Developing a measurement scale for sustainable high-rise building in city of Erbil

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ABSTRACT
The aim of this article is to develop a sustainable measurement scale that covers various aspects of socio-cultural, economic, and environmental activities in high-rise building constructions that are localized for Erbil city. To achieve this goal, the key methods that we used were to review the relevant literature to find the value and the global-scale rating system, which then formed the basis of the measurement and was tailored to make it more specific for high-rise projects. Discussions with relevant experts through semi-structured interviews for the localized and specialists in the measurement scale were also made. In addition to the interactions with known experts, the need for personal observation became clear. A total of five high-rise buildings were examined to understand the current scenario and preferences. Consequently, this article proposes a measurement scale for sustainable high-rise buildings (MSSHRB-E), which was specifically designed for new and existing buildings in Erbil city. This scale has nine environmental indicators, 14 socio-culture indicators, and four economic indicators, in addition to innovation issues. This research contributes to sustainable initiative methods by enhancing energy efficiency, quality of living, and cost to the users of high-rise buildings.

1. Introduction
By 2030, five billion people are expected to live in urban areas worldwide. Although 30% of the world’s population was urban in 1950, the share of urban dwellers in 2000 rose to 47% and is expected to grow to 60% by 2030 (Bloom and Khanna 2007; Bocquier 2005; United Nations 2002; Kotzeva and Brandmüller 2016; UN D 2014). Energy and power shortages, global warming, urban growth, air pollution, garbage overflows, water scarcity, diseases, and regional conflicts will be a legacy of the twenty-first century unless we push rapidly towards sustainability (Kalcheva, Taki, and Hadi 2016; Gospodini, Brebbia, and Tiezzi 2008; Ali 2008).

Burnett (2005) reports that the quality of high-rise office buildings and residential properties, and of manufacturing and total income in economic circumstances, depends on the quality of the workplace, which impacts on the health and comfort of the residents (Kohl 2019; McIntyre 2006; Largo-Wright et al. 2011; Bhui et al. 2016). Nevertheless, the majority of large buildings that are constructed nowadays are built with very little regards for sustainable growth and other strategies.

While the term “sustainability” is often written in books and literature, several pieces of it are still lacking and must be investigated (Burnett 2005; Akadiri, 2012). There are several different ways of describing sustainability in the literature and sources but the initial principles and meaning are the same as that of providing a pleasant life from the environmental point of view, friendly to nature, cost-effective and egalitarian across all pillars that are of great importance for climate, society, and economy (Al-Kodmany 2018a; Newman 2001; Sassi 2006; Jin et al. 2013). Sustainability in buildings can also be described as a form of technology. Sustainable buildings should provide a safe living atmosphere for the inhabitants, thereby ensuring and enhancing the ecological, well-organised social and economic situations (Ortiz, Castells, and Sonnemann 2009; Akadiri, Chinyio, and Olomolaie, 2012; Ortiz, Pasqualino, and Castells 2010). Therefore, it is evident that sustainability may identify and describe some important objectives.

Although buildings started to be constructed in ancient times, high-rise buildings have only relatively recently become a focus of interest and curiosity. Between 1930 and 2001, on average, only four projects a year were built above 282–200 m. Since that time, 679 buildings above this height have been built, with an average of 52 projects per year between 2002 and 2015 (Al-Kodmany, 2018; Chun and Cho 2016).

The difference in the average number of high-rise buildings completed over time has also been mirrored in Erbil City, which has emerged as a centre for new high-rise buildings for both administrative and residential use, as has the Kurdistan region as a whole and Iraq in general.
Although the basic reasons for the construction of high-rise buildings vary, the following considerations contribute more directly to the construction of buildings above 12 floors in Erbil city:

- Limited availability of land and cost.
- Demand.
- Power, status, and prestige.
- The use of the high-rise building in a large project as an attractive structure.
- Earn money.

The design guidelines, strategies, and concepts to build high-rise buildings for Erbil city, its ministries, and municipalities – as well as to survive and provide proper living conditions in the area, and for the satisfaction of human, financial, cultural, or environmental needs – have not yet been fixed. In addition, there are no measurement tools to assess and evaluate the construction scenario and these buildings are also being built to monitor or at least calculate the efficiency of the huge towers in Erbil city.

This paper seeks to establish measurement tools to provide an improved quality of life for all sustainable social, economic, and environmental aspects of high-rise buildings in Erbil. Although this research focuses on the city of Erbil, it should also apply to other cities that face the same condition. Therefore, the main research question is as follows: What criteria should be included in the measurement scale in economic, social and environmental aspects that could make Erbil’s high-rise buildings more sustainable?

To achieve this goal, we have used several methods. Our key methods are a literature review and textbook assessment. We have also discussed with experts in the related field via semi-structured interviews to explore the views, experiences, beliefs and/or motivations of individuals in the field of architecture, planners, and engineers on sustainable aspects of Erbil for high-rise buildings and to identify the criteria to achieve a localized measurement scale (Figure 1). In addition to interviews, personal observations are used to get inside views of selected high-rise buildings.

As a first step towards the creation of measures in addition to a literature review, the five global assessment frameworks for building-schemes – namely the BREEAM, LEED, CASBEE, HK-BEAM, and Green Star certificate – are used to establish a measurement (SHRBM-E) to create sustainable buildings in the city of Erbil. This measurement aims to provide guidelines for sustainable high-rise buildings for residential, commercial, and mixed uses.

The second step is to review high-rise buildings and their willingness to resolve weaknesses in the current measuring rating system. Consequently, the proposed model is based on the environmental, socio-cultural, and economic dimensions of sustainability.

Country status and interview expert, position and model specialization are used in Phase 3 to design and build the measurement scale to provide a set of indicators to measure the sustainability of high-rise buildings in compliance with the certification guidelines chosen as an objective of this study.

The key concerns of environmental sustainability, economic sustainability, and social sustainability have been applied to the current sustainable building concerns. This whole idea might raise concerns about the workability of these ideas. The answer to the question of whether these concepts can work well and be applied in real terms to high-rise buildings is significant for sustainable development. Several scholars have raised serious concerns here. For example, Ken Yeang (2008), a pioneer in sustainable high construction growth, stated that large buildings require enormous amounts of materials and complex structural concepts to design in such a way that they can withstand greater wind forces at higher heights. They also need more resources for constructing, running, and sustaining the building. Many of these problems are due to the vertical orientation nature of high-rise buildings.

Even though many existing buildings, including tall buildings, have been assessed and labelled as sustainable projects worldwide, some of our respondents lacked an understanding of some criteria for the assessment (Sassi 2006). In addition, high-rise buildings cannot be a successful project without being responsible for urban society (Zeiler 2017).

2. Literature review

2.1. Sustainability and sustainable building

There are major development patterns of sustainable architecture in high-rises and urban design in high-rise building districts. Only when the built environment around us is sustainable does sustainable architecture make sense (Gissen 2003; Öner and Pasin 2015). Furthermore, tall buildings are no longer perceived as isolationist structures.

To achieve a sustainable building, a number of scholars have proposed the following aspects for consideration: energy efficiency and functional flexibility, with a focus on a range of tasks that integrate living, working, retail, and leisure spaces into a single structure. There should also be a strong link between a high-rise building and its utilities, infrastructure, transport systems, distribution of water and waste, energy use, and its effect on the physical resources and infrastructure of the city (Kalcheva, Taki, and Hadi 2016; Ali and Armstrong 2010).
2.1.1. Socio-cultural dimension

In modern society, people live more inside buildings than outdoors. Many of their daily activities take place indoors such as working and relaxing (Yiu 2005; Burnett 2005). In particular, it has been estimated that people spend more than 90% of their time indoors and more than 70% of it at home (Sev 2009; Adgate et al. 2002). David Fisk, Imperial College London said that, “You cannot have a sustainable city without social cohesion” (Ijeh 2015). Architecture plays an important role in providing wellness, physiological comfort, physiological happiness, and efficiency.

Some scholars have pointed out that high-rise buildings are becoming a significant factor in the creation of a social partnership, proper treatment of specifics of outdoor interior designs, and high-rise building elements would provide a friendly living environment (Huang 2006; Gang 2016). Therefore, a well-planned high-rise building outdoor space can become a successful activity node, facilitating informal interaction between residents (Sassi 2006). Moreover, rooftops can be built to attract a variety of people of different ages, who can easily join and explore the same area of social communication.

Generally speaking, socio-cultural sustainable growth is consistent with traditional cultural and social values, and the maintenance of culture and linguistic identity (Keitumetse 2009; Saunders et al. 2020). Family and group life is another element of social sustainability in high-rise environments because the autonomy that empowers a child is missing (Story and Saul 2015). In large building projects, the presence or absence of recreational and social spaces affects housing overall satisfaction substantially more than that of low-rise environments (Prezza et al. 2001).

Poor design in low-rise or high-rise buildings also leads to less satisfaction for the residents. In poorly designed high-rise environments, frustration may be greater because of the vertical emphasis reflected by a stronger sense of confinement and distance from social street life (Prezza et al. 2001; Goodman, Buxton, and Moloney 2016).

2.1.2. Economic dimensions

The principle of sustainable construction should be applied to encourage optimum productivity and to reduce financial costs (Zavadskas, Saparauskas, and Antucheviciene 2018; Yu et al. 2018). The economic
activity of the building should be taken into account during the construction process and throughout its useful lifespan, especially regarding its maintenance and preservation. The lifecycle cost of the building consists of the initial cost, the cost of usage and the cost of recovery (Akadiri, Chinyio, and Olomolaiye 2012; Emmitt and Yeomans 2008). High-rise buildings have several factors that make them more expensive than low-rise buildings. In addition, they need expensive mechanical, electric and plumbing systems to cool rooms during a hot summer and to heat indoors in a cold winter. They also require massive amounts of energy to pump water to the upper floors. Furthermore, lifts not only incur substantial construction costs but they also occupy substantial usable space. The lift shafts also need specific construction techniques to ensure their proper vertical alignment. These buildings also require large teams of engineers who should be trained in the field of mechanical or electrical systems, information technology networking, software, and programming languages (Initiative 2010; Baiz 2012). Additional accessible spaces are often filled with vertical circulation structures, such as stairs and escalators.

### 2.1.3. Environmental dimensions

There is a growing consensus among many organisations that effective approaches and actions are needed to improve the sustainability of building activities (Raquez and Lambin 2006; Akadiri, Chinyio, and Olomolaiye 2012; Halliday 2008). Due to its size, the building is one of the biggest users of energy, water, and material resources and an enormous polluter of air. Practitioners in the building industry have already started to track and rectify environmental damage as a result of their activities. Architects, designers, engineers, and others involved in the construction process have a unique responsibility to introduce sustainability goals during the design stage of the construction project, which can help to substantially reduce the environmental impact.

Urbanisation can also destroy natural ventilation by blocking buildings from surrounding natural areas. Because of their higher altitude and large masses, large constructions influence the natural patterns of wind through the increasing wind shade gap and the reduction of airflow behind buildings. Therefore, saturation and air pollution concentration can decrease in contaminated urban environments (Aristodemou et al. 2018; Al-Kodmany, 2018).

Geological considerations are another component of environmental values. The geological structure of a location has several effects. In the field of energy and carbon emissions, high-rise construction and operating require a great deal of energy and produces significant amounts of carbon emission and air pollution, which contribute to global temperature. The construction of tall buildings and the rising issue of waste management is yet another issue. In addition, the construction of large buildings takes a great deal of energy. For example, heavy machinery can produce substantial carbon dioxide emissions, such as high-volume cranes and pumps (e.g. pouring water and concrete onto the top floors) and dump trucks (Felkner, Schwartz, and Chatzi 2019).

### 2.2. Sustainability measurement and rating system

“Sustainability measurement” is a quantitative term that describes the indicators used for informed sustainability management. The metrics used to calculate sustainability (which includes both individuals and various combinations; environmental, social, and economic sustainability) continue to evolve. This involves and is implemented in a broad variety of spatial and temporal scales, metrics, benchmarks, evaluations, indexes, and accounting, including appraisal, valuation and other reporting structures (Hak et al., 2007; Bell and Morse 2008).

Of the hundreds of sustainable assessment tools and systems that are available worldwide, 29 relevant systems are more suitable than others as assessment systems in high-rise projects (Khanh 2019). An intensive analysis with a complex criteria system has been performed and the top five systems are as follows: Leadership in Energy and Environmental Design (LEED), US and international; Building Research Establishment’s Environmental Assessment Method (BREEM), UK and international; HK-BEAM; Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), Japan; and Green Star, Australia.

### Table 1. All five systems according to assessment categories.

| Global Measurement tools | Health and wellbeing (IAQ) | Energy | Transport | Materials | Water efficiency | Waste | Land use and ecology (Site Aspects) | Pollution | Innovation | Regional priority | Quality of services |
|--------------------------|-----------------------------|--------|-----------|-----------|------------------|-------|-----------------------------------|-----------|-------------|------------------|---------------------|
| BREAM                    | ✓                           | ✓      | ✓         | ✓         | ✓                | ✓     | ✓                                | ✓         | ✓           | ✓                | ✓                   |
| LEED                     | -                           | ✓      | ✓         | ✓         | ✓                | ✓     | ✓                                | ✓         | ✓           | ✓                | ✓                   |
| CASBEE                   | ✓                           | ✓      | ✓         | ✓         | ✓                | ✓     | ✓                                | ✓         | ✓           | ✓                | ✓                   |
| Green Star               | ✓                           | ✓      | ✓         | ✓         | ✓                | ✓     | ✓                                | ✓         | ✓           | ✓                | ✓                   |
| HK-BEAM’s                | -                           | ✓      | ✓         | ✓         | ✓                | ✓     | ✓                                | ✓         | ✓           | ✓                | ✓                   |
According to our comparative analysis, all have a different number of categories, assessments, and weightings see (Table 1 and Table 2)

The present forms of monitoring the rating system have a range of shortcomings, which are summarised in three main points: (i) concentration and classification for high-rise buildings: the issues of high-rise buildings are largely overlooked and have not yet been addressed for their particular specialty; (ii) specialisation on sustainability issues: they are all centered on environmental issues, while social and economic aspects are ignored (at the basic level required, all facets of the economy and socio-culture are or are not overlooked); (iii) localization: there are no certain rating systems localized and specialized especially for Erbil city. The main explanation is that current rating systems cannot be implemented in various countries and the environment is not the criterion for the assessment itself. Current rating systems can be implemented anywhere in the world and any type of building; however, it will not give precise results because of different priorities of local conditions and type of buildings. So according to priorities of a specific type of building and local conditions, the rating system should be specialised and localised with special and localised credits and weights. That is why high-rise buildings and the city of Erbil’s concerns will be evaluated.

### Table 2. Weightings of assessment categories.

| Global Measure tools | BREAM | LEED | CASBEE | Green Star | HK-BEAM's |
|----------------------|-------|------|---------|------------|-----------|
| Management          | 12%   | -    | Complex weighting applied at every level | 10%        | -         |
| Health and wellbeing (IAQ) | 15%   | 35%  |         | 20%        | 20%       |
| Energy              | 19%   | 15%  |         | 25%        | 35%       |
| Transport           | 8%    | -    |         | 10%        | -         |
| Materials           | 12.5% | 10%  |         | 12%        | 8%        |
| Water efficiency    | 6%    | -    |         | 10%        | -         |
| Waste               | 7.5%  | 26%  |         | 8%         | 25%       |
| Land use and ecology (Site Aspects) | 10% | -    |         | 5%         | -         |
| Pollution           | -     | -    |         | -          | -         |
| Innovation          | -     | -    |         | -          | -         |
| Regional priority   | (+10) | (+6) |         | -          | -         |
| Quality of services | -     | -    |         | -          | -         |

2.3. Concerns of high-rise building

To fill the gap between concentration and specialisation for high-rise buildings, there is a concern of high-rise buildings. The high-rise building design possesses some characteristics and features that make them distinctive and impressive compared to other buildings. While the optimistic approach to high living standards was successful, it is related to a range of issues (Yuen 2011; Larcombe et al. 2019). Moreover, it is important to detect the issues that contribute to encouraging cultural, social, and environmentally sustainable practices that can improve high-rise living conditions.

The following points summarise a series of concerns related to high-rise living:

1. Safety:
   - Incidences of fire and safety: Over the years, fire protection has gained tremendous attention from high-rise buildings. Moreover, pieces of glass and metal on high buildings could rain down on the ground during a fire (Ahrens 2016).
   - Accidental high-rise falls: height falls represent one of the leading hazards, and height falls pose a great danger to builders and staff.
   - Building workers: The construction of tall buildings, particularly super high ones, can lead to the death and injury of construction workers when proper protective measures are not in place.

2. Vertical transport: All high-rise buildings have elevators, and their users are primarily concerned with elevator failure and travel times.

3. Crimes: Lift and hallway crimes, such as rape and robbery: crime can be a problem in high-rise buildings and many have become hubs for crime and distress (VanSoomeren et al. 2014; Townsley et al. 2013).

4. Scale and size:
   - Height of the building: Some people feel a high sense of fear when they are on a certain level of height because the visual system can provide data that clashes with those in the somatosensory and vestibular systems if the distance of the eye-object is greater than 20 m in a stationary location. If a person perceives the risk of falling, then they feel a risk (Yuen 2011; Salassa and Zapala 2009).
   - Understanding the human scale is important when designing the built environment to provide users with comfort. Likewise, high-rises also break down the urban scale by squandering nearby buildings, people, and public spaces.

5. Children:
   - Child behaviour and performance problem: Twice as many behavioural issues have been identified for children living in high-rises (compared to non-high-rise buildings), such as temper tanning and bed weeping (VanSoomeren et al. 2014; Gifford 2007).
   - The development and growth of children.
   - The lack of adequate children’s playgrounds.
(6) Social and community:

- Family life and society: If people lack access to outdoor areas or other social areas, then they are forced to spend more time indoors, which can become overcrowded and feel like prisons in the sky (Prezza et al. 2001; Goodman, Buxton, and Moloney 2016).
- Customised, introverted systems can make people feel like they live in vertical silos (Al-Kodmany, 2018). Nevertheless, the criticism was more focused on large buildings that cover the rich and the poor.
- Modification of social relationship: Weak social relations between users and others from outsiders (Gifford 2007; Auclair and Hertzog 2015).
- Neighbours: In high-rise buildings, the influence of neighbours is much higher than in low-rise buildings. Therefore, it is very important to apprehend this problem.

(7) Semiotics:

- Signs and symbols: Large buildings, both for the iconic function of the symbolic sense and for the public, have an important role to play in the design of the city. Tall buildings are synonymous with the negative sense of the human ego for many people (Roaf, Crichton, and Nicol 2009), the selfish, stubborn ego, which dwarfs its neighbours and most of the street level activities (Balint and Andras 2013).
- Placelessness and a civic domain. Low-level brick, wood, and stone neighbourhoods can feel more human than polished high-level steel and glass communities (Freedman 2014).

(8) Ecological considerations:

- Bird collision: Bird collisions with windows and glass are an unfortunate side effect of high construction around the world. Millions of birds are killed each year by glass collisions, which is the second-largest danger to birds after the loss of habitat in some cities with tall buildings (Loss et al. 2014; Machtans, Wedeles, and Bayne 2013).
- Wind load: The wind is a large force impacting tall or large buildings. Under heavy wind, many of these structures can experience a tremendous aerodynamic force (Mendis, 2007).
- Energy: Overall energy used and carbon emissions from high-rise buildings are nearly double that of a similar low-rise (Treloar et al. 2001).

(9) Health and well-being:

- Psychological feelings: Several studies show that people who live in high-rise buildings have psychological symptoms more often than people living in other low housing types.
- Stress and other psychologically adverse factors: Several studies found emotionally depressed and psychologically harmful experiences among the occupants of high-rise buildings. Research shows that unnecessary social interactions between tenants tend to create stress and tension when sharing floors and amenities (Prezza et al. 2001).

(10) Cultural and historical heritage:

- Protection and blocking views: High-rise buildings can block the views of low-rise buildings and other locations in the city.
- Respect and preservation of historic buildings and heritage.

(11) Privacy: Low-rise units provide greater privacy and negotiability than high-rise apartments (e.g. visual privacy, acoustic privacy, and odorous privacy).

(12) Cost, space, and destination: The geographical and construction costs of high buildings are not very surprising but are regarded as more economical.

3. Method

In the design and development of a MSSHFB in Erbil, several measures have been taken to define various criteria of sustainable high-rise buildings that exist worldwide, as well as the appropriate application on the Erbil high-rise buildings (e.g. literature reviews and screen reviews of the notable global rating system). We also used three scales to analyse local requirements and constraints in Erbil’s building sectors. This section also includes an overview of existing policies and regulations related to sustainable high-rise building measurement and rating systems.

3.1. Localization and specialization of the model

3.1.1. Country condition

Erbil governorate is situated about 350 km north of Baghdad and 81 km east of Mosul, in the northern Kurdistan area of Iraq. Following the establishment of Iraq in 1920, Erbil, as a historic city, has experienced significant growth. Since 2003, Erbil has experienced its largest expansion rate and 90% of the city was built in that period.

Erbil has been known as the cradle of civilization. The city of Erbil is one of the most ancient and permanently settled cities in the world, and many signs from past centuries can be seen. The city of Erbil is known to
have been in existence since at least 6000 BC. Erbil has a citadel, which is one of the most important structures not only in Iraq but in the Middle East and the world. The form and height of this castle have influenced the urban design of the communities in the same manner as concentric circles and radius axis. Erbil Citadel is at the heart of the city, which is estimated to be about 7000 years old (Erbil chamber of commerce and Industry; Hayran 2014).

Erbil is situated in the low mountainous region under Shb Zoom and it has a semi-arid climate, following Kopen’s world climate classification (Rasul, Balzter, and Smith 2017). The city of Erbil has many environmental issues including waste-water treatment problems, insufficient water, land management concerns, air pollution, and noise pollution. Erbil city has also faced many problems in terms of sustainable development, including air pollution, sound pollution, water pollution, and waste management, as summarised in Table 3.

Despite vast fossil fuel reserves, northern Iraq is still suffering from a serious shortage of energy supplies. The renewable energy source in Kurdistan is still relatively unexplored and must be further investigated in the form of hydropower, wind power, solar power, biomass, and geothermal energy. The electricity supply in Erbil’s governorate remains uncertain.

In general, the infrastructure remains poor and most areas are affected by extended power cuts. Connection for all households in Erbil, with significant differences across the different governorate districts, is also not available or effective (IOM 2015). Kurdistan’s young people find jobs very difficult. For those aged 18 and 34, more than 20 percent are unemployed and frequently lose hope for obtaining a job.

In many of its high-rise residential buildings, Erbil’s culture and traditions are not represented. There has been no study of the significance of the connection between high-rise residential buildings and the environment surrounding it. While the loss of visual privacy has been identified, children’s play areas and community space are still lacking. Urban planning and urban administration are subject to heterogeneity, poor collaboration, and overlap. In addition, the structure of planning, taking decisions and approvals are not unclear. The poor municipal structure does not permit community participation or representation.

Table 3. Erbil’s environmental hazards.

| Aspects                      | Properties                                                                 |
|------------------------------|---------------------------------------------------------------------------|
| Air Pollution                | Erbil (97.6 gm/m2 year) reported a drop-in dust.                         |
|                              | Vehicle and factory traffic pollutant gases                               |
| Sound Pollution              | Rapid growth, increase in vehicle numbers, commercial and industrial areas, numerous projects, etc. |
| Water pollution              | Erbil is fairly well equipped with strong, quality aquifers that are usually suitable for drinking and irrigation purposes, but issues such as leakage in the municipal distribution network currently affect the water supply. |
| Waste Management            | No city waste separation system in place and no sanitary waste collection system, all municipal solid waste collected and discarded in an open field or drains. |

The high-rise buildings in the buffer zone (municipality 1 district) are not approved and the buildings near the airport level were determined by the airport staff’s committee. Otherwise, there is no law that exists for regulating buildings and this has created many user-related problems, such as poor seasonal conditions, low occupancy levels, issues in public transports, high costs, lack of decent hospitality and qualified workers, lack of amenities, and poor quality of services.

3.1.2. Face-to-face and in-depth interviews

The research interview focusses on examining the viewpoints, perceptions, opinions and/or motives of architects, designers and engineers in Erbil for high-rise buildings on issues concerning social, economic, and environmental sustainability.

In this study, we interviewed 12 officials who are construction and building experts in the city of Erbil. The interviewed officials include architects, engineers, and experts from various ministries and administrations, and four qualified population frames: architects, designers, civil engineers, and other engineers. The questions answered by each party consist of several main issues that help to identify the areas to be discussed, while also allowing the interviewee to diverge to further refine a concept or answer in greater detail. The literature review and observation were used as a basis for designing the questions, the authors’ experience was also included (Table 4).

The respondents were told of the research and received a participating information sheet at the beginning of each interview. The participants were also given a consent form, which they were asked to sign. Depending on the availability of the participants, each interview lasted approximately 45 minutes. Great consideration was taken to ensure that sample participants supported their organisations, had diverse histories and represented each gender in different ways.

For analysing and evaluating the interview results, there are a number of steps that include coding the data obtained from the answers of interviewees with additional questions, phrases, sentences or sections, which will be done through the relevant meanings and areas. Thereafter, sorting to create different categories to conceptualize the data that do not have the same objects or process will be done. The third step will involve the labelling of the categories. The results obtained and the analysis and evaluation of the
interviews and discussions of the results in similar studies will be the final step (Table 5).

The sustainability criteria must be applied to all phases of buildings from inception to completion, which is one area on which the participants agree on. Generally, the responses provided are relevant for solving the problems of sustainability and can be added as the new indicators for the measurement scales.

A key discovery was that those working in the ministries are more careful about employing local people and those working in the private sectors are more careful about projects with short payback period, early reach to break-even point or higher rate of return, regarding economic aspects. Also giving an opportunity to the people of Erbil city in the decision-making process, providing multiple benefits of finance to communities are other opinions among the responders that give priority in localized and adapting new criteria on the measurement scale.

Another key discovery is that architectures are more careful about context architecture identity according to socio-cultural aspects. High-rise buildings should not be allowed around the Erbil city citadel as well as with respect to the viewing line of Erbil citadel, and people’s choices and the building culturally acceptable are very important. So, the location of the building will be important criteria some of the participants feel that the big companies that construct the big projects should respect the Erbil society, work with the local community, visual privacy for others, and consideration of religion and faith.

Again, it is necessary to mention that none of the global measurement tools includes the socio-cultural and economic dimensions of sustainable high-rise buildings. In addition, the socio-cultural and economic

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**Table 4. Sample categories.**

| Categ. | Number | Criteria |
|--------|--------|----------|
| Architects | 5 | Two from the Municipality and the Ministry of Tourism. Two from the Ministry of Higher Education with special training in the area of sustainability and high-rise buildings for their master degree. One from the private sectors that has experience in high-rise construction |
| Planners | 3 | Two from the Ministry of Planers |
| Civil engineers | 2 | One from the Ministry for Housing and Reconstruction |
| Other engineers | 2 | One from the private sector that already has the experience and knowledge on sustainability and city planning |
| Other | 2 | Different branches in engineering in the building construction. Mechanical and environmental engineer are selected because of their experience in high-rise construction |

**Figure 2.** Existing and new indicators of the proposed measurement scale.
aspects are one of the main issues in northern Iraq, and the city of Erbil has a specific issue of sustainable development.

The core issues included understanding the respondents’ level of knowledge of sustainable high-rise buildings through their experience and expectations for the future and the key driving forces of high-rise buildings in the region. We also gathered possible strategies to assess the other measures in various stages that are essential for the measurement scales. Finally, concern was expressed about high-rise buildings that are essential for the creation of measurement scales in different phases.

According to the participants’ views, sustainability initiatives should be taken into account when the design, construction and using processes are taking place. These new criteria were then used as the lack of sustainability indicators for high-rise buildings based on regional and expert criteria (see Figure 2).

Our sustainable assessment tool with its high-rise building indicators is established in the Erbil region. Consequently, it depends on existing common indicators and redefined indicators. Therefore, this study has rearranged the indicators and sub-indicators and established 9 environmental, 14 social, and 4 economic indicators for the development of sustainable high-rise buildings in the city of Erbil. Table 6 presents the environment, social, and economic, subcategories required for the acceptable certification level.

| Table 5. Interviewees’ opinions for new tool and localized criteria. |
|-------------------------------------------------------------|
| Interviewees | Economic Aspects | Socio-culture Aspects |
| In. 1 | Employee local people | -Participant in decision making | -Context architectural identity |
| In. 2 | Employee local people | -Projects with short payback period | -Respect to view line of Erbil citadel |
| In. 3 | Providing multiple benefits of finance to communities | -Projects with short payback period | -Respect to view line of Erbil citadel |
| In. 4 | Providing multiple benefits of finance to communities | -Projects with short payback period | -Respect to view line of Erbil citadel |
| In. 5 | Providing multiple benefits of finance to communities | -Projects with short payback period | -Respect to view line of Erbil citadel |
| In. 6 | Participant in decision making | -Employee local people | -Respect to view line of Erbil citadel |
| In. 7 | Projects with short payback period | -Projects with short payback period | -Respect to view line of Erbil citadel |
| In. 8 | Provide multiple benefits of finance to communities | -Participants’ desire to make their buildings | -Respect to view line of Erbil citadel |
| In. 9 | Projects with short payback period | -Consideration of religion and faith | -Respect to view line of Erbil citadel |
| In. 10 | Participant in decision making | -Respect to view line of Erbil citadel | -Respect to view line of Erbil citadel |
| In. 11 | Projects with short payback period | -Projects with short payback period | -Respect to view line of Erbil citadel |
| In. 12 | Provide multiple benefits of finance to communities | -Participants’ desire to make their buildings | -Respect to view line of Erbil citadel |

3.2. Indicators’ weighted for different categories

While some disagreements persist, the weighting is now accepted as an integral part of the methods to evaluate buildings. In other words, weighting is a significant issue when developing a building performance appraisal system (Ding 2008). The guidelines for their drawing up and their incorporation into building performance assessment systems are of great importance within the International Framework Committee. Clearly, the validity of weightings for measurement schemes may be counterbalanced.

Many aspects of sustainable development are obviously more relevant than other goals that change over time, from development type to building style, and from region to region. Specific weights are therefore usually applied to evaluation parameters, not only to reflect the variations in their significance in a given field but also to account for its effect on issues of sustainability (Papamichael 2000). Furthermore, the overall performance value of the building being assessed dominates weighting (Lee et al. 2002).

The selected region has suffered in all three dimensions of sustainability. So, for the Indicators’ Weighted for different categories, we follow the same system of LEED credits that has a minimum value of 1 point and every system has a base of 100 points (Ryu and Park 2016). Additionally, there are up to 10 bonus points when there are awards for “Innovation in Architecture” and “Regional Priority.” In this method, we use “yes” for “Applicable” and the measures added by “one”, “-” for “Applicable, but not assured of receiving Points”, “No”
Figure 3. Measurement for sustainable high-rise building for Erbil city with number of indicators.

for "not applied" and the measures added by "0", and "Required" for required indicators.

As explained earlier, there are 9 environmental, 14 social and 4 economic indicators, with subcategories either as required or collecting the point to get the acceptable level of the certificate (as shown in Figure 3).

The users of the proposed assessment tool must calculate the number of loans obtained under appraisal criteria for each issue, to obtain the overall result for any high-rise projects. The points of each indicator are then determined. To give the total score for getting certificate, an innovation score must be added. The evaluations and certificates are therefore categorised in six grades: A+ (>80 points), A (70–79 points), B (60–69 points), C (50–59 points) D (40–49 points), and no certificates (<40 points).

4. Case study

Within the scope of this research, there are five high-rise projects in Erbil that are used as sample cases for our questionnaire (see Table 7):

Muni.: Municipality

To better understand the socio-cultural, economic and environmental implications of living or working in these buildings, the scenario that occurs in Erbil high-rise buildings and their conditions are posed and explored through interviews and observations.

In the context of this project, the score will be calculated using various measures to calculate each sub-issued score, apply the net weighting for each sub-issue, and use all the weighted sub-issue score by using the control list of the suggested sustainable calculation tools. It is necessary to mention that almost 60 percent of the indicators are new and related to localization, to Erbil city, and specialization, to two other pills of sustainability and concentration and classification for high-rise buildings, the model as it has been explained before. The purpose of it is to evaluate more precisely and not just environmental aspects as an existing measurement rating system.

5. Results and discussion

New indicators were identified and applied to specific indicators according to the results obtained from the interviews and literature, which are mainly correlated with the concerns regarding high-rise buildings and local conditions, which are present in selected world rating system guidelines. It is clear that the newly developed metrics for calculating localized and specific parameters are referred to in socio-cultural and economic terms. To determine the viability of these structures, elements are provided for each class of indicators to consider.

Consequently, three choices are available for calculating the indicators: "yes" for "Applied", "-" for
Table 6. New sustainable measurement scale for high-rise buildings in Erbil city.

(a) Environmental dimension

| Environmental dimension | Indicators                          | Sub-indicators                                                                 |
|-------------------------|------------------------------------|--------------------------------------------------------------------------------|
| Indoor Environmental    | Quality                             | Environmental Tobacco Smoke Control; Providing Natural Ventilation; Solar Control and Thermal Comfort Design; Natural Lighting; Considering of Building Envelopes; View Quality; Acoustic |
| Outdoor Impact Quality  | Natural Ventilation of Nearby Buildings; Avoiding Negative Effect on Surrounding Birds Savers; Consideration of Global Warming; Direct Contact with Nature |
| Waste and Pollution     | Recycling Waste; Land Pollution; Reducing and Avoiding Wastes; Air Pollution; Noises Pollution; Reducing and Avoiding Dusty |
| Site Management         | Land and Green Area; Selecting Site; Vertical Green Farms; Avoiding the Destroy of Surrounding Efficiency in Construction Standards; Construction Safety; Construction Process; Durability |
| Construction Practice   | Energy and Atmosphere               | Using Energy Efficiency; Minimum and Optimize Energy Performance; Providing Onsite Renewable Energy; CO2 Emissions; Reduced Peak Energy Requirements; Improve Energy Efficiency Use |
| Material Use            | Metering and monitoring* Time management* Using Local Material*; Recycled and Recyclable Material Minimizing Wasting Material; Building Reuse; Using Sustainable Material; Easy Maintenance Material |
| Water Use               | Water Quality*; Avoiding Wasting Water; Rainwater Collection; Recycling Rainwater Stormwater Management Strategies; Reuse Grey Water Communication and IF Management* Electric Equipment; Plumbing and Drainage; HVAC Systems; Impact of City Infrastructure; Regular Maintenance |
| Building Services and   | Management                          | * Required                                                                      |
| * (b) Socio-culture dimension |

| Socio-culture dimension | Indicators                                    | Sub-indicators                                                                 |
|-------------------------|-----------------------------------------------|--------------------------------------------------------------------------------|
| Local Opportunity       | Building Long-Term Relationship with Local and Client; Supplier Satisfaction; Client Satisfaction; Employee Satisfaction |
| Construction and Staff  | Respect for Staff; Partnership Working       |
| Accessibility and Traffic| Shared Public Spaces and Central Districts*; Responsible to The Main Transportation; Public Transport Nodes; Minimize Traffic Disruption and Delays; Pedestrian and Cyclist; Access with the Disability; Car Park Capacity; Cleaning the Facade |
| Culture and Privacy     | Visual Privacy and Open Space*; The Building Culturally Acceptable; Visual Privacy for Others; Consideration with Religion and Faith |
| Health and Wellbeing    | Psychological Feeling                        |
| Safety                  | Fire Safety; Accidental Falls from The Height; Safety While Maintenance and Cleaning; Safety for Construction Workers Elevators; Travel Time in Elevator |
| Vertical                | Crime and Security                           | Crime in Corridors; Crime in Elevators as Rape and Robbery; Monitoring and Controlling |
| Transportation          | Crime in Elevators as Rape and Robbery       |
| Scale and Size          | Human Scale; Building Height                 |
| Children Behavior       | Behavior Problem in Children*; Children Development; Playing Space for Children |
| Social and Community    | Social Interaction*; Effective Channel for Communication; Family and Community; Who the Neighbors Are; Neighborhood Facility, And the Public Realm Of The Livability Of the Street Respect to Heritage and Historical Buildings; Respect to Whole of the Erbil Citadel; |
| Heritage Respect        | Knowledge and Skills of Users; Staffs Knowledge; Spaces for Education |
| Awareness and Education | Sign and Symbol; Context Architectural Identity; Placelessness and Public Realm |
| * (c) Economic dimension and Innovation |

| Economic dimension | Indicators                                       | Sub-indicators                                                                 |
|--------------------|--------------------------------------------------|--------------------------------------------------------------------------------|
| Local Economic     | Support Local Community*; Improved Productivity; Consistent Profit Growth; Developing Client Business Growth |                                                                                 |
| Jobs Opportunity   | Employment Local People*; Providing Job; Working with Local Community; Provision of Equal Opportunity; Participation in Decision Making |
| Shorter and More    | Projects with Low Cost, Multiple Benefits of Finance to Communities; Projects with Short payback period; Reducing Maintenance Cost; Reducing service Cost; Increased Cost Predictability; Ongoing Costs; Vanity Height Predictable |
| Supply-side         | Supply and Demand; Consumption Economics         |                                                                                |
| Innovation          | Innovation in Design; Innovation in Techniques and Technologies; Innovation in Benchmarks; Exemplary and Enhancement Level of Perform . . . Etc. |
| * Required          |                                                 |                                                                                |

"Applicable, but not assured of receiving Points", and "No" for " not applied". These approaches are considered to measure the sustainability of high-rise buildings, such that the sustainability percentage of high-rise buildings is calculated. As stated in Section 3.2, each indicator with its basis of 102 and more than 10 innovation points is based on the importance of the proposed rating system.

Each tower was assessed based on its position and types (Table 8). In other words, building role is one of the goals during the assessment. To prove if any surrounding facilities exist, it is not enough for the residential high-rise buildings to get value for the commercial building.

From these results, it can be seen that in terms of energy and atmosphere, the use of energy in the city creates an energy crisis, thereby affecting the environment. The situation is almost similar in water use and construction materials.

It is clear that all of these towers have tremendous economic advantages, which is the key and obvious justification for constructing the high-rise buildings on
a local basis, as well as on an international level. However, the reason for their unsustainability in the economic aspects is that they do not support the local people and do not have clear benefits for Erbil’s local society.

The effect of socio-cultural non-sustainability in many units is increasing and the owners seek to convert their function from the original function by changing the furnishings, and lease or use them by themselves. For example, they have changed a number of units from residential to office use.

The main Erbil infrastructure and public transportation system can be seen as another unsustainable indicator. The road and transport networks are not appropriate. Therefore, this argument further emphasises that high-rise buildings cannot be isolated from the city and are difficult to develop within sustainable areas if they are not built. Some other elements of unsustainability have a direct effect because the identity of the consumers is more alien than the local population, including their cultural views. In other words, the majority of consumers are foreign citizens.

The sustainability of each building is illustrated in Chart 1. They all faced socio-cultural problems that are discovered by the new proposed measurement tool, which rises in residential towers more than commercial and mixed-use towers. However, commercial high-rise buildings are in much better condition than the residential towers. Consequently, none of the buildings can get a certificate according to SHRBM-E (see Chart 1).
Figure 5. Sustainable high-rise buildings measurement of Erbil city.

Table 8. Results for all five high-rise buildings according to the new measurement of sustainable high-rise buildings.

(a) Environmental Aspects Results

| Indicators                  | Raj empire Tower | World Trade Centre | Justice Tower | Esan Towers | Quattro Towers |
|-----------------------------|------------------|--------------------|--------------|-------------|----------------|
| Indoor Environmental Quality | Y 2 3 1          | Y 1 3 0            | Y 3 2 1      | Y 1 2 1     | Y 2 3 1        |
| Outdoor Impact              | 0 2 3            | 0 1 4              | 0 3 2        | 1 0 4       | 0 2 3          |
| Waste and Pollution         | N 3 2 0          | N 0 2 3            | N 1 2 2      | N 0 5 0     | N 0 3 2        |
| Site Management             | 3 0 1            | 2 2 2              | 1 2 1        | 0 2 2       | 2 2 2          |
| Material Use                | N 2 1 2          | N 1 1 3            | N 2 1 2      | N 1 3 1     | N 1 1 3        |
| Water Use                   | N 0 1 4          | Y 1 0 4            | Y 1 0 4      | Y 0 1 4     | Y 0 1 4        |
| Building Services and       | N 3 1 1          | N 4 0 1            | Y 4 0 1      | Y 3 1 1     | N 4 0 1        |
| Construction Practice       | 3 1 0            | 1 3 0              | 1 2 1        | 3 1 0       | 1 2 1          |
| Totals                      | 16 12 67         | 13 12 20           | 13 13 19     | 11 13 21    | 10 15 20       |

(Continued)
6. Conclusions

For the sustainable high-rise building measurement of Erbil city, we have used literature reviews, screen reviews of the global rating system and data collection to define different criteria for sustainable high-rise buildings that exist globally to establish a MSSHRB in Erbil. This was also used to analyse local conditions and constraints in Erbil’s development sectors. We include an overview of the latest policies and regulations applicable to sustainable high-rise buildings measurement and ranking systems (see Figure 4). Then, the task of determining the key parameters to be taken into account in the measuring scale and assigning their corresponding weighting amount was introduced. This is based on an interview with minimal stakeholders. The processes have been driven through data collection, results, and analysis.

Therefore, the categories and their subcategories have changed globally, which added the number of categories from the literature and interviewers to be possibly implemented in the study area.

This article presents a sustainable measurement scale for high-rise buildings based on our results and principles, in which key factors take the form of environmental, economic, social/cultural issues with a concord on high-rise constructions and architectural aspects (see Figure 5).

The key aspects and definition of sustainable construction, sustainable buildings, sustainable high-rises, and different dimensions of sustainable construction
were seen in a broad literature review. To explore the economic, cultural, social and environmentally sustainable high-rise building limitations and parameters, the current environmental protection criteria for HRBs have been recognised as the environment and climate conditions, pollution and waste management, site management, energy, and building material. Correspondingly, worldwide existing parameters of socio-cultural sustainability for HRBs were found to be communication and social interaction, local and opportunity, accessibility to potential requirements and traffics, culture and faiths, safety and security, and finally health and well-being. Worldwide existing parameters for the economic sustainability of HRBs were recognised as local economic growth, jobs and occupations, cost and finance, supply and demand, and finally short and more predictable.

This study has established 9 environmental (50 sub-indicators), 14 social (48 sub-indicators) and 4 economic (16 sub-indicators) indicators to develop

### Table 8. (Continued).

| Economic Aspects | Roj Empire Tower | World Trade Centre | Justice Tower | Escan Towers | Quatto Towers |
|------------------|------------------|--------------------|---------------|--------------|---------------|
| Local Economic Growth | N 1 2 0 | N 2 1 0 | N 2 1 0 | Y 1 1 1 | N 2 1 0 |
| Jobs Opportunity | N 2 1 1 | N 2 1 1 | N 2 1 1 | N 2 1 1 | N 2 1 1 |
| Shorter and more Predictable | N 2 1 2 | N 2 1 2 | N 2 1 2 | N 2 1 2 | N 2 1 2 |
| Supply-side | 1 1 0 | 1 1 0 | 1 1 0 | 1 1 0 | 0 1 1 |
| Totals | 5 7 1 | 7 5 1 | 6 6 1 | 5 4 1 | 8 5 2 |

#### Chart 1. The five high-rise buildings in terms of environmental, socio-cultural, and economic aspects in the level of sustainability.
sustainable high-rise buildings in the city of Erbil, within the context of the environment, society, and economy.

In addition to the interviews, we also used site observations to learn from sensitive issues in five high-rise buildings by using the proposal model scale to measure their situation according to sustainability. It is expected that the next act and standards of high-rise buildings in Erbil will improve. Subsequently, over time, rules and regulations will be fair and revised, support sustainable technology, local skills and a sense of the problem will progress, and sustainable growth will be achieved. Unfortunately, no one can get the required compensation for obtaining certificate. In addition, the proposed definition is by no means definitive or conclusive in this study.

For the standards specified in the proposed model, it is recommended that this structure is gradually revised or modified over time. In any state, the government should begin the process of legislating and establishing different building codes and measures of practices and regulations, which would protect buildings not only from the destructive effects but also from any other load of social-cultural, economic and environmental problems.

We recommend that future research should design and improve suitable weightings for situations or metropolises other than those used in this report (e.g. Sulaymaania, Dhok, and Halabja in Iraq) and that a model or system should be developed using the SHRBM-E as a particular sustainable measurement scale.

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**Table 7. Summary of five case studies.**

| HRBs name        | No. of stories | Height | Functions | Location | Tower Properties |
|------------------|----------------|--------|-----------|----------|------------------|
| Roj Empire Tower | 27             | 129    | Commercial| Muni.2    | in a group of towers. |
| World Trade Centre | 21            | 92     | Commercial| Muni. 2   | in a group of towers. |
| Justice Tower    | 37             | 125    | Mix-used  | Muni. 6   | one tower         |
| Esca Tower       | 27             | 90     | Residential| Muni. 4   | two Towers        |
| Quatro Towers    | 31             | 103    | Residential| Muni. 2   | four towers       |

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