, experience (years in practice) and stakeholder roles. The final list of experts and their affiliated organisation, country, educational background and discipline are listed in Table 1, which demonstrates the representative nature of the expert panel.

<Insert Table 1 about here>

2.3 The IUSAF hierarchy model

AHP is typically used to solve complex problems and turn them into manageable elements presented in hierarchical levels; e.g. goal, indicators and sub–indicators (Saaty 1990). The first level of the IUSAF hierarchy model is the goal, as shown in Figure 2. The goal represents the central issue; i.e. the scope, and subsumes indicators, which in turn incorporate respective sub–indicators. The hierarchical AHP structure allows the identification and capture of interrelationships among the IUSAF components.

<Insert Figure 2 about here>

2.4 Pairwise comparisons

The pair-wise comparison (PC) method is the main AHP stage, through which a hierarchy model is built on the consensus results obtained from the Delphi method (Tavana et al. 1996; Luzon and El-Sayegh 2016). PCs are essentially a mathematical structure (matrices), built upon by the paired comparison of each factor (indicator/ sub–indicator) over another (Saaty 1994). Saaty's nine-point scale was used in this study to identify the importance or intensity of the experts' judgments, as given in Table 2. The size of the comparison matrix varied depending on the number of urban factors. Table 3 shows the largest combined pairwise comparison matrix (reciprocal matrix $= 18 \times 18$). Pair-wise comparisons were carried out for all IUSAF urban factors and were later sent to the selected experts via email; i.e. sixteen experts out of the twenty who answered the comparisons.

<Insert Table 2 about here>

<Insert Table 3 about here>

2.5 Analysis

To extract reliable weightings of the urban factors, it is necessary to measure the reliability and validity of the decisions that have been taken. In AHP, the overall consistency of judgment is measured by a consistency ratio (CR) that determines the degree of inconsistency in the experts' judgments. Saaty (1990) suggests that $CR > 0.1$ is unacceptable, requiring the pair–wise comparison matrix to be reconstructed. To implement the analytical phase of AHP, Microsoft Excel™ was used because of its compatibility with the requirements of the AHP analysis (Kabak et al. 2016; Vaidya and Mayer 2016). Expert judgements can be made according to the importance of factors and their priority in the hierarchical structure, despite the possibility of re–evaluation of the factors, either with or without changing the proposed judgements (Saaty 1990). The operational process of AHP is illustrated in Figure 3. In this study, three responses were unacceptable, due to their CR exceeding 0.1. The thirteen remaining answers were within accepted limits and have been used to determine ratings.

<Insert Figure 3 about here>

3 The proposed IUSAF assessment framework

Despite the shared aim of environmental sustainability, each of the existing assessment methods for urban sustainability has its own strategy for categorising urban factors. In the IUSAF, urban factors were identified systematically through an extensive literature review, a national questionnaire and the Delphi consultation in stages 1–3, as discussed in the methodology. The development of a coherent and comprehensive framework can be complex. However, emerging difficulties have been ameliorated in consultation with experts. Figure 4 illustrates the IUSAF indicators and sub-indicators. The weighting has been assigned to each factor, indicator and sub-indicator. Microsoft Excel™ has been used to analyse the input data — thus simplifying the implementation of the AHP process, as shown in Table 4. Aggregating the factors into the IUSAF entailed the following steps, discussed in detail in the subsections that follow.

1. Identify an appropriate structure for indicators and sub-indicators, under which the factors are aggregated;
2. Weighting allocation;
3. Credit allocation;
4. Mandatory factors;
5. Rating formulae; and

6. Certificates.

<Insert Figure 4 about here>

<Insert Table 4 about here>

3.1 Weighting allocation

The results of the pair-wise comparisons revealed reliable judgments as evidenced by a consistency ratio (CR) of less than 0.1. CR is calculated using Equation 1.

$$CR = \frac{CI}{RCI} \tag{1}$$

where RCI is random consistency index and CI is consistency index, computed using Equation 2.

$$CI = (\lambda_{\max} - n)/(n - 1) \tag{2}$$

where $\lambda_{\max}$ is the principal eigenvalue and n is the number of compared elements.

Consistency ratio, CR is 0.047, for which this study is considered valid (Saaty 1994; Triantaphyllou and Mann 1995; Salmeron and Herrero 2005). The synthesis of the pair-wise comparisons in Figure 5 reveals the weights of the urban indicators, arranged in descending order to illustrate their priority. The indicator 'water' is the top priority with 8.5% of the total weighting, followed by 'safety' with 7.9%. Weightings of other key factors are: 7.80% for 'transportation and infrastructure', 7.60% for 'local economy', 7.00% for 'jobs and business', and 6.3% for 'housing'. The lowest weighting is for 'well–being' (3.00%), just after 'urban space' (3.70%).

Experts considered water to be the top priority, which is consistent with concerns about severe water shortages in most Middle Eastern countries. Two of the existing urban sustainability assessment tools, PCRS and GSAS — developed in the UAE and Qatar respectively, also consider water to be a top priority. However, the IUSAF framework is unique because of its focus on several urban indicators such as safety, transportation and infrastructure, economic factors and housing, which are considered critical for Iraqi cities (CSO 2013).

<Insert Figure 5 about here>

3.2 Credit allocation

The next step in AHP is to determine the weighting of the sub-indicators under each indicator, based on the pair-wise comparisons, as illustrated in Table 5. Given that the Delphi consultation via the expert panel reached consensus on urban factors according to their relative importance, the IUSAF needs to develop ways to distinguish between these factors. Factors that exceeded 70% or had a mean score of 3.5 out of 5 are considered appropriate (Okoli and Pawlowski, 2004) for assessing the sustainability of urban development in Iraqi cities. To differentiate between various urban factors, the IUSAF allocated three levels of credit. Factors rated above 3.5, 4.0 and 4.5 out of 5 are awarded one, two and three credits, respectively. The allocation strategy is expected to encourage the prioritisation of higher rated urban factors in urban projects. A total of 150 available credits in the IUSAF have been distributed among all factors, as described in Table 5.

<Insert Table 5 about here>

3.3 Mandatory factors

The IUSAF adopts a 'mandatory and optional urban factors' approach to achieve a flexible system for implementation. Mandatory factors (MFs) are the most important local urban factors that achieved higher mean scores of 4.5 or more in the Delphi consultation. They ensure that urban development projects reach a minimum level of sustainability throughout the planning stages. Table 6 shows how mandatory factors are embedded in the final rating — implying that to achieve even the minimum rating, all of the mandatory factors labelled as 'required' in Table 5 must be accomplished. The IUSAF rating system has ten mandatory factors of performance. A development proposal cannot achieve an IUSAF certificate and rating without addressing all of these.

<Insert Table 6 about here>

3.4 Rating formulas

As shown in Table 6, the IUSAF provides a single final score, combining the scores of its constituent parts — to reflect the level of sustainability of urban development projects. The aggregated score is calculated in two steps, as follows.

Step 1: The rating of each sub-indicator is calculated using Equation 3. The IUSAF framework has eighteen indicators resulting in eighteen different rating scores.

$$RSSI = \frac{CA}{AC} \times W \tag{3}$$

where $RSSI$ is the rating score of the sub-indicator, CA is credits achieved, AC is available credits and W is weighting of the sub-indicator given in Table 5.

Step 2: The overall rating, R is obtained from Equation (4). R provides the summation of the eighteen rating scores, considering the maximum available credits of 150.

$$R = \sum_{n=1}^{n=18} RSSI_n \tag{4}$$

3.5 Certification

Since the emergence of BREEAM, the first environmental sustainability assessment method, assessment results are converted into a single ranking expression or rating (Ameen et al. 2015). Despite significant differences in factor weightings, other global assessment methods such as CASBEE, LEED, SBTool^{PT}–UP and PCRS — all have followed the same strategy of converting overall scores to a rating for certification purposes (Ameen et al. 2014; Kamaruzzaman et al. 2016). Benchmarked rating levels simplify the communication of sustainability performance and enable stakeholders to compare the performance of urban projects in a standardised manner.

The IUSAF adopts an approach similar to BREEAM Community and PCRS by using a percentage-based scale. It includes seven different levels of certification, as shown in Table 6. The first level fulfils the mandatory factors that reflect the main challenges in the Iraqi context, and are deemed fundamental. At the second level, the project is considered ‘unclassified’ if the total score is below 30%. Also, the project is not awarded any star. At the third level, with a score between 30% and 44%, the project is awarded one star and considered ‘classified’. At the fourth level, the project is awarded a two-star rating and considered ‘good’ if the overall score is between 45% and 59%. At the fifth level, with a score between 60% and 74%, the project is considered ‘very good’ and awarded a three-star rating. At the sixth level, the project is awarded a four-star rating and considered ‘excellent’ if the overall score is between 75% and 84%. Finally, a rating of five-star is awarded to the project if the score is above 85%, which is considered ‘outstanding’. This final level is aimed at innovative urban solutions that meet the criteria of the majority of the urban factors.

4 Discussion

The scope of IUSAF and the indicators differ from the existing urban sustainability assessment frameworks, primarily because of the differences in the context; i.e. *developing* vs. *developed*. Additionally, the decades of political instability in Iraq have resulted in unique challenges for Iraq which have contributed to the final composition of the list of indicators. Also, the IUSAF diverged from other assessment frameworks regarding urban assessment indicator weights and credit allocation. It is, therefore, pertinent to discuss the relevance of the IUSAF weighting system, as well as the urban indicators in the Iraqi context.

4.1 Variations in urban factors and weightings

Weightings of the urban indicators are significantly different in the IUSAF, compared with other global tools such as BREEAM Community, LEED-ND, and CASBEE-UD. Despite their intended global use, they have primarily been designed for use in developed countries with different urban challenges to the developing context. Developed countries are more conscious and concerned about environmental issues and energy/resource efficiency (Ameen et al. 2015; Komeily and Srinivasan 2015), while developing countries seek to emphasise challenges associated with growing population and urbanisation; e.g. the availability and quality of water, and the lack of infrastructure and housing. However, there are common elements among all global assessment frameworks; e.g. energy efficiency, quality of the environment, resource management, site strategies, transportation, and the quality of services. To illustrate how these frameworks vary from one another, weightings of the IUSAF's urban indicators are compared with BREEAM Community, LEED-ND, PCRS and GSAS, as shown in Figure 6.

IUSAF weightings range between 3% and 8.5% with an average of 5.6%. Compared with the relatively narrower distribution of IUSAF weightings, the other tools are heavily skewed towards one or two indicators — suggesting that developing countries face challenges in almost all dimensions of sustainability, not just a few. BREEAM Community, for instance, rates 'ecology' and 'transportation' highly, at approximately 20% of the total for each (BRE 2013). 'Energy' and 'governance' are joint third, at 9.5%. In LEED-ND, 'ecology' does not have a high weighting (4% only) but 'transportation' is considered a highly significant indicator, at 22%. LEED-ND also focuses on 'land use', 'governance', and 'energy' in its assessment, awarding them high weightings of 14%, 12%, and 11.5%, respectively (USGBC 2011). As for the PCRS and GSAS, both tools compliments IUSAF in considering 'water' as an extremely important indicator, because of the scarcity of drinking water and the shortage of water resources in the Middle East. GSAS and PCRS also rank 'energy' as a highly important indicator, at 20% and 17% respectively (ADUPC 2010; Horr 2013). Each assessment method thus prioritises and ranks urban factors differently — according to the local urban challenges of its country of origin. The contextual divergence in priorities and weightings of global frameworks highlights the importance of developing local assessment frameworks such as IUSAF, preferably starting from the identification of locally–relevant urban factors through extensive stakeholder consultations. At the very least, the localisation of the weightings needs to be conducted if global tools must be used.

<Insert Figure 6 about here>

4.2 Important factors for the Iraqi context

The IUSAF is unique due to its predominant focus on contextual urban indicators, such as safety, transportation and infrastructure, economic factors and housing, as well as on other urban development issues, which are considered vital and fundamental to the current circumstances in Iraq. The highly significant IUSAF indicators relevant to the Iraqi context are discussed below.

4.2.1 Water

Water is awarded a high weighting of 8.5% in the IUSAF, which represents one of the main environmental challenges — the decrease in Iraq's access and share of water from its rivers. Statistics provided by the CSO (2015) reveals that Iraq's per capita share of water decreased by 35.2% in just two years, between 2012 and 2014. Water in the Tigris and the Euphrates is projected to decrease by between 50 and 80% by 2025 (CSO 2013). The degradation in water quality do to the high levels of contamination exacerbates the situation. Moreover, the amount of water available per capita in Iraq by the middle of this century is projected to be half of that currently available, driven by population growth, climate change and pollution (Michel et al. 2012). The supply of drinking water in Iraqi cities is also projected to decrease, potentially causing a humanitarian crisis (UNESCO 2010). Hence, water recycling and the promotion of the use of available alternative sources of water is viewed as major priorities by the experts. Interestingly, some global tools such as BREEAM Community and LEED-ND considered the 'water' indicator to be less important than other categories such as 'ecology', 'transport' and 'energy'.

4.2.2 Safety

Most other assessment tools did not pay much attention to safety factors. This is demonstrated by the low weighting accorded to the safety indicator by BREEAM Community (0%) and LEED-ND (1.9%). Similarly, the two Gulf tools, PCRS and GSAS respectively ascribed a 0.7% and 0.65% weighting for safety — a reflection of how countrywide stability is perceived. Iraq has seen a deterioration in security and an increase in political violence especially after the political regime change in 2003, specifically in the north-west region (Rathmell et al. 2006). Terrorist acts have become one of the key urban challenges for many Iraqi regions. Therefore, it is necessary to consider security factors and the reduction of terrorism to mitigate the threat and reduce damage to individual buildings and urban areas. It is also important to ensure that the required level of protection is provided without compromising the capacity to create aesthetic and functional urban spaces (UN 2007). Hence, the safety and security of urban places and has been given a high weighting score of 7.9% of the IUSAF.

4.2.3 Transportation and infrastructure

Transportation is one of the key indicators that drew the attention of many assessment methods, including the IUSAF. The lack of long-term transportation planning is a major challenge for Iraq, which is exacerbated further by ongoing political instability (El-Geneidy et al. 2013). Nowadays, regardless of the destruction and deterioration of infrastructure and public services and the urgent need to provide an efficient infrastructure, there is a significant lack of alternative transportation modes such as rail, subway/tramway, shipping and air. Emphasis on alternative transport modes is essential to increase mobility and accessibility. Moreover, innovative transport networks and efficient infrastructure can have a positive impact on the environment. Practising sustainable transport can enable an in-depth understanding of, and the identification of bottlenecks in the system, and thus assisting in developing strategies that help to inform and improve the decision-making process in implementing transportation solutions. Emphasis is needed on the increase in diversity in transportation modes and promotion of the use of public transport (UNEP 2015). This indicator has been awarded 7.8% weighting by the IUSAF.

4.2.4 Local economy

More than four decades of political instability had a severe impact on Iraq's economy and its productivity and competitiveness. Reviving the economy is, therefore, essential to help restore its damaged and neglected infrastructure and expand its core services, while developing other sectors such as housing, health, education and industry (UNEP 2015). Economic factors such as promoting the local economy and providing jobs and businesses were also considered important alongside other economic factors related to tourism and investment oriented urban development (Steck 1999). Hence, the IUSAF has allocated 7.6% of the total weighting for the 'local economy' indicator in addition to 7% for 'jobs and business'.

4.2.5 Housing

As shown in Figure 6, the various assessment tools did not draw much attention to the 'housing' indicator, as evidenced by low weightings of 2.7% in BREEAM Community, 2.9% in LEED-ND, 1.6% in PCRS, and 0% in GSAS. In contrast, the IUSAF awarded the 'housing' indicator a weighting of 6.3%. Access to a safe, secure, habitable, and affordable home is a fundamental right, which most developing countries are still aspiring to provide. Hence, 'housing' represents one of the important socio-economic urban challenges for most developing countries, including Iraq. The housing shortage in Iraq has been perpetuated by the country's inability to produce new homes in sufficient quantities to cover the needs of an increasing population. Official estimates suggest that about two million housing units were required in Iraqi cities by 2016 (MOCH 2010). As a consequence, overcrowding has emerged as a social problem in Iraq, especially in low-income neighbourhoods. 13% of Iraqi households have more than ten occupants living together in one residential unit (UNDP 2015).

5 Conclusion

This study presented a unique contribution to the development of urban sustainability assessment frameworks by highlighting the need to consider local relevance of sustainability dimensions and constituent factors. Key contributions include the identification of context-relevant urban indicators and sub-indicators, methods for ranking their importance based on local priorities, and the development of a robust weighting system that aggregates scores against constituent dimensions into one rating. The methodology for ranking and the development of the weighting system is based on the engagement with key stakeholders and decision–makers, which was aimed at building consensus while eliciting their views and perceived priorities.

In addition to developing a consensus–based sustainability assessment framework, this research draws on several conclusions that will impact the process of sustainability assessment. First, the main findings of the study strongly suggest that global assessment methods weighting systems are inappropriate in the Iraqi urban context. The global tools are not as transferable to the local and developing contexts as the literature may suggest. Ideally, sustainability assessment should be grounded in the local contexts, and framework development should start from the identification of locally-relevant urban indicators before embarking on generating the hierarchy of indicators and assigning weights against them. At the very least, if resources are not available and global tools have to be used, the ranking and weighting of indicators must be localised in consultation with informed experts. Second, in contrast with the developed context, social, economic and cultural dimensions of sustainability have greater importance in the developing context. Participants of this research highlighted the need for responding to socio-cultural aspects rather than an absolute focus on conventional approaches to reducing undesirable ecological impact and energy use. Economic aspects of urban development and regeneration are particularly important for countries with a troubled past, and the ones that are rapidly developing. Finally, this study provides substantial evidence of significant differences regarding the types of urban indicators and a high disparity in weightings between the IUSAF and a number of well-known assessment tools. In contrast with global assessment tools, water and safety are the two most important urban sustainability indicators in the IUSAF reflecting the unique urban challenges in Iraq.

The developed framework, IUSAF is envisaged to play a key role in the promotion of built environment sustainability in Iraq by stimulating market demand for sustainable buildings, cities and conurbations. The framework comprises 18 indicators and 69 sub-indicators, identified through extensive nationwide stakeholder consultation and refined through three successive rounds of Delphi exercise. The weighting system developed in this research reflects and prioritises the urban challenges faced by a country that underwent several decades of political instability. Hence, the IUSAF can assist in identifying and creating local, sustainable urban policy objectives and support decision making for existing cities as well as new urban projects. Implementation of the IUSAF requires buy-in from relevant stakeholders, especially from the local government and departments responsible for planning and development. With the assistance of the Engineering Consultancy Bureau, Karbala Governorate and the Ministry of Housing, avenues of IUSAF implementation are currently being investigated.

Although the framework is more relevant to Iraq because of its unique context regarding decades of political instability; lack of infrastructure and local resources; and urban challenges, priorities, practices and institutions, the findings and methods of this research are transferable to other contexts — developing and developed alike.

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Figures

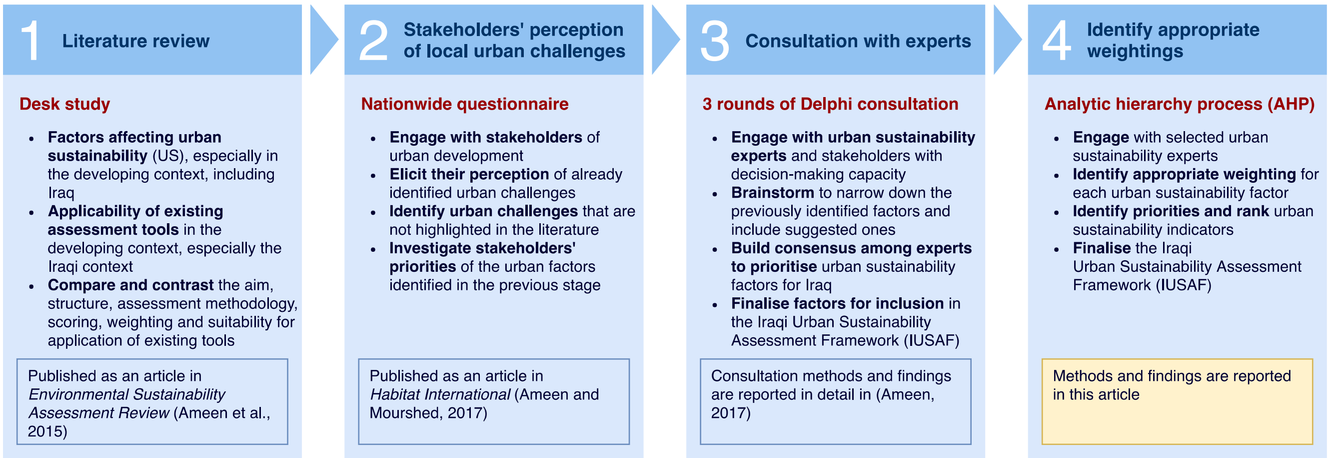

Figure 1: Stages of development of the Iraqi Urban Sustainability Assessment Framework (IUSAF).

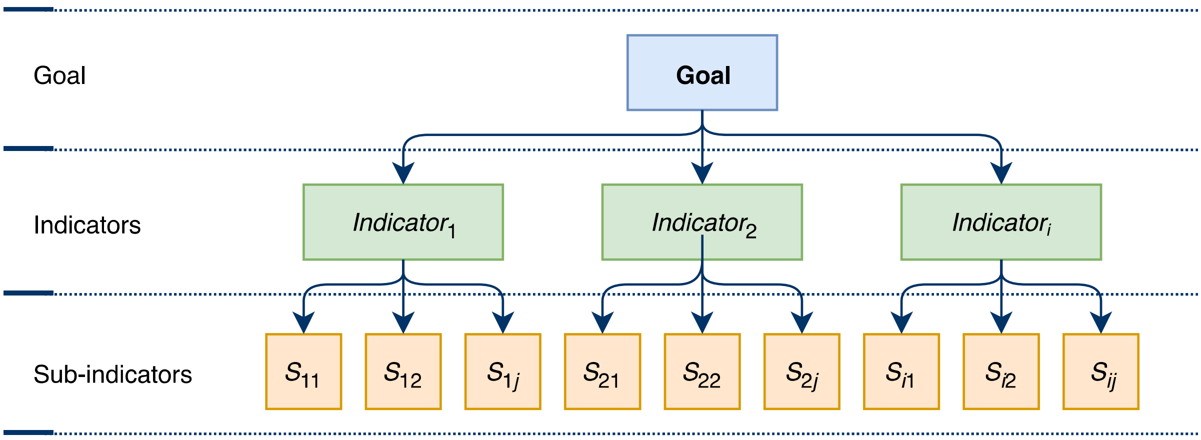

Figure 2: The proposed IUSAF hierarchy structure. The goal comprises several indicators $(I_i, i = 1, \ldots, m)$ and each indicator in turn comprises several sub-indicators $(S_{ij}, i = 1, \ldots, m; j = 1, \ldots, n)$.

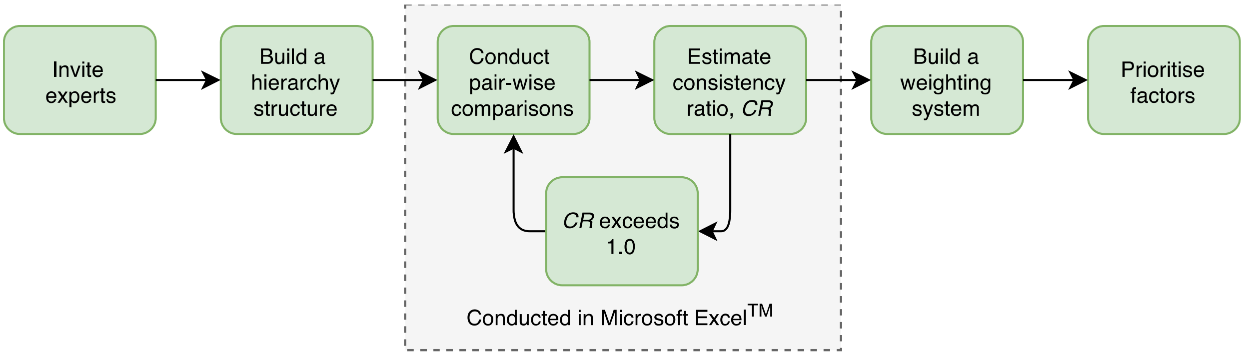

Figure 3: The AHP operational process (after Saaty, 2008).

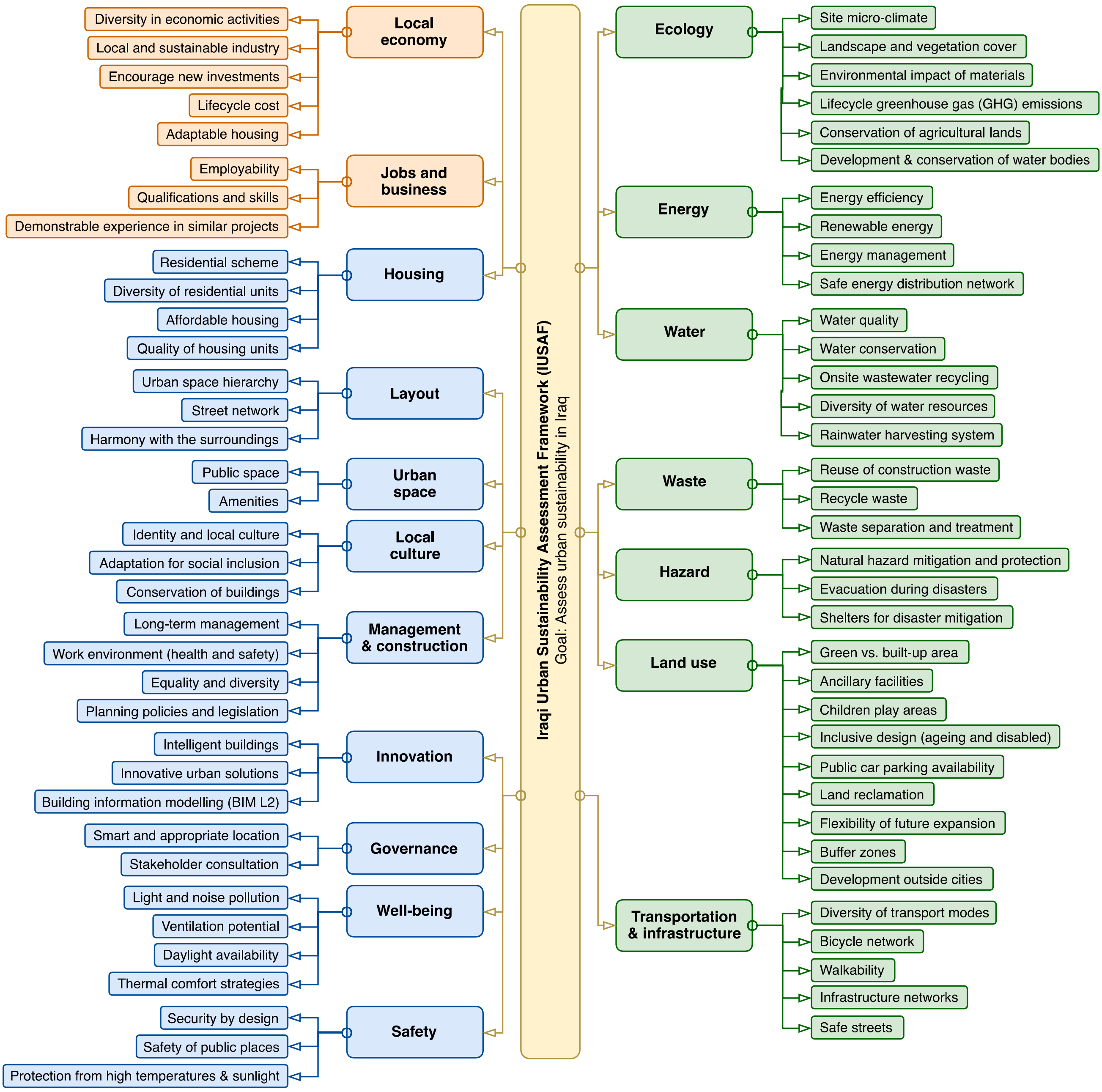

Figure 4: IUSAF hierarchy structure.

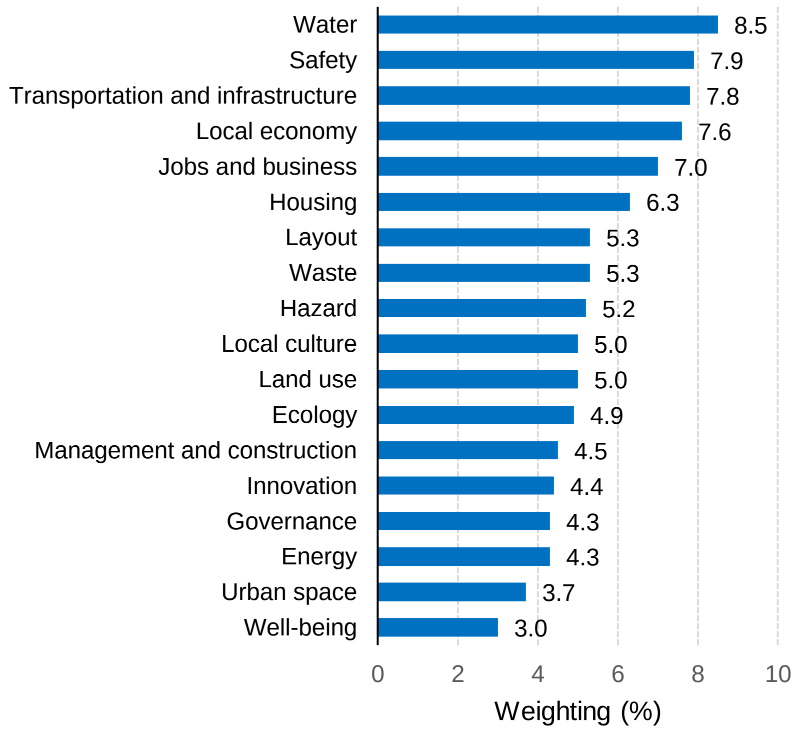

Figure 5: The priorities of assessment indicators that derived from pair-wise comparison.

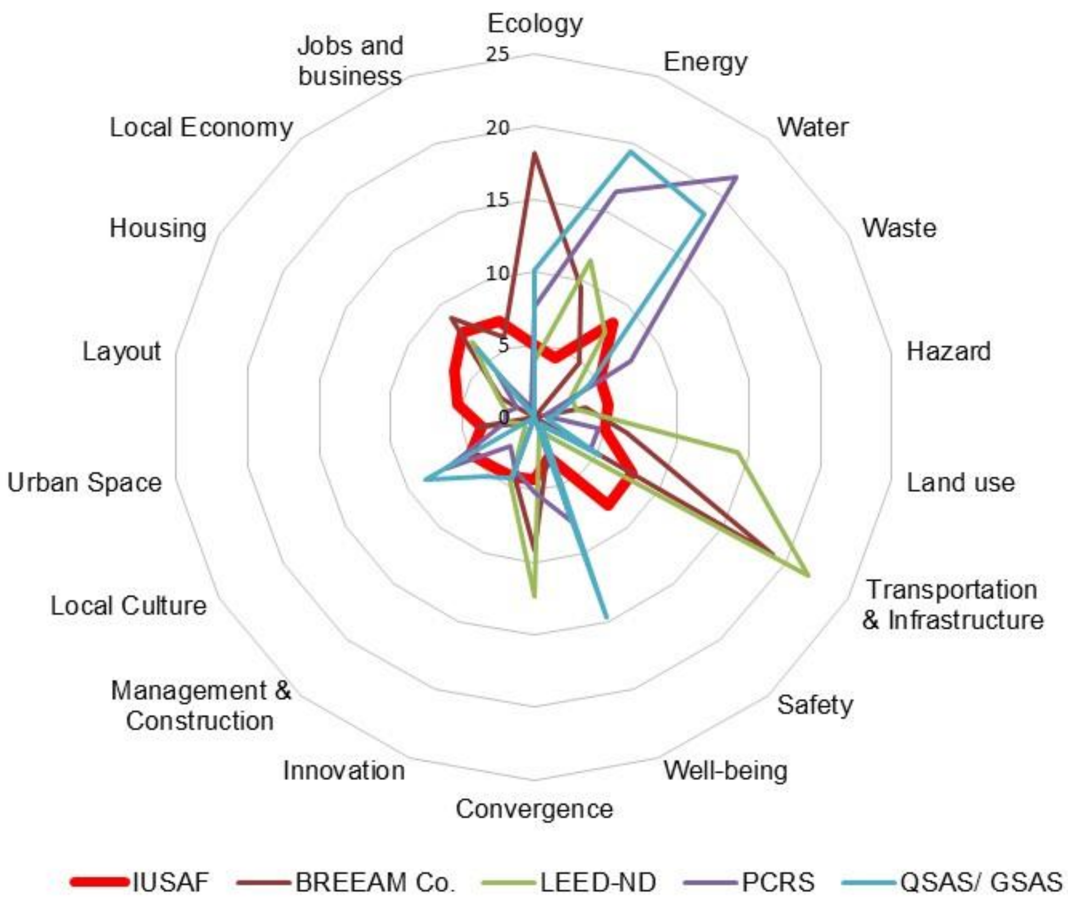

Figure 6: The comparison of the weightings of indicators among urban sustainability assessment frameworks. Weightings in the IUSAF is more widely distributed than the rest suggesting that compared with developed countries where infrastructure and governance is more established, the developing countries face urban development challenges in almost all dimensions of sustainability.

Tables

Table 1: The background of the panel of expert

Group	Distribution (%)	Organization	Country	Discipline[2]					
				ARC	ENG	CON	HLT	UDP	UTI
Academia	**34%** (42% PhD, 33% MSc, 25% BSc)	Liverpool John Moores University	UK		●	●			
		University of Al-Kufa	Iraq	●	●			●	
		University of Al-Mustansiriyah	Iraq		●	●			
		University of Arkansas	USA	●		●			
		University of Babylon	Iraq	●	●			●	●
		University of Baghdad	Iraq	●	●	●		●	
		University of Bassrah	Iraq		●	●			●
		University of Karbala	Iraq	●	●	●	●	●	●
		University of Kentucky	USA		●	●			
		University of Nahrain	Iraq	●				●	
		University of Technology	Iraq	●	●	●		●	●
		VHS for Education & Training	Germany		●	●		●	
Government, professional institutions, and non-governmental organisations	**42%** (19% PhD, 34% MSc, 47% BSc)	Directorate of Urban Planning	Iraq		●			●	●
		Institution of Urban and Regional Planning	Iraq	●				●	
		Imam Hussain Organization	Iraq				●	●	
		Iraqi Engineers Union	Iraq		●	●			
		Ministry of Environment	Iraq				●	●	●
		Ministry of Health	Iraq				●		
		Ministry of Housing	Iraq	●		●		●	
		Ministry of Municipality and Public Services	Iraq		●	●		●	●
		UNESCO[1]	Switzerland				●	●	
Industry	**24%**	Al-Emara Engineering and Contracting	Iraq	●		●			
		Al Abadaly Engineering Consultancy	Iraq			●			
		Alharam for Engineering Constructions	Iraq	●	●	●		●	●
		Aljadwa Construction	Iraq	●	●	●			

	(4% PhD, 12% MSc, 84% BSc)	Almerqal Construction Company	Iraq		●	●			
		Engineering Consulting Bureau – U. of Karbala	Iraq	●	●		●	●	●
		Llewelyn Davies - Architects, Planners, Designers	**UK**	●				●	
		Mahadin Engineering Consulting	Iraq	●		●	●	●	
		Nahr Al Salsabeel Construction	Iraq		●	●			
		Parsons Corporation	**USA**		●	●			●
		Shnashel Consultants	Iraq	●	●			●	
		Tariq Al Yusr Construction	Iraq	●	●				
		The Tenth Team for Architecture	Iraq	●		●			●
		Xylem[3]	Sweden			●			●

Notes:

[1] United Nations Educational, Scientific and Cultural Organization
[2] Disciplines. ARC: Architecture, ENG: Engineering, CON: Construction, HLT: Health, UDP: Urban development and planning, UTI: Utilities and infrastructure.
3 Water technology provider to transport, treat, test and efficiently use water in public utility, residential, commercial, agricultural and industrial settings.

Table 2: Relative importance scale (1–9) of AHP (Saaty, 1994).

Scale	Degree of importance	Reciprocal (decimal)
1	Equally important	1 (1.000)
2	Equally to moderately important	1/2 (0.500)
3	Moderately important	1/3 (0.333)
4	Moderately to strongly important	1/4 (0.250)
5	Strongly important	1/5 (0.200)
6	Strongly to very strongly important	1/6 (0.167)
7	Very strongly important	1/7 (0.143)
8	Very strongly to extremely important	1/8 (0.125)
9	Extremely important	1/9 (0.111)

Table 3: An example of pair-wise comparison between ecology and the remaining indicators.

Indicator	Weighting score[1]																	Indicator
	← More importance than								Equal	Less importance than →								
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Energy
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Water
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Waste
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Hazard
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Land use
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Transportation & Infrastructure
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Safety
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Well-being
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Governance
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Innovation
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Management & construction
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Local culture
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Urban space
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Layout
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Housing
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Local economy
Ecology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	Jobs & businesses

Note:
[1] Weighting scores are: 1 = equal, 2 = equal to moderate, 3 = moderate, 4 = moderate to strong, 5 = Strong, 6 = strong to very strong, 7 = Very strong, 8 = very strong to extreme, and 9 = Extreme.

Table 4: An example pair-wise comparison matrix generated using Microsoft Excel™.

Indicator	Abbr.	Indicator																	
		EC	EN	WT	WS	HZ	LU	TI	SA	WB	GO	IN	MC	LC	US	LO	HO	LE	JB
Ecology	EC	1	4	4	7	2	3	2	4	7	3	4	2	3	7	3	3	1	1
Energy	EN	0.250	1	0.333	0.333	0.500	0.250	0.200	0.200	0.500	0.500	0.200	0.250	0.167	0.500	0.200	0.200	0.143	0.143
Water	WT	0.250	3	1	6	3	1	1	1	6	3	1	3	1	6	3	3	1	1
Waste	WS	0.143	3	0.167	1	1	1	1	1	3	3	1	2	1	3	1	1	0.330	0.500
Hazard	HZ	0.500	2	0.333	1.000	1	0.333	0.333	1	2	1	0.333	0.250	0.250	2	0.250	0.250	0.170	0.170
Land use	LU	0.333	4	1.000	1.000	3	1	1.000	1.000	4	1.000	0.500	0.500	0.333	2	1.000	1.000	0.330	0.330
Transportation & Infrastructure	TI	0.500	5	1.000	1.000	3	1	1	1	4	1	1	1	1	3	1	1	1	1
Safety	SA	0.250	5	1.000	1.000	1.000	1	1.000	1	1.000	1.000	4	4	1.000	4	4	4	7	7
Well-being	WB	0.143	2	0.167	0.333	0.500	0.250	0.250	1	1	1.000	0.200	0.200	0.143	1.000	0.140	0.140	0.140	0.140
Governance	GO	0.333	2	0.333	0.333	1.000	1	1.000	1	1	1	0.333	1	0.500	3	1	1	0.500	0.500
Innovation	IN	0.250	5	1.000	1.000	3	2	1.000	0.250	5	3	1	3	0.333	1	1.000	0.500	0.500	0.500
Management & construction	MC	0.500	4	0.333	0.500	4	2	1.000	0.250	5	1.000	0.330	1	0.333	3	1	1	1	1
Local culture	LC	0.333	6	1.000	1.000	4	3	1.000	1	7	2	3	3	1	4	4	4	1	1
Urban space	US	0.143	2	0.167	0.333	0.500	0.500	0.333	0.250	1	0.333	1.000	0.333	0.250	1	0.330	0.330	0.200	0.200
Layout	LO	0.333	5	0.333	1.000	4	1	1.000	0.250	7	1	1	1	0.250	3	1	1.000	1.000	1.000
Housing	HO	0.333	5	0.333	1.000	4	1	1.000	0.250	7	1.000	2	1.000	0.250	3	1	1	0.330	0.330
Local economy	LE	1.000	7	1.000	3	6	3	1.000	0.143	7	2	2	1.000	1.000	5	1	3	1	1.000
Jobs & business	JB	1.000	7	1.000	2	6	3	1.000	0.143	7	2	2	1.000	1.000	5	1	3	1	1

Table 5: Allocated credits and the weightings of IUSAF urban indicators and sub-indicators.

Indicator	Sub-indicator	Weight (%)	Mean (-)	Maximum credit (-)	Credit (%)
Ecology		**4.9**		**14**	
	Landscape and vegetation cover	Required			
	Conservation of agricultural lands	Required			
	Site micro-climate	0.4	4.20	2	0.2
	Landscape and vegetation cover	0.8	4.50	3	0.266
	Environmental impact of materials	0.6	4.20	2	0.3
	Lifecycle greenhouse gas (GHG) emissions	0.6	4.35	2	0.3
	Conservation of agricultural lands	1.2	4.62	3	0.4
	Development and conservation of water bodies	1.3	4.43	2	0.65
Energy		**4.3**		**8**	
	Energy efficiency	0.9	4.30	2	0.45
	Renewable energy	1.6	4.22	2	0.8
	Energy management	0.9	4.25	2	0.45
	Safe energy distribution network	0.9	4.35	2	0.45
Water		**8.5**		**11**	
	Water quality	Required			
	Water quality	1.5	4.63	3	0.5
	Water conservation	1.6	4.33	2	0.8
	Onsite wastewater recycling	1.7	4.08	2	0.85
	Diversity of water resources	2.1	4.18	2	1.05
	Rainwater harvesting system	1.6	4.11	2	0.8
Waste		**5.3**		**6**	
	Recycle waste	Required			
	Reuse of construction waste	1	3.70	1	1
	Recycle waste	2.1	4.53	3	0.7
	Waste separation and treatment	2.2	4.43	2	1.1
Hazard		**5.2**		**4**	
	Natural hazard mitigation and protection	1.7	3.83	1	1.7
	Evacuation during disasters	2	4.13	2	1
	Shelters for disaster mitigation	1.5	3.89	1	0.75
Land use		**5**		**19**	
	Green vs. built–up area	Required			
	Green vs. built–up area	0.3	4.53	3	0.1
	Ancillary facilities	0.3	4.28	2	0.15
	Children play areas	0.6	4.45	2	0.2
	Inclusive design (ageing and disabled)	0.6	4.20	2	0.3
	Public car parking availability	0.8	4.45	2	0.4
	Land reclamation	0.6	4.33	2	0.3
	Flexibility of future expansion	0.6	4.25	2	0.3
	Buffer zones	0.5	4.19	2	0.25
	Development outside cities	0.7	4.49	2	0.35
Transportation and infrastructure		**7.8**		**12**	
	Diversity of transport modes	Required			
	Infrastructure networks	Required			
	Safe streets	Required			
	Diversity of transport modes	1.8	4.68	3	0.6
	Bicycle network	1	3.83	1	1

	Walkability	1.1	4.15	2	0.55
	Infrastructure networks	2.1	4.65	3	0.7
	Safe streets	1.8	4.54	3	0.6
Safety		**7.9**		**6**	
	Security by design	2.5	4.30	2	1.25
	Safety of public places	2.6	4.33	2	1.3
	Protection from high temperatures and sunlight	2.8	4.24	2	1.4
Well-being		**3**		**8**	
	Light and noise pollution	0.7	4.08	2	0.35
	Ventilation potential	1	4.22	2	0.5
	Daylight availability	0.6	4.18	2	0.3
	Thermal comfort strategies	0.7	4.18	2	0.35
Governance		**4.3**		**4**	
	Smart and appropriate location	1.7	4.10	2	0.85
	Stakeholder consultation	2.6	4.40	2	1.3
Innovation		**4.4**		**6**	
	Intelligent buildings	1	4.22	2	0.5
	Innovative urban solutions	1.5	4.15	2	0.75
	Building information modelling (BIM L2)	1.9	4.32	2	0.95
Management and construction		**4.5**		**8**	
	Long–term management	1	4.43	2	0.5
	Work environment (Health and safety)	1	4.28	2	0.5
	Equality and diversity	1	3.65	1	0.5
	Planning policies and legislations	1.5	4.49	3	0.5
Local culture		**5**		**6**	
	Identity and local culture	2	4.00	2	1
	Adaptation for social inclusion	1.4	4.10	2	0.7
	Conservation of buildings	1.6	4.46	2	0.8
Urban space		**3.7**		**4**	
	Public space	1.6	4.03	2	0.8
	Amenities	2.1	4.45	2	1.05
Layout		**5.3**		**6**	
	Urban space hierarchy	1.5	4.00	2	0.75
	Street network	1.6	4.30	2	0.8
	Harmony with the surroundings	2.2	4.08	2	1.1
Housing		**6.3**		**9**	
	Affordable housing	Required			
	Residential scheme	1.1	4.28	2	0.55
	Diversity of residential units	1.2	4.38	2	0.6
	Affordable housing	2.1	4.55	3	0.7
	Quality of housing units	1.9	4.38	2	0.95
Local economy		**7.6**		**10**	
	Diversity in economic activities	1.3	4.08	2	0.65
	Local and sustainable industry	1.8	4.33	2	0.9
	Encourage new investments	2.1	4.38	2	1.05
	Lifecycle cost	1.1	4.25	2	0.55
	Adaptable housing	1.3	4.11	2	0.65
Jobs and business		**7**		**9**	
	Demonstrable experience in similar projects	Required			
	Employability	1.9	4.40	2	0.95
	Qualification and skills	2.1	4.33	2	1.05

	Demonstrable experience in similar projects	3	4.57	3	1
Total		**100%**		**150**	

Table 6: The IUSAF ratings and requirements.

Requirement	IUSAF rating achieved	Description
All mandatory factors (MF)		Accepted for rating
MF + < 30 % score	-	Unclassified
MF + ≥ 30 % score	☆	Classified
MF + ≥ 45 % score	☆☆	Good
MF + ≥ 60 % score	☆☆☆	Very good
MF + ≥ 75 % score	☆☆☆☆	Excellent
MF + ≥ 85 % score	☆☆☆☆☆	Outstanding