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Towards developing a sustainability assessment framework for residential buildings in Iraq

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Towards developing a sustainability assessment framework for residential buildings in Iraq

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“In the name of Allah, his guidance and blessings, perfected goodness this work has been completed”

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Abstract

Anthropogenic activities are depleting the planet's natural resources and having a significant negative impact on the environment, leading to manifestations of climate change. Energy consumption within the built environment is a major contributor responsible for 40% of the total energy consumption, 40% of global resources, 25% of water as well as a third of global Green-House Gas (GHG) emissions resulting in global warming.

Sustainability assessment frameworks are developed with a specific country in mind. Even though the leading assessments such as LEED and BREEAM are used internationally; there is wide academic evidence that these assessments are not very suitable for use in other countries. However, countries, such as Iraq, with no building standards or energy codes. This study focuses on developing a sustainability assessment framework for residential buildings in Iraq. The study begins with cross comparison between well-established assessments in the Middle East region and other parts of the world to identify areas of similarity and difference that are most applicable to the building context in Iraq.

For this research, a sustainable assessment framework was developed using the Delphi technique that relied on achieving a consensus amongst a panel of experts to establish building sustainability performance indicators for Iraq with their relative priorities. This was followed by evaluating the weighting of categories and subcategories for these indicators using the Analytical Hierarchy Process. The research concluded that the weighting for water stress issues was highlighted as the most important category, of which 19.6% owing to the scarcity of this resource compared to other categories within the assessment. The study was one of the first endeavours allowing for evaluating and comparing the performance of sustainable building in Iraq. The main contribution of the research is the establishment of specific sustainability indicators and their weighting for the socio-economic and environmental conditions of Iraq.

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List of abbreviations

ASHRAE	The American Society of Heating, Refrigerating and Air-Conditioning Engineers
BIM	Building information Modelling
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CDD	Cooling Degree Days
CSH	Code of Sustainable Homes
CV	Coefficient of Variance
EIA	U.S. Energy Information Administration
GBCA	Green Building Council of Australia
GPRS	Green Pyramid Rating System
GSAS	Global Sustainability Assessment System
HDD	Heating Degree Days
IEA	International Energy Agency
IISBE	International Institute for a Sustainable Built Environment
IUCN	International Union for Conservation of Nature
$KgCO_2/m_2$.year	Annual kilogram of carbon dioxide per square meter of building floor area
kWh/m_2.year	Annual electricity consumption defined by kilowatt hours per square meter of building floor area
LEED	Leadership in Energy and Environmental Design
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
PV	Photovoltaics
SABA	Sustainability Assessment for Buildings in Jordan
SBTool	Framework for Rating the Sustainable Performance of Buildings
SEAM	Saudi Environmental Assessment Method
USGBC	U.S. Green Building Council
VOC	Volatile Organic Compound
St.Dev	Standard Deviation

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Chapter 1: Introduction

1.1 Background

The development of human activities and constant population growth has created a huge demand for energy. These anthropogenic activities were a result of urban sprawl and rapid economic growth that increased industrial production and caused a significant increase of population growth leading to high energy consumption in most countries across the world (Bilgen 2014). Buildings in most countries account for 40% of total energy consumption, 40% of global resources, 25% of water resource, together with a third of global Greenhouse Gas (GHG) emissions which are the main cause of global warming (UNEP 2016). Because of high energy and carbon emissions in the buildings, the potential for GHG emissions reduction is very high, especially if there is a significant reduction in building energy consumption.

Energy consumption is high in Middle Eastern countries compared to the world average owing to many reasons, including: the large size of home/residential buildings and the subsidy on energy bills by the government which encourages occupants to over-consume electricity beyond their actual needs (Woertz 2008). To tackle the issue of climate change and to reduce the depletion of natural resources, most developed countries started creating their own sustainable construction practice alongside the creation of energy and environmental codes. In most cases the performance standards were included within sustainability assessment frameworks for buildings such as BREEAM, LEED, CASBEE, and ESTIDAMA as a mandatory requirement. On that basis, countries in the Middle East developed their own versions of building assessment like GSAS in Qatar, ESTIDAMA in UAE, SABA in Jordan, Green Pyramid in Egypt and SEAM in Saudi Arabia (Banani et al. 2016). Other countries like Iraq did not have any energy or sustainability standards to be followed by construction practitioners and the stakeholders of buildings.

Currently there is a gap between housing demand and the supply of residential buildings in Iraq, leading to a shortage of housing to accommodate expected population growth of 50 million for the next decade, with expected housing demand growth of 1.27 million units (Un-Habitat 2006; UNEP 2016). The growth in demand for housing created a challenge for new investors and key stakeholders who then needed to deliver affordable and sustainable housing. The lack of building energy codes and environmental standards in Iraq hindered the ability of developers to deliver sustainable housing across the country. Iraq provides an excellent opportunity for developing a sustainability assessment framework for residential buildings with the aim of reducing the use of unhealthy natural resources while maximising the satisfaction and wellbeing of occupants.

1.2 Rationale for this research

The developed sustainability assessment frameworks such as LEED and BREEAM have common criteria for evaluating buildings based on different categories such as: energy, location, management, water, indoor environmental quality and so forth. The structure of each sustainable assessment is comprised of categories, sub-categories and indicators. The assessment evaluation of buildings is based on calculating the total points scored relative to the assigned weighting of different categories. The final rating of the building is established based on the total accumulated points achieved.

The components of these assessments are developed to reflect certain conditions and to reinforce regulation or future planning policy set by these countries or regions. For example, LEED has been developed originally to reduce the energy consumption in buildings as the energy category was assigned the highest weighting compared with other categories within the assessment. The reason behind this can be tracked back to the high electricity consumption by the united stated which was considered one of the main highest energy consumer in the world and only topped by Sweden and Luxembourg in Europe (IEA 2014). Another example can be seen in Estidama which was developed to emphasise on future development of Abu Dhabi and UAE; the main purpose of developing Estidama was to transform the current buildings standards into sustainable ones that comply with Abu Dhabi’s 2030 vision to be the capital city of sustainability in the world (Shareef and Altan 2016).

Many scholars investigated applying international and established assessment frameworks to various countries in the world to assess their applicability in various regions and countries. For example, (Neama 2012; Moussa and Farag 2017) investigated the applicability of LEED in Middle East region and they realised that the weighting system of these frameworks is not applicable to Middle East due to the emphasis on energy and indoor environmental quality categories and placing less weighting on issues that are highly important to Middle East such as water resources category. They also discovered that despite the unsuitability of the weighting system assigned for these categories, the indicators representing these categories needs to be modified to accommodate the needs and address the future barriers to building sustainability in the region.

This led to the development of local assessment in Middle East to represent the issues that particularly important for each country. Ali and Nsairat (2009) developed local sustainable assessment in Jordan and argued that each country should develop their own assessment as the severity of local conditions varies between different countries and climatic regions of the world. The importance of the categories and their indicators within assessment for each country may also varies for different building typologies. Therefore, researchers in Saudi Arabia developed two different assessments for domestic and non-domestic buildings each one has different weighting structure and indicators due to the variance of buildings types (Banani et al. 2016). Therefore, it appears that socio-economic and environmental factors vary significantly between countries.

Iraq as developing country in Middle East does not have any framework or standards to evaluate the performance of sustainable buildings. Furthermore, the country has a significant shortage of electricity due to the failing infrastructure, the lack maintenance and increasing electricity demand due to population growth (Saeed et al. 2016). Iraq as major oil producing country relies on fossil fuel to generate electricity. Meanwhile Iraq has a vast land with great potential of using renewable energy which currently are not employed efficiently. Hence, there is a great need in developing sustainability assessment framework for residential buildings to improve and transform current buildings into higher sustainable and environmental standards that reflects the local condition for the country.

1.3 Research Questions

The main argument supporting this research is that the existing international sustainability assessment frameworks used for residential buildings in other countries in the world are not suitable for the Iraqi building environment. They are not suitable owing to political, environmental, climate, social and cultural variations between countries. The differences are explained by the lack of understanding of the current availability of natural resources, local architecture, economic conditions and domestic energy use, together with the need to take account of the special characteristics and performance conditions of residential buildings in Iraq. So to study this in depth, four research questions were formulated, and these were:

RQ1: What are the main components of sustainability assessment frameworks that are used to evaluate and assess residential buildings in the Middle East and the rest of the world?

RQ2: What are the local factors that affect residential buildings and the built environment in Iraq?

RQ3: What are the applicable categories, subcategories and indicators that are important for sustainability assessment framework for residential buildings in Iraq?

RQ4: What is the most appropriate weighting and scoring method that should be implemented within the sustainability assessment framework for residential buildings in Iraq?

1.4 The research aim

The main aim of this research is:

‘To develop a sustainability assessment framework for residential buildings in Iraq”.

The developed framework should be based on the overall sustainable performance and environmental benefits. This will provide a great opportunity for contractors, architects, clients and professional investors to transform sustainability principles in the residential buildings sector. Moreover, the framework is expected to reduce over-consumption of natural resources while encouraging and promoting the use of renewable resources for residential units. To deliver this aim, a number of objectives have been developed and these are discussed in the following section.

1.5 The Research Objectives

1. To review the concept of sustainability and investigate current assessment frameworks used for assessing residential buildings in various countries across the world;
2. To review current passive architecture strategies in hot arid climates alongside issues that affect the housing market in Iraq;
3. To analyse applicable categories, subcategories and indicators needed for a new sustainability assessment framework for residential buildings in Iraq;
4. To develop a weighting system for use with the sustainability assessment framework for residential buildings in Iraq;
5. To develop a sustainable building benchmarking and labelling certification system for residential buildings in Iraq;

1.6 Brief methodology

Due to the nature of this research multiple methods were used to achieve the validity and reliability of the outcome. This thesis employed the use of two methods. Firstly, the use of secondary research in the form of a desk study that included the review of official documents and building codes. Secondly, the use of primary research, using the Delphi technique which included a survey with multiple rounds of questionnaires that helped to underpin the final indicators for the sustainability assessment for residential buildings with their weighting values. It was important to collect the data as a heterogeneous sample from multiple stakeholders to provide different perspectives on the nature of the research and help the researcher to generalise the final outcomes.

Quantitative analysis was employed for this study by the use of statistical methods such as mean, coefficient of variance and standard deviation in order to reach a consensus on the indicators for the assessment framework, together with the use of the analytical hierarchy process (AHP) to evaluate the categories and subcategories of the indicators for determining the final weighting system.

1.7 Findings of the thesis

This study is one of the first attempts to develop empirically a framework for residential buildings in Iraq. A detailed list of all the findings and the contribution of the study is highlighted in Table 1.1 and Table 1.2

Table 1.1 Findings of the thesis

Research objectives	Research problem	Relevant parts of thesis	Chapter or section of thesis	Findings of the thesis
To investigate the current sustainable assessment frameworks used for assessing residential buildings in various countries across the world	Even though there are global sustainable assessment methodologies, there is a lack of deep understanding and comparative analysis of the applicability of the sustainability indicators when their appropriateness for the Middle East and Iraq is considered.	Chapter 2	Literature review	The study identifies the key themes of potential indicators that are relevant to the Middle East region and Iraq. This has been developed through an in-depth critical review of various assessments worldwide
To review the current passive architecture strategies in hot arid climates alongside the issues affecting the housing market in Iraq;	There is evidence that new modern buildings are not integrating the passive cooling and vernacular architecture which historically has been a key part of Middle Eastern Architecture. Also, these issues are not included in the current sustainability assessment frameworks developed for residential buildings in the Middle East. There is also a lack of appropriate building standards and energy codes for Iraq.	Chapter 3	Literature review	The study reviewed the energy resources, economy and local architecture features that are most suitable for assessment in Iraq. This looked at the passive strategies that have been applied successfully in the past.

Table 1.2 Contribution of the study

Research objectives	**Research problem**	**Relevant parts of thesis**	**Chapter or section of thesis**	**Contribution of the thesis**
Develop applicable categories, subcategories and indicators needed for new sustainability assessment framework for residential buildings in Iraq	There are already well-established sustainability assessments for buildings globally and within the Middle East region, but the literature suggests that the assessments should take account of the specific local conditions which include climate, resources, cultural and economic aspects.	Chapter 4 & 5	Methodology & Analysis	The study uses the Delphi technique as the foundation to adapt the process of identifying and prioritising various indicators required for the development of a sustainability assessment framework for residential buildings. The process includes clarifying and determining the most applicable techniques to measure consensus, stability of responses and when to terminate the study, based on collected data.
Develop a weighting system to be applied to the sustainability assessment framework for residential buildings in Iraq	Assessment need a weighting system to ensure evaluation of these indicators	Chapter 5 & 6	Analysis and discussion	Using the Analytical Hierarchy Process (AHP), the study developed a weighting system by evaluating the main indicators established using the adapted Delphi

				technique alongside the main categories and subcategories of the sustainability assessment framework.
Develop a labelling and certification system for benchmarking the sustainability of buildings in Iraq	No current benchmarks or scale that can compare the sustainability performance of buildings in Iraq	Chapter 6	Discussion	The study developed a building labelling and certification system for Iraq. This will establish a benchmark for the sustainability of buildings in Iraq and will allow for comparison with other sustainability assessment frameworks for residential buildings across the world. The study will help the buildings practitioners and academics to use the developed framework as tool to improve the performance of the buildings through applying these categories and indicators on their buildings.

1.8 Thesis structure

The thesis comprises of seven chapters, as illustrated in Figure 1.1 .These chapters are explained as follows:

Chapter 1: Presents the background, limitations, aim and objectives of the thesis. A brief description of the methodology used for data collection has been presented. Finally, the contributions of the study have been summarised.

Chapter 2: This chapter critically reviews the literature for the research subject area and provides an understanding and interpretation of sustainability in buildings that assists in defining the main aim and methodology of the research. It examines the idea of sustainability within various disciplines and its evolution over the last few decades. The chapter also presents cross-comparisons of the various sustainability assessment frameworks for residential buildings, showing the similarities and differences of the main categories and indicators that underpin these assessments.

Chapter 3: This chapter investigates the specific situation in Iraq, identifying and discussing its energy resources, economy, climates, building strategies and vernacular architecture. Following the discussion of these themes, the chapter then highlights the main issues affecting residential buildings in Iraq while demonstrating the benefits of developing a sustainability assessment framework for residential buildings in Iraq.

Chapter 4: This chapter presents research theories, considerations and purpose as well as presenting the research methodology and methods used for data collection. A comprehensive procedure for the Delphi technique has been presented including a detailed description of the analysis methods used to quantify and construct the final assessment framework.

Chapter 5: This chapter describes the analysis procedure and discusses the results from multiple rounds of questionnaires, while interpreting and explaining the relevance of final indicators, categories and subcategories for the local buildings in Iraq. The construction of the final weighting system has been developed for the categories and subcategories of the indicators.

Chapter 6: This chapter discusses the results as well as justifying the weighting for each category by comparing them with other existing sustainability assessment frameworks and data sources for building sustainability indicators. Moreover, it develops a benchmark for building labelling and certification to be used for domestic buildings. This will include ranking formulas, weighting categories and subcategories as well as the final scoring used. This chapter also demonstrates a way to implement more effectively the sustainability assessment frameworks for varying microclimates in Iraq by discussing the climate impact on assessments from the current year until 2080.

Chapter 7: this chapter presents a summary of the research, the research contribution as well as its limitations and recommendations for further study.

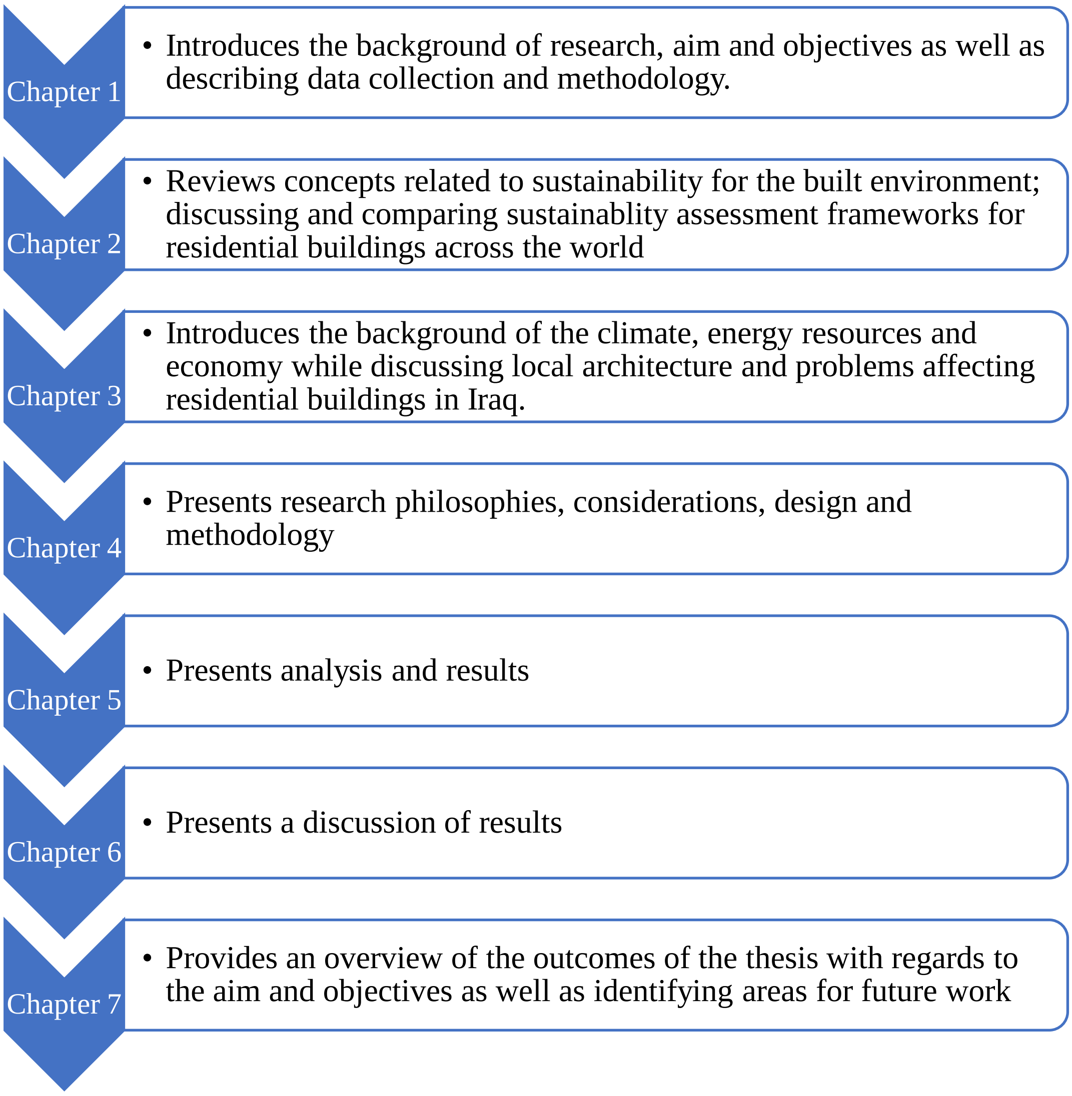

Figure 1.1 Structure of thesis

1.9 Summary

This chapter provided an overview of the thesis outline which focused on developing a sustainability assessment framework for residential buildings in Iraq by formulating and prioritising its indicators and corresponding categories. There are no current standards or methods for benchmarking sustainable residential buildings in Iraq. Therefore, this study developed a sustainable assessment framework using the Delphi technique combined with the analytical hierarchy process (AHP) to formulate the final assessment.

The next chapter provides a critical review of sustainability with its related definitions and influence on buildings. Furthermore, the chapter compares different sustainability assessment frameworks for residential buildings as well as identifying key similarities and differences among these frameworks to test their relevance for Iraq.

Chapter 2: Sustainability assessment frameworks

2.1 Introduction

Human activity has a huge impact on the environment through economic growth, construction and industrialisation. These activities are continuously growing to an unsustainable level whilst consuming a huge amount of natural resources and combusting more fossil fuels every year (Siegel 2016). It is estimated that buildings account for 40% of both CO_2 emissions and landfill waste, while they are responsible for consuming 16% of fresh water withdrawal (Reed and Sims 2014). This amount of unhealthy consumption of resources poses a significant threat to human prosperity and the environment. Possible measures to mitigate these negative impacts from buildings, include the use of sustainability assessment frameworks that aim to achieve sustainable levels of resource consumption while enhancing the wellbeing of occupants. Currently the guidance and regulatory regimes that encourage the use of sustainability practices in construction are weak.

This chapter reviews the status of sustainability for buildings and discusses the impact on the environment. Following the discussion of these concepts, a comparative analysis of the various sustainability assessment frameworks for residential buildings was presented, by analysing categories and the corresponding weighting (i.e. level of importance). Finally, the indicators of these frameworks were investigated to identify the key missing themes from the existing frameworks so as to incorporate them in a new framework for Iraq.

2.2 Environmental background

The environmental movement started after the end of World War II as a response to a series of environmental disasters such as: The Great Smoke in London 1952 and the hydrogen bomb test in 1954 (Dury 1986; Kessel 2010). As such, environmental activists started to address the danger posed by the activity of humans on the ecosystem. The pioneer activist who identified the importance of the balanced ecosystem was Rachel

Carson in her famous book 'The Silent Spring', *where* she depicted the impact of environmental contaminants, such as pesticides, on the ecological system and human health (Carson 1965). Her contribution was significant as her findings caused the establishment of the Environmental Protection Agency (EPA) which laid down the rules for environmental laws and policies. Owing to this, the environmental problems affected the political agenda on a global scale, thus there were many global environmental conferences and summits convened to discuss the environmental issues over various years.

Hens (2005) summarised these events as: The UN conference on the human environment in Stockholm 1972; the UN conference on the environment and development (UNCED) in Rio de Janeiro 1992; the Kyoto protocol in 1997 and the world summit on sustainable development (WSSD) in Johannesburg 2002. These events were followed by the most recent environmental agreement called the Paris Climate Change agreement, in which 154 countries in the world agreed to participate and set a target for their carbon emissions that must come into force by 2020 (European Commission 2017). All the summits and conferences were aimed at ensuring human activities derived from economic growth would not undermine the ecological system or cause further damage to the environment, as shown in Figure 2.1. Overall the environmental issues that were emphasised within these summits were: resources constraints, climate change and air pollution.

Figure 2.1 key points highlighted by the UN environmental summits (Hens 2005; European Commission 2017)

2.3 The natural resources constraint

The problem with the depletion of natural resources was first mentioned by Thomas Malthus (1778) in his famous essay on population (Hall and Day 2009). He argued that the exponential growth in population would undermine food production and eventually cause starvation (Hall and Day 2009). Indeed, it was the main factor that kept food production and healthcare in pace with population growth, yet, the prediction of Malthus was wrong as his theory did not account for technological advancements that occurred during the twentieth and twenty-first century that boosted agriculture as well as food production; Similar views to Malthus were mainstreaming during the sixties and seventies, as many scholars tried to address the problem of increased population on finite resources. This was published in Garret Hardin's article, 'Tragedy of the Commons' (1968), Barbara Ward's book, 'Spaceship Earth' (1966), and Herman Daly's book, 'Steady-State Economics' (1977). Meadows et al (1972) published a book called 'Limits to Growth' in which they assumed that population growth, in parallel with rapid economic growth, will impact the quality of life and cause environmental pollution through overconsumption of natural resources. Their predictions were followed by the peaking of oil prices in 1973 and 1979, due to the oil embargo by Arab oil producers, leading many to believe that the assumptions were a reality. However, in 1980, the theory was ruled out of the public discourse as oil resources were abundant and cheap owing to the number of oil reserves discovered during that period of times. However, a recent study showed again that the predictions of Meadows were close to reality (Bardi 2011).

The responses to ‘Limits to Growth’ raised questions relating to pollution and the natural environment. There were various attempts to address the impact of chemical detergents and fertilisers on the ecological system. (Robbins and Worster 1994; Craige 2001) The rising concern following this helped to establish the interdisciplinary science of the so-called “ecological economics” (Costanza et al. 2015).

Schumacher emphasised the relationship between the environment and the economy. Girardet (1999) acknowledging that relationship by defining the so-called “meta-economics” as being concerned with the study of humans within an environmental context. Daly (1996) argued that humans can only consume what already exists. Also, they can only create from what exists (i.e. what economists call “matter/energy”), from either production or the re-arrangement of production. And finally, they will “consume” their modified matter/energy output eventually. Daly labelled what is produced through the flow of natural resources, labour and capital as the “value added”. This value is the sum of our consumption and production which is equal to the national income. The question that arose from this argument was, “if the national income was equivalent to the natural non-replaceable resources, consuming what has already been produced without any extra outcomes?” In other words, are the environmental resources that are available finite?

Scholars have debated this question and provided various viewpoints, for example, Brooks and Andrews (1974) argued that the notion of running out of natural material is ridiculous as the world is full of minerals and will never run out of energy, and it’s sufficient to supplement our economic development and growth. Georgescu-Roegen (1979) opposed this argument by arguing that the world is full of energy, for instance, the ocean is full of energy, but it is impossible to render its energy in a sufficient form that could serve the economy due to its inherent gradient temperatures, thus the form of this sort of energy is not applicable for economic activities.

A similar view was highlighted by Daly (1996) in which he defended his argument by stating that consuming more of what you already produce is impossible. According to Daly, resources are finite and consuming the biophysical resources to feed economic growth while increasing the rate of pollution as a result comes at a cost. One fundamental question which needs to be understood is, “Is our current usage of non-renewable resources overshooting the current biophysical capacity?”

So far, the world consumes 61.23% of fossil fuel for energy, while wind and solar energy combined are only 2% of total energy consumption (World Energy 2016). Since the world is already in a post peak oil production era and non-renewable resources are the most dominant source of energy, if the world continues with the same trajectory of energy consumption, its resources will run out and there will be a limit to its growth.

2.4 Pollution and climate change

Climate change has no doubt become one of the most dominant topics discussed by scientists and politicians across the world. Throughout the history of the earth, the sun emits an intense amount of ultraviolet and infrared radiation, one third of these two sources of energy being reflected back through the earth’s surface and the atmosphere (Romm 2015). The rest of this energy is absorbed by the earth surface, and radiated as heat. Greenhouse gases, such as CO_2 and CH_4, used to keep this energy trapped in the atmosphere to keep the earth warmer by 15.55°C (Romm 2015). Greenhouse gases have increased significantly in the atmosphere causing a global temperature to rise by 0.85°C since the mid-nineteenth centuries and the temperature has kept rising until the current time (IPCC 2014). The current level of CO_2 is about 400 parts per million (ppm) as compared with 280 ppm which was recorded 250 years ago (Romm 2015). According to IPCC (2014), under baseline projection scenarios, the temperature is projected to rise by 2°C by 2100, with an increment of more than 2°C and up 4°C with high emission scenarios. The only scenario that the IPCC identified which can prevent the catastrophic consequences of the temperature rising by 2°C and to keep the temperature rise equal to/or below 1.5°C is by limiting the CO_2 levels to 430 ppm or below, as shown in Figure 2.2.

The share of CO_2 emissions from buildings is expected to be around 19% which relates to both electricity generation and total energy consumption. Therefore, mitigation and de-carbonisation strategies are relevant to buildings since they are responsible for part of these emissions.

Figure 2.2 IPCC simulated scenarios of CO_2 Levels from 2000 to 20100 (IPCC 2014)

One possible solution, as recommended by IPCC (2014) and Su et al. (2017) is to reduce the emissions associated with operational energy use, as well as the energy consumed during manufacturing, transportation and construction. Other solutions could also include reducing energy by controlling social behaviours, using integrated design and encouraging the use of renewable energy and sustainability in buildings. Therefore, policy makers, architects and designers need to address these solutions collectively to curb the carbon emissions, reducing them to sustainable levels whilst protecting the earth from warming above 2°C, which will significantly reduce the consequences (e.g. sea level rise).

2.5 The emergence of sustainable development (SD)

The concept of sustainable development (SD), emerged at the beginning of 1980's (Clark et al. 1987), as a multifaceted solution, to close the gap between environmental problems presented by climate change and resource depletion on the one hand and social-economic problems on the (i.e. inequality, poverty, human needs). It is believed that SD has been substituted with terms such as: "ecological sustainability"; or "environmental development" (Lele 1991). This could be because SD originated to solve the ecological and environmental problems that arose during the 60's, 70's and 80's. There are different definitions of sustainable development according to the different disciplines that use them. The most famous and cited definition of SD was introduced by Brundtland (1987) as;

> *"Sustainable development is the development that meets the needs of current generations without compromising the ability of future generations to meet their own needs"*.

Sustainability on the other hand, seems to be the broader aspect of SD, for instance, in buildings it represents efficient management of the whole life-cycle (Phiri and Chen 2014). This definition has been followed by other definitions as shown in Table 2.1.

Table 2.1 Sustainable development definitions based on the context/discipline

Source	**Definition**	**Context/Discipline**
(Lynam and Herdt 1989: 384)	"*The capacity of a system to maintain output at a level approximately equal to or greater than its historical average, with the approximation determined by historical level of variability*".	Ecology
(Barrow 1995:369)	*"Sustainable development is a goal for a world under growing stress"*	Ecology
(Fresco and Kroonenberg, 1992:155)	*"The sustainability of natural ecosystems can be defined as the dynamic equilibrium between natural inputs and outputs, modified by external events such as climate change and natural disasters"*	Ecology
(Camagni et al. 1998:116)	*"Urban sustainability' is a complex concept which refers to the interaction of three critical environments which characterise an urban system; the physical, the economic and the social environments"*	Urban planning
(Hamilton et al. 2002:109)	*"Urban sustainability is the process of developing a built environment that meets people's needs whilst avoiding unacceptable social or environment impacts"*	Urban planning

(Addanki and Venkataraman 2017:3)	*"Sustainable cities involves making the city more efficient and providing people with a high quality living environment; without draining humongous amounts of natural resources"*	Urban Planning
(Gökçekuş et al. 2010:459)	*"Sustainable development is the management and conservation of the natural resources base and the orientation of technological and institutional change in such manner as to ensure the attainment and continued satisfaction of human needs for present and future generations"*	Ecology
(Turner 2005:580)	*"Sustainability is a state or process that can be maintained indefinitely the principles of sustainability integrates three closely intertwined elements- the environment, the economy, and the social system- into a system that can be maintained in a healthy state indefinitely"*	Buildings
(ASHRAE 2006:6)	*"Providing for the needs of the present without detracting from the ability to fulfil the needs of the future"*	Buildings

It is obvious from the definitions listed in Table 2.1, that there is no agreed consensus on the definition of sustainability, most of the definitions are focusing on improving the needs of humans in the future while taking the opportunity to enhance their quality of life. From the built environment and buildings perspective, the definitions focus on maintaining a balanced state through the conservation and management of natural resources. This is achieved by minimising energy/water usage and producing less or zero waste, while maximising the outdoor and indoor quality of the occupants. The next section will explain the sustainability elements as identified by various scholars.

2.5.1 Sustainable development dimension

It is obvious from the previous section, that the ideas for sustainable development are extracted from the environmental, economic and social dimensions. Figure 2.3 demonstrates the interconnectivity between these ideas and sustainable development.

Figure 2.3 Sustainability's main pillars (IUCN 2006)

The environmental dimension of sustainability is comprised of issues related to renewable resources, wellbeing, and human anthropogenic activities that affect the atmosphere. Economic growth deals with delivering welfare and financial services that support human development, while the social dimension concentrates on issues such as health and fulfilment of human expectations. Sustainability should be achieved by simultaneously balancing these three key aspects (IUCN 2006).

2.5.2 Environmental sustainability

The environmental dimension of sustainability embraces such issues as resource consumption, the biological diversity of energy, negative environmental impacts and human health and wellbeing. It could be argued that environmental sustainability is achieved though preserving the natural renewable resources for the future (Howe et al. 2010). This means that human activity should be performed without depleting the resources of the biosphere. Therefore, minimising the use of natural resources and energy consumption should be considered as the ultimate objective for environmental protection. Similar views are highlighted by Howe et al. (2010), who argued that preserving the environment can be achieved through minimising the footprint or increasing the thermal efficiency of buildings; reducing the embodied energy associated with construction materials; preventing urban expansion or sprawl and reducing all harmful pollutions associated with buildings.

Having clean water, clean air and productive lands are fundamental objectives that enable a healthy environment. It is also impossible to imagine a scenario of achieving a sustainable environment without considering the social and economic dimensions of sustainability to support the existence of a healthy environment. Hence, assessing and evaluating sustainability in buildings must consider all these three dimensions of sustainability.

2.5.3 Social sustainability

This dimension of sustainable development seeks to focus on efforts to provide and foster equal opportunities in life for everybody. Therefore, by achieving social sustainability through the provision of jobs and meeting essential human needs, will help people to protect and manage the ecosystem and subsequently achieve sustainability (Vallance et al. 2011). In this sense, Khan (2016) argued that achieving social sustainability in buildings might extend beyond the traditional human needs to more advanced needs like thermal comfort, satisfaction for the occupant, visual comfort and productivity. However, these living standards will only be sustainable if the consumption patterns are within the limitations of the ecological capacity. This could be exemplified in buildings by the amount of energy consumed or daily waste produced to achieve the desired satisfaction and comfort levels. Within this context (Carpenter 2002) argued that sustainable development is a continuous evolutionary movement toward a better lifestyle that is limited by the ecological carrying capacity of the planet. This developmental trajectory must, at each point, be technically possible as it is necessary to focus not only on the product of the buildings, but also on the eco-evolutionary dynamics of the system if it is to be managed efficiently.

In another word achieving social sustainability, particularly in buildings, should consider, for example, maintaining thermal comfort, not only at the current time, but also in the future, as variables are continually changing and evolving (e.g. climate change, social behaviour, available natural resources, traditions culture, etc.).

2.5.4 Economic sustainability

The economic dimension of sustainable development embraces factors that foster and enhance profitability, resources, time management and manpower. In construction, for example, these activities include cost reduction by decreasing energy consumed throughout the whole life cycle (i.e. cradle to grave) of buildings and improving the efficiency to generate added value. For instance, economic sustainability can focus on reducing the operational and maintenance costs (Cetiner and Edis 2014). Other interpretations of economic sustainability in buildings were highlighted by Berardi (2013) and Adamczyk and Dylewski (2017) as: (1) decreasing resource consumption; (2) recycling resources; (3) using recycled resources; (4) use of life cycle costing and (5) return on investment.

It is the responsibility of the architects and other construction professionals to ensure that the buildings they design, and construct support all inhabitants within the built environment and they should consider doing this by implementing cost effective solutions whilst not compromising on the social and environmental dimensions of sustainability.

2.5.5 Sustainable architecture and green buildings

Sustainable development (SD) is the main agenda that promises to improve human living conditions. By not considering this conceptual idea the health and wellbeing of current and future generations will be compromised.

Revesz et al (2011) argued that to understand how SD is applied to buildings and architecture it needs to be understood what the term means. They elaborated that the first part of the term, "sustainable", means doing the same thing indefinitely, whilst the second part, "development", means to generate or to achieve a better state. Hence, for buildings to be sustainable they should be treated as part of a complex system that interacts with living species and should be considered to enhance and contribute to their better life. Buildings should be treated as a "means" rather than an "end" because creating more buildings destroys the biosphere and living organisms.

Sustainable architecture could be perceived as a conceptual idea that borrows from the accepted definition of sustainability, that is: "meeting the needs of the present generation without compromising the needs of future generations “. Iyengar (2015) argued that the main purpose of sustainable architecture was to maintain the ecological system as well as to curb energy use.

Often sustainable architecture and green buildings are used interchangeably; however, researchers in the literature distinguish between these two terms. Cole (1999) argued that green buildings are only relatively better than standard ones, while sustainable architecture is the absolute performance that is assessed against the carrying capacity of the biosphere. Mclennan (2004) addressed the reasons behind the misconception towards buildings ‘green’ labelling is due to the inclusion of green technologies that reduce some of the environmental impacts, but does not guarantee a holistic sustainable performance; therefore, some architects were reluctant to follow or adopt this new movement.

Nevertheless, being green or even sustainable does not simply push for monumental change in architecture to attain economic and social benefits, but rather to achieve a greater good for society as whole. Achieving sustainable architecture cannot be accomplished with green technology per se, but rather it should incorporate a comprehensive approach that includes design, use of materials and the needs of occupant.

Despite the broader definitions of sustainability within architecture and in the context of buildings, sustainable architecture should be dealt with comprehensively to promote long term rather than short term goals. In this regard, Sassi (2006) argued that sustainability favours long term solutions over short term benefits; therefore, to achieve its full potential, sustainability in buildings must be interconnected with all components of the built environment. In addition, the quality of life must be re-evaluated against the ethics, traditions and the culture that is embedded within. Thereby, buildings should minimise their ecological footprints which are the result of the use of non-renewable resources during the whole building life-cycle, whilst they should address the practical needs of people and enhance the environmental carrying capacity.

It is the responsibility of architects and other construction professionals to ensure that the buildings they design and construct, support all inhabitants within the built environment and they should consider this the ultimate objective through the continuous performance improvements that influence the design and operation of buildings.

2.5.6 Buildings sustainability assessments

Green building assessments are defined as tools that evaluate the buildings against sustainable criteria or standards (World Gbc 2017). The field of environmental and sustainable assessment for buildings is vast, and different tools have been developed by various institutions and research bodies. There are multiple classifications of these tools based on their sources; the most famous one by Berardi (2011), defined the assessment tools into the following categories:

1- Assessment based on the total energy demand of the building: which focuses on energy consumption.
2- Life cycle assessment (LCA): which focuses on the environmental aspects of the building.
3- Comprehensive multi-dimensional sustainability assessment frameworks for buildings verified by third parties: which focuses on the evaluation of building design and construction against environment, economic and social dimensions of sustainability.

The first two groups under these classifications are interactive tools, which give the user the opportunity to take a proactive approach and discover various options in an interactive way (Klemes 2015). The third and fourth groups, however are less interactive and can be classified as third-party passive tools that support the decision maker. This research focuses on a comprehensive sustainability assessment framework that assesses and rates the whole building, which will work as a decision-support tool for various construction stakeholders. The following section discusses and compares the well-established sustainability assessment frameworks for residential buildings in the Middle East and the rest of the world. It is worth mentioning that frameworks are not strictly limited to one group of building sustainability assessment as some of these assessments might combine two or more groups into one assessment. The next section explains these three types.

2.5.7 Assessment based on energy consumption

These tools evaluate and measure the energy consumption in various types of buildings. They measure various energy demands in building, such as: heating, cooling, lighting, ventilation, hot water and equipment usage (Klemes 2015). The distinction between energy demand activities are important as in some cases these measurements can be used to evaluate one energy demand activity, or can include multiple activities at the same time.

Often these tools measure the cumulative annual energy consumption of the building by kWh/m^2.year (Passivhaus 2011). Other types of units might include an index based on levels 0-150 such as HERS, used in the USA (IEA 2010). The final certificate produced after the evaluation of the building helps to demonstrate the degree of compliance to the national building codes as well as providing an incentive to reduce energy use.

Overall, energy assessments or certificates are useful tools for stakeholders as they enable the comparison between buildings as well adherence to both local codes and energy requirements. Having said that, these tools lack the inclusion of regional economic and social criteria and they are only concerned with mono-dimensional measures such as energy consumption.

2.5.8 Life cycle assessments (LCA)

Assessments that are based on the life cycle approach (LCA) are used to evaluate the environmental impact of a service or product (ISO14040 2006). In buildings, they are used to measure and assess CO2 consumption either during the operational stage, or during the whole life cycle of the building (Vilches et al. 2017). LCA for ISO14040 (2006) is comprised of four stages: inventory; impact; assessment and improvement. LCA’s assessment duration is normally 50 years, as this duration is considered the minimum age of the building (Klemes 2015). The main component assessed through LCA in buildings are construction materials, therefore, the environmental assessments for these materials are calculated using a regional database based on the country or region where they are currently implemented (Klemes 2015). However, the United Nations Environment Program developed an international database called Carbon Metric, which can be used by multiple countries and regions to evaluate, compare and report LCA in buildings (UNEP 2017). The final reporting measured unit is $kgCO_2/m_2$.year.

Environmental LCA lacks the inclusion of economic and social criteria; therefore, studies have tried to incorporate these (Collinge et al. 2014) and (Mostavi et al. 2017). However, there is still a lack of comprehensive approaches to evaluate these issues for developing countries such as Iraq, as there is no database currently available to evaluate environmental issues.

2.5.9 Sustainability assessment frameworks

Sustainability assessment frameworks evaluate buildings against multiple issues such as: energy consumption; pollution; GHG emissions, as well as economic and social criteria. According to Cole (2005) these frameworks are arranged in a structured manner; each of its categories and indicators being assigned either points or weights.

these frameworks are calculated by assigning either points or weights or both for the category and their indicators, then a final report is produced to show the level of sustainability performance achieved through the assessment's process. The sustainable assessment frameworks are easy to use by stakeholders, unlike the LCA assessments which are more complex to calculate. In addition, sustainability assessment frameworks attract more stakeholders and encourage their engagement during the design and construction stages of the building.

For this study, the sustainability assessment frameworks are selected as the main tools used for the development of a sustainability assessment framework for Iraq. Following the selection of the tools used for this research, a comparison was established to summarise the differences and similarities amongst these well-established frameworks to inform the process of developing a new tool for Iraq. The selection of assessment tools for the comparison was based on two criteria:

(1) The inclusion of the oldest and most well-known sustainability assessments that are currently available and these are the code of sustainable homes in UK and the SBTool internal assessment framework developed by the IISBE institute;

(2) Inclusion of sustainability assessments frameworks that are used in regions with climates like Iraq, where because of the hot climate, energy is mostly spent on cooling rather than heating, as shown in Figure 2.4. These assessments are: Estidama in UAE; Green pyramid rating system in Egypt; LEED in USA; Green star in Australia and GSAS in Qatar.

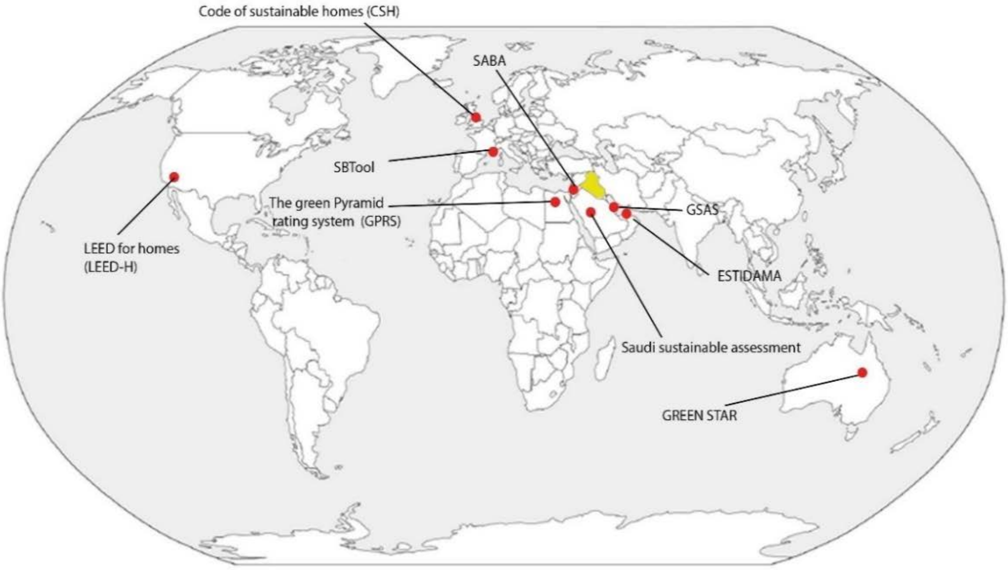

Figure 2.4 selected assessment for comparison around the world

2.5.10 BREEAM Rating tool

The Building Research Establishment Environmental Assessment method (BREEAM) was developed in the UK in 1990 by the Building Research Establishment (BRE) Global. It is considered to be one of the first assessment methods for green buildings (Kibert 2007). Different types of buildings have been included within the rating system, such as: offices, homes, industrial, schools and retail (Fowler and Rauch 2006). For instance, the BREEAM office tool version 2008 is only appropriate for the requirements of office buildings, and it is not applicable to other type of buildings. BREEAM refurbishment and fit-out has been designed to only be applicable for certifying refurbished buildings. There are also multiple versions of BREEAM for different regions in the world, such as: BREEAM Hong Kong, BREEAM Gulf, BREEAM Canada and BREEAM International (Haapio and Viitaniemi 2008), which are adapted to suit the specific requirements of different countries and regions. BRE developed the Code of Sustainable Homes (CSH) in 2007, specifically for residential buildings, which was made compulsory by some local authority planning authorities in England, Wales and Northern Ireland up until 2015. Now it is no longer mandatory but voluntary and operational (Designing Buildings 2016).

2.5.11 Code of Sustainable homes (CSH)

The Code for Sustainable Homes (CSH) is a British national environmental assessment and rating, used for certifying new residential projects in the UK. It was launched by BRE in collaboration with the UK government in 2006 as an initiative to reduce carbon emissions and to promote sustainable standards which were above the minimum building regulation requirements (Designing Buildings 2016).

According to GOV (2010), the code uses an evaluation of (1-6) levels. Level 3 is the minimum standard that must be achieved by all the new homes as this level is equivalent to the requirements of the affordable housing built by the government in 2008.

The code consists of 9 categories (i.e. Energy/CO2, water, materials, surface water runoff, waste, pollution, health and well-being, management, ecology) as demonstrated in Table 2.2. For each category, credits are awarded for each category and a weighting factor assigned to each credit. The final score of the code is determined by summarising all the achieved credits per category multiplied by its relative weighting factor, as explained in Figure 2.5. The CSH has set mandatory indicators that must be met (i.e not creditable) and failing to achieve these measures will result in zero scoring, and these are:

- Materials; environmental impact of materials
- Surface water run-off; management of surface water run-off from development
- Waste; storage of non-recyclable waste and recyclable household waste.

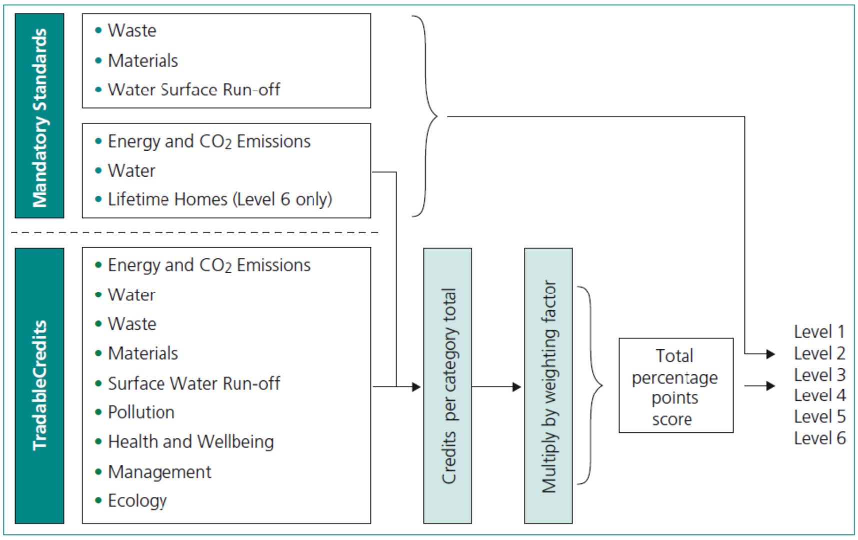

Figure 2.5 shows scoring methodology in CSH, adopted from (GOV 2010)

Table 2.2 CSH categories' credits and weights (GOV 2010)

Category	points	Weighting factor
Energy (Ene)	31	36.4%
Water (Wat)	6	9%
Materials (Mat)	24	7.2%
Surface run-off (Sur)	4	2.2%
Waste (Was)	8	6.4%
Pollution (pol)	4	2.8%
Health and Wellbeing (Hea)	12	14%
Management (Man)	9	10%
Ecology (Eco)	9	12%
Total allocated credits and weighting factors	107	100%

Upon completing the final scoring for the categories, the building is expected to have one of the following awards or certifications based on their total credits achieved out of 100%, and these levels are: level 1 (33.64% credits); level 2 (44.85%); level 3 (53.27%); level 4 (63.55%); level 5 (78.50%); level 6 (84.11%).

It's noticeable from Table 2.2 that CSH has focused mainly on energy with 36.4% as the global weighting factor, which equals the total credits allocated for the category of energy multiplied with its corresponding weight factor. Energy is followed by 14 % and 12% for health& wellbeing and ecology respectively. The reason behind the high emphasis on energy by the CSH could be the aspiration to achieve a zero carbon target planned by the government by the UK building regulations which are influenced by the European directive policy mandates, as all new buildings need to achieve nearly zero energy emission by 2020, which means the annual energy consumption of building should be roughly equal to the renewable energy produced on site (Zero Carbon Hub 2009).

There is no separate category allocated for the social and cultural categories. This clearly shows that the there is a bias in the CSH assessment making it imbalanced in terms of embracing the environmental, social and economic pillars of sustainability. Ironically, this is contrary to the BRE's statement that CSH is developed to improve the sustainability of new homes. The following suggestions could be adopted by BRE to balance the sustainability according to its weighting importance:

- Incorporating separate categories for social and economic categories;
- Incorporating indicators that reduce the cost of construction; support the use of local labour in construction; and improve the local microclimate.

2.5.12 The LEED assessment

LEED is an environmental system that was developed in the United States and was designed by the U.S. Green Buildings Council (USGBC), in order to transform the market for green buildings (Sev 2011). LEED was established in 1998 as a trial version which was known as LEED Version 1.0. LEED 2.0 was developed in 2000, incorporating improvements and providing a maximum of 69 credits and four different ratings; Platinum, Gold, Silver, and Bronze building certification (Kibert 2007). At the current time, LEED was the second most widely used sustainability assessment framework for buildings after BREEAM worldwide (Roderick et al. 2009). Within this context, most of the academic studies referred to LEED and BREEAM as the foundation for the development of all the assessments in the world (Poveda and Lipsett 2011). This may be due to the strength of the construction industry within which they are developed and also the influence of the UK and US construction industry in the global construction market.

2.5.13 LEED for homes v.4 (LEED-H)

LEED-H for homes is an environmental assessment scheme, which has been developed by the USA building green council. LEED-H is meant to certify houses that are healthier and use less energy when compared with others, with some cases that reported up to 60% less energy use (Zero Carbon Hub 2009). Within this assessment, houses are evaluated by assessing their performance against 7 main categories, which consisted of 124 indicators, whereby 19 of these indicators are mandatory and must be achieved in order to comply with the minimum level of practise. The total number of assessment categories are seven with a total of 110 credits as shown in Table 2.3.

Upon completing the scoring emulation, each project will be awarded a qualitative evaluation that is divided into four types: certified (40-49); silver (50-59); gold (60-79) and platinum (80+).

Table 2.3 LEED's categories and their allocated points (USGBC 2017)

LEED categories	Points	Number of mandatory indicators
Integrative Process	2	0
Location & Transportation	15	1
Energy and atmosphere	38	3
Water efficiency	12	1
Indoor environmental quality	16	7
Innovation and design process	6	1
Regional priority	4	0
Total	110	13

LEED-H has focused on energy consumption with 35%, followed by 15 % and 14% for indoor environmental quality and location & transportation respectively. More houses are certified in USA compared with other countries as demonstrated by LEED in the motion report (USGBC 2014). 136,731 of these buildings were located in USA followed by 2,332 in Canada, 809 in the Middle East and 98 in China.

Similar to (CSH), LEED-H did not include a separate category for the economic dimension; however, these were embedded within other indicators that aim to reduce energy consumptions; water consumption and life-cycle cost. Likewise, there was no social category, but social indicators were embedded within the assessment to improve the health and wellbeing of the occupant.

Furthermore, LEED-H did include a category called regional priority (RP) to allow for regional differences but included them within the assessment; for example, a hot arid climate (RP) will include the following:

- Annual energy use (12 points required from 29);
- Renewable energy (4 points required from 2);
- Active solar-ready design (1 point required from 1);
- HVAC start-up credentialing (1 point out of 1);
- Enhanced ventilation (1 point out of 1);
- Site selection (3 points required out of 8);
- Compact development (3 points out of 3);
- Total water use (5 points required out of 12);
- Indoor water use (3 points required out of 6)

By achieving four of the regional priority indicators out of the nine indicators listed for (PR), four extra points are added to the total ranking under that particular category. However, the regional priorities are not mandatory as the project may still achieve the platinum award without applying regional priorities. For example, a building can be awarded a platinum certification which is the highest ranked award in LEED by only achieving 80 out of 110 points, without the need to comply with (PR) category and indicators. Thus, LEED-H is still lacking an implementation of regional measures as the original indicators were not developed with consideration for the local architecture and passive cooling in the Middle East.

2.5.14 GREEN star rating tool

The Green Star design, as built, is an Australian environmental rating system launched in 2003, which was developed by the Green Building Council in Australia (GBCA 2017). The assessment tool was originally developed to accommodate requirements for building in hot climates, where cooling and solar shading systems are considered to be of high importance (Roderick et al. 2009). The council designed the tool to meet the needs of the people and to consider environmental issues in the design of the buildings through the use of multiple processes. The main objectives of the tool were to: enhance productivity; improve the health of the users of the buildings and reduce economic cost, as well as decreasing the environmental impact on the surrounding environment (GBCA 2017). Furthermore, the assessment tool has its own rating system to deliver its intended sustainable purposes. Green Star has four classifications levels, and these are: 1-3 stars (10-44 points); 4 stars (45-59); 5 stars (60-74 points); 6 stars (75+) (Roderick et al. 2009).

The main goal of the most of these categories is to assess the impact of the building on the environment and to provide a comfortable and healthy indoor environment for the building occupants. The tool is also well known for its flexibility and adaptability when it comes to the rating system, as the points assigned for the categories and indicators to complete the assessment process are not identical for all type of projects (Roderick et al. 2009). The reason behind this flexibility is that the Green Star has been designed with different systems and tools, to be adapted and applied to different building types (GBCA 2017).

Table 2.4 Green Star Ratings Points (GBCA 2017)

Green star's categories	Points
Management	14
Indoor environmental quality	17
Energy	22
Transport	10
Water	12
Materials	14
Land and Ecology	6
Emissions	5
Innovation	10
Total	110

It is obvious from Table 2.4, that Green Star focuses on reducing energy consumption as the energy category was assigned the highest points, followed by the indoor environmental quality. This could be due to the reason that Australia is aiming to reduce its (GHG) in 2030 by 50-52% per capita (Lu et al. 2017). As far as energy category is concerned, active solar energy on site was not specified and only 1 point was assigned to this indicator out of 22 available. There were also no mention of passive cooling and design strategies addressed by the assessment, as well as separate categories for social and economic categories. Finally, from the material perspective, there was no indicator that encourages the use of traditional materials, but instead it encourages the use of timber which might be due to its availability in Australia.

2.5.15 Comprehensive Assessment System for Built Environment Efficiency (CASBEE)

CASBEE for homes was developed by the Japan Sustainable Building Consortium. The first version of CASBEE is for offices and was first released in 2002, followed by new construction, existing buildings, renovation and homes.

According the CASBEE technical manual (IBEC 2014), the CASBEE version consisted of two major measures; (Q) the environmental quality of the building, and the environmental load reduction (LR). The assessment's categories included in Q are the: Qh1 comfortable, healthy and safe indoor environment; Qh2 ensuring long service life; Qh3 creating a richer townscape and ecosystem. Whereas the categories within LR are: LRh1 conserving energy and water; LRh2 using resources sparingly and reducing waste; LRh3 Consideration for the global, local and surrounding environment.

The assessment is comprised of 6 categories and 63 indicators that are evaluated via a points-based scoring system (from 5-1) where 5 is the maximum points and the best practice that could be awarded for each indicator, whilst 3 points represents the standards for building requirements that are set by the government in Japan. It is noted that CASBEE has adopted the non-linear performance for the scoring level; this could be exemplified as flexibility for the assessor, with the freedom to manually evaluate various performance levels of the intended project, based on the level of achievement.

The scoring method of the assessment is based on assigning a score for each indicator, which is multiplied by the weighting coefficient, and then adding up into a final score for quality (SQ), and a score for environmental load reduction (SLR). Thus, by assigning different scores to (SQ) and (SLR), the Building Environmental Efficiency (BEE), determines the final certification of the assessed project. The BEE is calculated by using the following equation;

$$\text{BEE} = \frac{\text{Q}}{\text{L}} = \frac{[25 \times (\text{SQ} - 1)]}{[25 \times (5 - \text{SLR})]} \quad \text{(Equation 2.1)}$$

Which:

Q= environmental quality;

L= Environmental load

The BEE is obtained after multiplying each (SQ) and (SLR) by 25 so the final outcome will fall within a scale of 1-100, broken down into 5 levels of certification: S excellent; A very good; B+ good; B- fairly poor; C poor. The minimum level of certification is B+ which represents the current practise for new buildings in Japan. It is clear from the obtained formula of rating that CASBEE assesses each indicator/item based on their environmental load or impact and this could undermine other indicators that are sustainable but do not relate to economic, social and cultural issues.

2.5.16 Estidama (Pearl rating system for Villa)

Estidama is a sustainable rating system. The term 'Estidama' in Arabic means sustainability. Estidama aims to ensure the provision of a high quality of living for human generations, by targeting and delivering cultural, economic, social and environmental needs for the current and future generations in the Middle East, particularly in United Arab Emirates (Estidama 2010). Estidama was developed by the Abu Dhabi urban council as part of a bigger plan for 2030 that aims to transform the current urban fabric and buildings in the city to make them both contemporary and sustainable. Moreover, Estidama has also been circulated and mainstreamed through the government's planning initiatives such as: the coastal development guidelines, the Abu Dhabi development code, the urban streets design manual and the sustainable urban design principles (Estidama 2010).

Figure 2.6 Estidama categories and weighting values (Estidama 2010)

Estidama is comprised of various versions (i.e. community rating system, building rating system, villa rating system) that targets specific type of buildings. Regarding categories, weighting, energy and water were the most important with 21 points allocated for each one out of 93 and an equivalent of 23%, as shown in Figure 2.6. The reason behind this could be that water and energy in UAE are interconnected issues as the country cannot meet its water demands without relying on desalinating sea water and this process accounts for 30% of the total energy consumption (Karlsson et al. 2015). Therefore, there is a pressure on current infrastructure in the country to curb the consumption of water and energy resources to improve UAE sustainable status.

The Estidama rating system for villas adopts an additive points system that is calculated by achieving maximum points for all indicators. Thereby these points determine the weighting for each category. Similar to LEED and CSH, Estidama requires mandatory credits to be achieved as a minimum standard for certifying the project, as shown in Table 2.5. 1-pearl represents achieving all mandatory requirements, whereas 5-pearl represents achieving exemplary performance.

Table 2.5 Estidama scoring points with its certification levels (Estidama 2010)

Points Achieved	Pearl Award-Level
Completion of all mandatory requirements	1-Pearl
All mandatory requirements with 30 credits achieved	2-Pearl
All mandatory credits with 44 credits	3-Pearl
All mandatory credits with 57 credits	4-Pearl
All mandatory credits with 57 credits	5-Pearl

Finally, Estidama seems to address some of the passive cooling strategies that are appropriate to the Middle East region such as the use of reflective roof material, and limiting the size of fenestration to 10% in any conditioned living space within the building to reduce the heat gain. However, the assessment does lack the inclusion of enactors that address: social and cultural values for the occupants; quality of the interior; quality of the infrastructure and dust protection.

2.5.17 GSAS for Residential Buildings

GSAS is has been developed by the Gulf organisation for research and development to promote environmental, healthy, and resource & energy efficient building practise in Qatar (GSAS 2017). The assessment has been designed to include different components and building types (i.e. commercial, core & shell, single residential building, schools, hotels, mosques, light industry, sports, neighbourhoods and parks).

According to the GSAS overview manual (GSAS 2017), the assessment was developed by reviewing 140 global sustainability assessments and codes for buildings across the world. After that it was filtered and narrowed down into 40 assessments, in which only the applicable indicators were imported and modified to be used by the assessment. GSAS-assessment’s categories and their weighting percentages have been explained in Figure 2.7, and its main categories are discussed below:

1- Urban connectivity [UC]- this category includes issues that consider urban design and planning strategies.
2- Site [S] - this category aims to contribute positively to the development area or land for the building.
3- Energy [E] - this category aims to control and reduce the fossil energy that is consumed by the building.
4- Materials [M] - this category aims to minimise the negative impact of the building on the environment.
5- Indoor Environment [IE] - this category aspires to provide a healthy comfortable atmosphere for the occupants of the building.
6- Cultural and economic Value [CE] - this category aims to optimise and enhance the richness of the cultural values of the building

7- Management and Operations [MO] - this category aims to reduce the cost over the whole life span of the building.

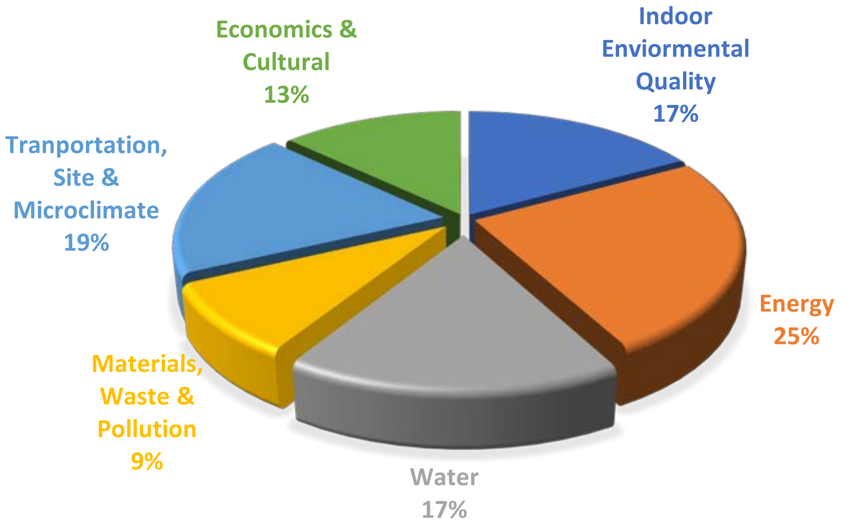

Figure 2.7 GSAS categories and their weighting values (GSAS 2017)

The scoring methodology is achieved by assigning a score that ranges from (-1 to 3), after this, the score is multiplied by its weight divided by 100 and the final score is then calculated by accumulating for each category, the scores for each indicator, to obtain the final score.

The final certification levels will range from (-) value up to +3, as the minimum level of certification is 1 and the exemplar performance is expected to be between 2.5 and 3 as shown in Figure 2.8.

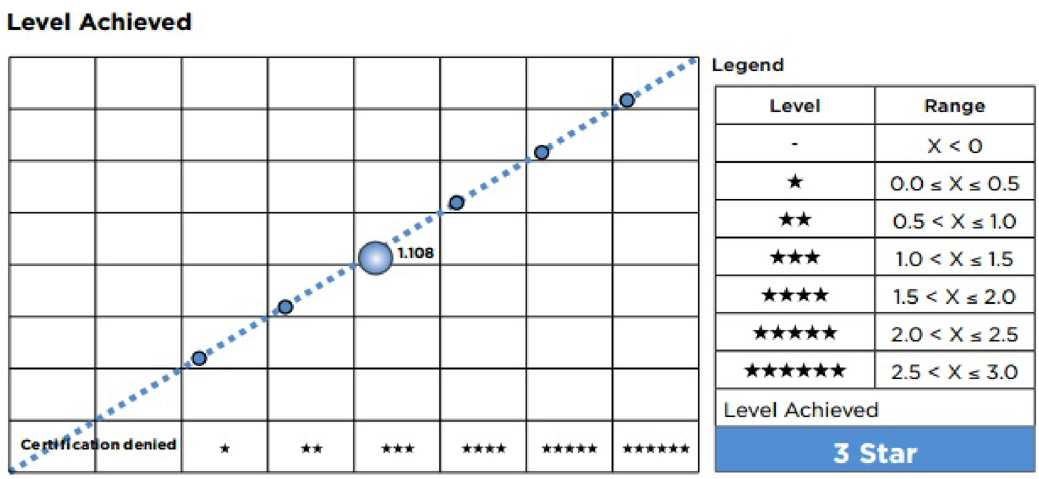

Figure 2.8 GSAS certification levels adapted from (GSAS 2015)

The inclusion of cultural and economic aspects is limited to two indicators within GSAS, and these are: 1- heritage and cultural identity; 2- support national economy. This shows that the inclusion of important indicators introducing affordable housing and supporting vernacular architecture were not counted within the assessment. Finally, the assessment does not account for any design strategy that can reduce energy consumption for a hot climate which considers, for example, diurnal temperatures and the orientation of buildings. The energy calculations, on the other hand, rely only on producing an energy certificate that compares building performance with a reference building without identifying solutions and advocating any measures that could curb the use of energy, such as, the incorporation of passive cooling strategies.

2.5.18 SBTool

The SBTool is an adaptable generic framework that assesses the sustainable performance of different buildings and project types. It has been developed by The International Imitative for Sustainable Built Environment (IISBE), an international non-profit organisation that aims to promote sustainable principles in buildings (IISBE 2015). The framework is meant to be used by a third party, such as a design team or any other organisation with more freedom to modify its categories and indicators to suit the regional or project context. The assessment evaluation is based on 7 categories: site regeneration and development, urban design, energy consumption, environmental loadings, indoor environmental quality, service quality, social-cultural aspects and economics cost aspects. Each category has its own indicators and measurements and all categories and indicators have assigned a default weighing which is supposed to be adjusted by the authorised third party. Moreover, the assessments structure is comprised of excel companion files (A and B) which requires setting the benchmark and the performance target in file A then calibrating and assigning benchmarking measures in file B.

Inside the basic input information for each project, the authorised party has the choice of setting the size of the scope of the assessment which varies between (53 for minimum indicators and 115 for maximum indicators). From a scoring perspective, the assessment follows a unique scoring methodology which comprises of an evaluation from (-1, 0, 3, 5), where 5 represents the best practise and -1 is the lowest performance. For each indicator in a category this score is then multiplied by the assigned weighting and the final certification score is then obtained by summing up these values for all categories. The final stage in the calculation (Ruckert 2010) consists of converting the numerical aggregated scoring number into an equivalent labelling letter score starting from A (best practise) to G (the minimum performance of practise).

The assessments are not easy to follow as the Excel spreadsheets are not well designed, plus the environmental issues are not adequately measured, as some will require various inputs and measurements that cannot be easily obtained in developing countries, such as, the baseline of energy consumption for building types. Another important issue worth mentioning is that the developer can only adjust the weight of the categories by + or – 10% which can undermine the flexibility and adjustment capabilities for the end users.

2.5.19 The Green Pyramid Rating System (GPRS)

The Green Pyramid rating system was established by the Egyptian Green Building Council in 2009, and has been revised and updated in recent years to include the green building codes and efficient technologies that promote sustainability in buildings (Ammar 2012). The main reasons for developing the green pyramid rating system are: (1) to provide a benchmark for buildings that evaluates its sustainable features; (2) to minimise the impact of the building upon the surrounding environment and (3) to promote an awareness of sustainable and green buildings within the Egyptian society. To be eligible for rating, the buildings must meet statutory requirements and local codes in Egypt which are embedded within the system as mandatory indicators. The final score is awarded after calculating and accumulating all individual scores that are achieved from each indicator. Upon the completion of calculating the final score, the building is assigned a certification label that describes its performance level, as explained below:

- Uncertified: less than 40 points;
- Certified: 40-49 points;
- Silver pyramid: 50-59 points;
- Gold Pyramid: 60-79 points;
- Green Pyramid: 80- above points

Regarding the importance of the categories within the assessment, water and energy were assigned the highest weight with 27% and 23% respectively as show in Figure 2.9. The total points achieved from the main categories excluding the innovation are 100, while including the innovation will add an extra of 10 points.

Figure 2.9 Green Pyramid’s categories and their relevant weighting (Ammar 2012)

The assessment lacks the inclusion of economical categories and indicators, while it does include social and cultural indicators within the innovation category. However, the score for the cultural indicator is very limited and does not affect the final certification as it only considered as bonus credits. Furthermore, the energy category only focuses on reducing energy consumption through simulating the energy use of the new building and comparing its energy reduction percentage with a reference building without demonstrating or suggesting actual design solutions. Possible solutions to guide the designer might include specifying the use of passive design strategies; local architecture considerations and the limitation of the heat island effect. Hence, the assessment needs to address local issues to be more comprehensive and applicable to the Middle East context.

2.5.20 Jordanian Sustainability Assessment (SABA)

The Jordanian Sustainability Assessment was developed to respond to the environmental, economic and social challenges faced by Jordanian buildings and construction (Ali and Al Nsairat 2009). The assessment was focused on evaluating residential buildings by assessing their performance against the following categories: site, energy efficiency, water efficiency, materials, indoor environmental quality, cost and economics. The assessment also consisted of 7 categories and 47 indicators (Ali and Al Nsairat 2009). It is clear from Figure 2.10, that water was selected as the most important category with 27% of allocated weight, followed by energy with 23% weight.

Figure 2.10 SABA's categories and their relevant weight percentage (Ali and Al Nsairat 2009)

The reason behind prioritising water against other categories is due to the other limitations for water in Jordan, as the country is classified as one of the lowest in terms of water availability per capita which is expected to be 90/m3/year in 2025 (Zaidi 2007). The country also imports 96% of its oil and natural gases from neighbouring countries to support its growing energy demands (Al-Omary et al. 2017). Therefore, energy is highlighted as the second most important category within the assessment.

Overall, the Jordanian assessment did not include cultural or social indicators. However, it does include economic and cost category for each of the 6 categories available within the assessment. Without identifying how these indicators can reduce cost and improve the economy there is still some ambiguity with the implementation of indicators related to the economics category.

2.5.21 Saudi Sustainability Assessment (SEAM)

The Saudi sustainability assessment was developed to promote sustainable buildings and green architecture in Saudi Arabia (Alyami et al. 2013). The assessment is comprised of

11 categories, in which water and energy was highlighted as the most important category; with 25% of weight allocated for the former and 18% allocated for the latter as shown in Figure 2.11 (Alyami et al. 2014).

Figure 2.11 Saudi sustainable assessment (Alyami et al. 2014)

Like Jordan and Qatar, Saudi Arabia relies on groundwater and sea water desalination in order to meet its water demands. Furthermore, the government subsidises energy and water prices; therefore, the country burns more fossil fuel and has had to increase its oil exports to sustain the level of cheap utilities. Consequently, occupants started to consume more energy, and carbon emission increased significantly in the atmosphere; hence Saudi Arabia is considered as one of the top carbon polluters in the world (Global Carbon Atlas 2017).

With regards to the assessment indicators and measures, it was found that the energy efficiency does not consider local architecture strategies in Middle East such as: buildings orientation; passive cooling; heat island effect; diurnal temperature variations strategies; offsite renewable use; use of non-fossil transportation and the social energy-consumption behaviour of occupants. Therefore, the Saudi assessment needs to be more comprehensive, by including more local indicators that reflect the climate and architecture of the Middle East.

2.5.22 Comparisons of the current international sustainability assessment frameworks

It is worth mentioning that CSH, LEED-H, SBTool and CASBEE are classified in the same domain as passive tools for rating systems, which require a third party to facilitate the assessment process. The central function of sustainability assessment frameworks is the examination of building environmental performance which requires the assessment of a list of categories that have a score or weight to reflect the priority within the assessment. To fully understand these systems, a full cross-comparison of these assessments was created to identify the similarities and the differences between them, as shown in appendices (A-I). The indicators that were applicable to Iraq was first identified then these were compared in later stages of the research with the indicators obtained from the panel in order to verify them. The most relevant indicators are considered for the new sustainability assessment framework after evaluating the level of relevance to the Iraqi context. These comparisons are discussed further in the following sections.

2.5.22.1 Energy

This category aims to reduce the overall energy consumptions of the building. From the comparisons on Appendix A, some sustainability assessments frameworks have a minimum energy performance, such as LEED-H, which is based on a local code called the House Energy Rating System (HERS) that evaluates the buildings according to the energy saving cost (Resnet 2017). CSH on the other hand, calculates the energy consumptions according to the CO2 emissions, fabric performance and their associated units of kwh/m^2.year. Other sustainability assessment frameworks define a baseline performance level and award the assessed building credits based on the energies reductions compared to a reference model. The problem with this approach is that adapting a baseline of these assessments and applying it to another country or region might not work, as these baseline levels have not yet been identified in countries such as Iraq. Thus, it could be hard to verify and implement this approach by awarding building, points based on energy performance. Moreover, from the comparisons there was no evidence that the sustainability assessment frameworks emphasised on glazing orientation or other passive house features in hot climates, such as wind catchers or evaporative cooling. Implementing passive house features in the assessment could be very useful, as they will guide the designers or the architects to gain credits by improving the performance of the building while simultaneously reducing annual cost and carbon emissions.

2.5.22.2 Water

This category is concerned with issues related to the use of water in construction. All the sustainability assessments frameworks for residential buildings that include this issue, in order to reduce over-consumption of water in construction, as outlined in Appendix B. Most of the sustainability assessment frameworks include indicators for reducing the consumption of water through the implementation of high efficient water appliances. These measures include reducing interior and exterior water usage as well as saving water by recycling grey water and rainwater for various uses. Furthermore, some such as the SBtool address the reduction of water consumption through the construction stage. This issue was not mentioned by other sustainability assessment frameworks. All the compared assessment frameworks failed to address two key issues in this category:

(1) Availability of potable water in buildings, which is a real problem in a country like Iraq. According to (Washdata 2017) only 57% of rural areas have access to fresh water as the infrastructure has been damaged owing to war and lack of maintenance.

(2) Lack of consideration for the social behaviour of water consumption, as all the assessments focused only on water efficient technologies. However, this issue could be addressed in an assessment by incorporating credits that regulate the consumption of the user such as, adding a tariff after exceeding the daily water quota consumption.

Lastly, water resources and annual fresh water availability various from country to country and from one region to another. Hence, adapting these sustainability assessment frameworks without considering the availability of resources could hinder the sustainable goals that are encompassed by these assessment frameworks.

2.5.22.3 Management

This section aims to organise and regulate the process of building construction. The main indicators for this category were compared and outlined in Appendix C. The main indicators include an integrated process of design, using engineers and specialist teams in the early design process of the project; which is a very important indicator almost ignored in Iraq. In most cases, the owners buy a plot of land and build the house with any engagement of specialist construction teams like ecologists (Un-Habitat 2006). Another important indicator was highlighted from the comparisons is the implementation of construction best practise. Iraq does not have a current standard or a benchmarking practise to follow **(**Un-Habitat 2006). Therefore, adapting construction best practise and encouraging the integration of a specialist design team early on in the project could improve the quality, alongside the improvement of sustainability standards in buildings.

2.5.22.4 Materials

Building materials are a very important component in building owing to the impact on the occupants of buildings and the environment. This element overlaps with other categories such as; pollution, energy consumptions, and indoor environmental quality. From the outlined comparisons Appendix D, all the sustainability assessment frameworks for residential buildings incorporated indicators that encourage the re-use of materials through the various stages of the life-cycle of the building. This will serve two purposes: (1) reducing the cost and (2), reducing the carbon emissions associated with the materials use. It is worth mentioning that only the LEED-H, SBtool, GSAS and GPRS include the protection of endangered materials and use of regional materials.

Iraq does have a problem with the supply of materials owing to ongoing security conflicts. Meanwhile, the country also suffers because it does not develop buildings from local materials to meet the growing demands of construction. Therefore, the new developed sustainability assessment framework for residential buildings should incorporate and emphasise indicators that encourage the development of local materials, such as cement or similar construction materials that produced locally in Iraq.

2.5.22.5 Pollutions

This category focuses on reducing the emissions and pollution in buildings and improving the environment. This issue was not included as a separate category in some sustainability assessment frameworks like LEED-H, CASBEE and Estidama, as outlined in Appendix E. It is worth mentioning that all the sustainability assessment frameworks excluding CASBEE and SABA include measures that limit the contamination of building sites. While CASBEE, LEED-H and SBTool do have measures to enhance combusting ventilation, other sustainability assessment frameworks do not mention this indicator. The inclusion of global warming measures that reduce harmful emissions on Ozone layers, are only included in codes for sustainable homes and within Estidama schemes, owing to the high usage of air conditioning in UAE. Regional sustainability assessment frameworks in the Middle East, like Estidama and GSAS, fail to address the limiting of the negative impact of the solar potential of adjacent buildings and only included in SBtool and GSAS. Some indicators, as shown from the comparisons in Appendix E, could be adopted and used in the Iraqi sustainability assessment framework but their priority should be re-adjusted to suit the Iraqi residential buildings context.

2.5.22.6 Site, Microclimate and Transportation

This category focuses on reducing the site and construction pollution, while enhancing the outdoor thermal-comfort of the microclimate. About thermal comfort, some sustainability assessment frameworks do not include this issue explicitly like GPRS, while they do award points for construction that leads to the enhancement of the landscape and use of trees. Other sustainability assessment frameworks like LEED-H do not include this indicator instead they provide some design compliance steps to be followed by the designer such as: the inclusion of screen projection, projected canopies and trees for shading. However, none of the compared sustainability assessment frameworks included water features that could be incorporated to enhance the microclimate and reduce the heat wave islands, as demonstrated in Appendix F. It also worth mentioning that only one SBTool did include indicators to reduce the outdoor heat around the building and this was achieved by encouraging the designer to use light coloured external walls.

Most of the sustainability assessment frameworks seemed to address the need to reduce carbon emissions associated with the use of cars, by making sure that all essential amenities were within walking distance to the buildings as well as encouraging the use of public transportation, see Appendix F. Nevertheless, most of the sustainability assessment frameworks failed to address the connectivity to main roads, limiting the car usage per resident to curb the use of carbon emissions by occupants. Hence these measures can be incorporated to improve the outdoor air quality while simultaneously cutting down all harmful emissions.

2.5.22.7 Indoor Environmental Quality

This category will focus on the issues such as the comfort of occupants, health and wellbeing. This category overlaps with energy, materials, and pollution, therefore some of the indicators may be included in other categories. As outlined in comparison listed in Appendix G, some sustainability assessment frameworks like LEED-H focus on enhancing the ventilation, thermal comfort, maximising day light and reducing harmful emissions from materials, whilst omitting issues such as glare control, roof shade, noise and durability in buildings. All sustainability assessment frameworks fail to include interior indicators that improve the quality and perception of interior design, therefore, these issues should be addressed in order to maximise the indoor environmental qualities for building's occupants.

2.5.22.8 Social and Cultural

This category should improve and enhance the social and cultural dimensions of design by integrating these features into buildings. Only GSAS and SBtool include social and cultural aspects as a separate category while other sustainability assessment frameworks did not include this category. According to appendix H, consideration of the visual accessibility from the interior to the exterior spaces and the need to design an aesthetic exterior were mentioned in SBtool, and SEAM while other sustainability assessment frameworks failed to acknowledge this issue.

Neighbourhood harmony on the other hand, was included in Estidama within its urban systems assessment while GSAS, SBTool and SEAM devoted an indicator for a similar purpose. Overall, the number of social and cultural indicators were very limited in all sustainability assessment frameworks. Hence the new assessment in Iraq should incorporate social and cultural indicators that reflect the local context of the country.

2.5.22.9 Economy

This category aims to reduce the cost of construction and support the local economy. As shown in Appendix I, the cost of construction was included in LEED-H, Estidama, GPRS, SABA, SBtool and SEAM. GSAS has one indicator that reflects the economy by supporting the national economy; it is assessed by including the purchases of all local products and services for the building. On the other hand, affordability of operation and maintenance cost was only included in CASBEE, SEAM and SBtool. It is also worth mentioning that affordability of living cost was only listed in SBtool and SEAM. The economic issues were not fully embraced and included within all sustainability assessments frameworks, and only SBtool and GSAS included a separate category dedicated for the economical aspect, this shows that the economic aspects of the design of buildings should be considered and included in any future frameworks that aims to be sustainable and comprehensive.

2.6 Summary

This chapter provided a comparative analysis among the well-established sustainability assessment frameworks for residential buildings worldwide. The review of assessments paid special attention to the following issues: (1) weighting system; (2) indicators and their relative score distribution; and (3) the similarities and differences among various systems embedded within frameworks. It is worth mentioning, that CSH in UK and LEED-H in USA focused mainly on reducing the energy consumption in buildings, while the assessments in the Middle East prioritised water compared to other issues, except GSAS in Qatar which considered energy as the most important category within the assessment. Most frameworks lack the inclusion of indicators that encouraged the use of passive design strategies; limited the number of cars per residential unit; delivered fresh water to residents; the harvesting of energy per residential district; the use of water cooling strategies for indoor and outdoor; building orientation and the cutting of energy use by addressing the social behaviour of occupants.

Finally, the comparisons helped to provide a theoretical route for further development of the Iraqi framework. The integration of the newly developed indicators were discussed based on their relative applicability to the Iraqi residential buildings context.

Chapter 3: Iraq's built Environment

3.1 Introduction

This chapter presents an overview of the climate and other issues that affect building performance in Iraq. The chapter discusses the country's current and projected future macro and microclimates, followed by a review of the current situation regarding the country's economic background, water availability, energy use, as well as the building morphology and architecture. The final section concludes with a summary of the key points which emerged from the issues discussed in the various sections, bridging the gaps in the literature by providing an argument for why sustainable building assessments are applicable to Iraq.

3.2 Iraq Climate

Climate conditions have a direct impact upon energy consumption and potential energy savings using renewable strategies in buildings. As such, it is important to examine these climate conditions in Iraq to identify at early stage the appropriate design solutions for buildings under these conditions.

Figure 3.1 Iraq map adopted from (CIA 2017)

Iraq has a total area of 438 320 km2 and shares its borders with Turkey, Iran, Syria, Jordan, Saudi Arabia and Kuwait, as shown in Figure 3.1. Its geographical regions are divided into three areas (Frenken 2009; Kazem and Chaichan 2012) and these are:

- Northern region with Mediterranean climate, with mild summer and cold winter—its territory starts from south of Turkey and ends south of Mosul;
- The desert region which lays and extends from north of Baghdad to the south and west border of Jordan and Saudi Arabia accordingly. It is identified with a hot arid climate;
- The irrigated area that lays between the main two rivers Tigris and Euphrates. It extends from north of Baghdad to the south of Basra.

To understand the weather performance in these three regions, a microclimate variable for typical and future scenarios in 2080 was generated using a meteorological database (Meteonorm 2017).

The weather files were used within IESVE software and a detailed analysis of the climate variables was carried out such as: temperature, heating and cooling, annual solar resource etc. The results showed three climate classifications according to ASHRAE (2007), Baghdad and Basra have the same climate (1B very hot and dry), while Mosul having two climates (3B warm dry) for typical year and for 2080 (1A very hot humid), as shown in Table 3.1. All three climates showed the presence of cooling degree days (CDD) which is measure of the severity of warm temperature over a specified period. Also shown are heating degree days (HDD), which is a similar measure to (CDD) but only focuses on measuring heating days (EIA 2016). Therefore, most of the energy consumption for buildings in Iraq, based on current and projected future conditions, is on cooling, as the maximum temperature in Baghdad reached 50°C with CDD increasing for all cities in 2080.

Table 3.1 Climate variables for typical year and 2080 for three Iraqi cities (Baghdad, Basra and Mosul) generated through IESVE

City & weather file	Climate Classification	Temperature		Heating & Cooling		Precipitation	Wind		Annual solar resource
		Max	Min	HDD	CDD	Annual rainfall	Annual speed	Direction	
Basra typical weather file	1B Very hot and dry	48.5 °C	2.9 °C	478.8	5577.7	140.6 mm	3.3 m/s	E of N 337.5°	2049.9 kWh/m^2.year
Basra in 2080	1B Very hot and dry	50.0 °C	5.5 °C	187.3	7070.3	140.6 mm	3.3 m/s	E of N 337.3°	2066.9 kWh/m^2.year
Baghdad typical	1B Very hot dry	50.1 °C	2.7 °C	475.7	5646.9	140.6 mm	3.5 m/s	E of N 321.8°	1930.7 kWh/m^2.year
Baghdad 2080	1B Very hot dry	50 °C	6.9 °C	138.7	7462.9	323.7 mm	3.5 m/s	E of N 322.1°	1942.6 kWh/m^2.year
Mosul typical weather	3B Warm dry	43.8 °C	-3.8 °C	1574.3	3376.5	323.7 mm	3.1 m/s	E of N 191.3°	1835.2 kWh/m^2.year
Mosul in 2080	1A Very hot Humid	50.0 °C	-0.8 °C	893.8	5043.4	710.4 mm	3.1 m/s	E of N 191.7°	1881.9 kWh/m^2.year

It can be seen from Table 3.1 that most of the rainfall occurs from December to April. Summer is the most dominant month where the temperature is expected to exceed 50.1°C on extremely hot days, while winter is mild, in the Southern region and it becomes colder towards the Northern region with the highest HDD reaching 1574 for a typical year in Mosul.

3.3 Economy

The economy of Iraq is mainly dependent on the oil sector and is especially vulnerable to the swing in the prices of hydrocarbon commodities. An example of this was the cut in expenditure that occurred during 2008-2009 in all Arab oil exporting countries, including Iraq, due to the volatility in oil prices (IEA 2012). According to the same report, the energy sector was the cornerstone of Iraq’s economy with oil exports contributing more than 95% of government revenues, which translated into 70% of GDP in 2011. Furthermore, the public sector was responsible for creating 40% of the total employment in the country owing to the revenues generated by oil exports. On average, compared to other country in the world, the report showed that the public sector was responsible for providing 90% shares of total employability within the country (IMF 2016).

To sustain the level of long term employment, Iraq needs to diversify its economy from oil, and to allow for more investment in other sectors of the economy to provide another primary source of job creation in the future. Shifting from public to private sector requires investment in small to medium size enterprises, however, Iraq was ranked 165 out of 190 countries in its ease of doing business according a World Bank survey (Doing Business 2016). This is mainly due to the existing restrictions on accessing lands, electricity, finance, as well as the absence of regulations. As a solution to this, business investment and foreign direct investments (FDI) should be encouraged in non-oil sectors such as construction and manufacturing. It is also essential that as the country grows that sustainable policies and regulations for buildings are implemented to ensure sustainable socio-economic and environmental development. One way to achieve this ultimate objective is to encourage investment in the building sector. For example, it is essential to develop a sustainability assessment framework for residential buildings, to ensure new buildings are designed and constructed with a responsible use of energy, subsequently leading to job creation as well as mitigating the impact of oil price volatility on the country's development.

3.4 Energy and Resources

The energy consumption of Iraq has quadrupled over the last three decades; however, this is about a fifth higher than the average of the Middle East and double the average global consumption (IEA 2012). Regarding the energy mix, Iraq relies on fossil fuel to supply energy and generates electricity as oil which constitutes for more than 80% of its total energy mix while oil usage is only 50% in other Middle East countries (IEA 2012), see Figure 3.2.

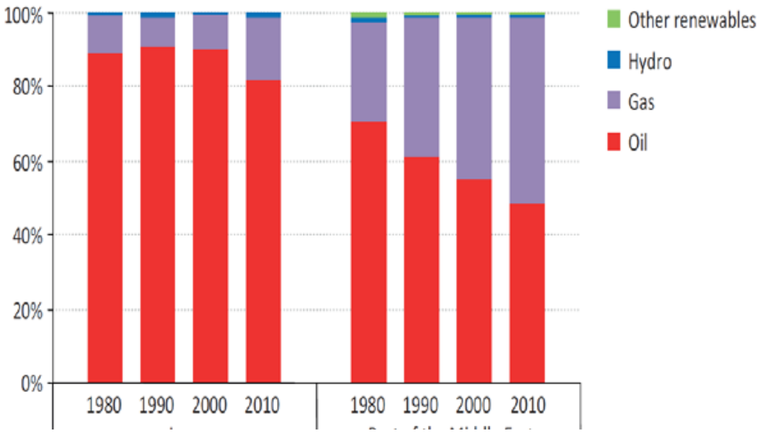

Figure 3.2 Energy's mix in Iraq and the Middle East adapted from (IEA 2012)

The transport sector is the highest consumer of energy which accounts for 57% of consumption, followed by the buildings sector with 26%, as demonstrated in Figure 3.3.

Figure 3.3 Energy demand by sector adapted from (IEA 2012)

Based on energy consumption at buildings level, the country is falling short on providing an adequate amount of electricity necessary to meet the peak demand which is estimated to be 15 GW, whilst the actual production was only 9 GW in 2011 (Saeed et al. 2016). The peak demands increase significantly in the extreme hot ambient temperature in summer with more than 50% above the supplied electricity coming from the national grid (IEA 2012). The problem with electricity in Iraq was discussed by IEA (2012), IMF (2015) and Saeed et al. (2016), their findings being summarised as follows:

1- Transmission and distribution losses in Iraq are the highest in the Middle East, which accounts for 34% of the total electricity production transferred through the national grid. This is due to the old degraded infrastructure of Iraq as well as rural electrification efforts to widen energy access.

2- Most of the electricity power stations run on gas, however, most of the time these stations will use liquid fuel to generate electricity instead of gas owing to the shortage of supply by the government;

3- Problems arise from the distribution of electricity, as most of the generators in Iraq are in the south of the country which feeds the entire country.

4- Private generators was used to meet the shortage in demand. However, this approach does come with plenty of pitfalls such as the with air and sound pollution;

5- Very cheap electricity was provided by the government through the national grids owing to the subsidy of electricity prices—this encouraged the residents to waste electricity which led to an increase in the overall demand of electricity.

To overcome the problems of the electricity supply to buildings, Iraq could utilise solar power to generate electricity to meet the increasing energy demands for both urban and rural or remote areas. The country has a great solar energy resource which is estimated to range from 1,800 to 2,390 kWh/m^2.year (Doyle and Jaafar 2009), see Figure 3.4. Supplying electricity through solar energy could also overcome the transmission and distribution losses as photovoltaics can be employed on the roof tops of buildings in Iraq to supply electricity during periods of peak demand. In addition, utilising biomass, as suggested by (Kazem and Chaichan 2012), by the conversion of: sugar cane; dates; as well as municipal waste, into biomass energy, will help to offset the energy production that relies heavily on oil in Iraq.

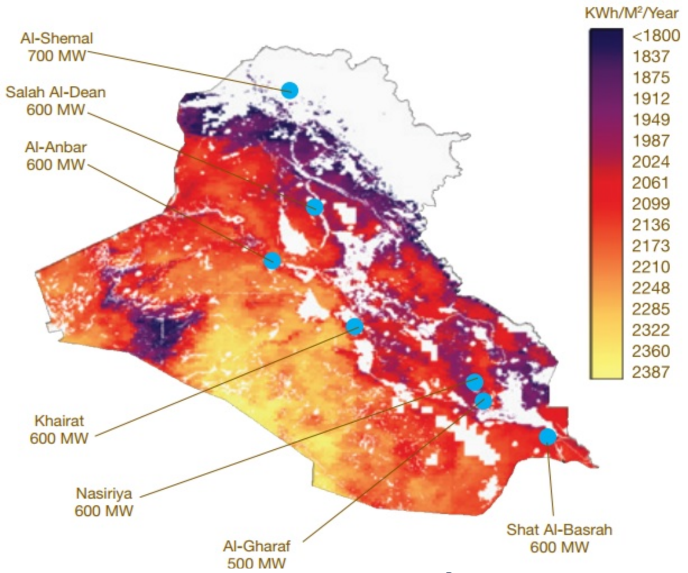

Figure 3.4 Solar potential in Iraq (kWh/m^2.year) (Kazem and Chaichan 2012)

Therefore, investing in renewable energy is vital in Iraq and should be implemented by the practitioners. Policy makers should develop policies that will shift the country away from a carbon intensive economy into a green and sustainable one.

3.5 Water

Iraq's two rivers Euphrates and Tigris both originate from Turkey and travel through the Iraqi territories. According to Frenken (2009), the Euphrates flows for 1000 km and the Tigris is longer and equals to 1300 km. Their confluence is in Southern Iraq and forms the Shat al-Arab that ends at the Persian Gulf. Turkey is the major contributor to Iraqi rivers supplying 71% of the water, followed by internal water resources in Iraq with 8%, while the rest was 6% and 4% that comes from Iran and Syria respectively (Al-Ansari et al. 2013). Therefore, water issues have arisen owing to the construction of dams in Turkey which has reduced the flow of the Euphrates to Iraq and Syria (Frenken 2009). In 2008, all the Riparian countries[1] including (Turkey, Syria and Iraq) agreed to cooperate and establish a panel which consisted of 18 experts chosen to represent each of the three countries. The panel conducted continuous studies and informed the concerned parties with future policies that should be undertaken to manage water resource distribution and use (Habeeb et al. 2012). According to Al-Ansari et el. (2013), another rising issue in

[1] Riparian countries: are the countries that share common water resource like rivers and they manage the flow and usage of these resources through certain laws and agreements (Habeeb et al. 2012)

Iraq was the water distribution and network efficiency, as only 79% of the total population had access to potable water, 92% coming from urban areas and 57% from rural areas While only 83% of the population had access to improved sanitation facilities.

Furthermore, they reported that the network efficiency was estimated to be 32% and was decreasing over time owing to the lack of maintenance, aging, and losses which occurred owing to continuous leakage. In addition, the water demands are expected to increase in the future because of oil facilities, which will add more pressure to the current existing problems of water shortage in Iraq. As the country is looking to increase its oil production in the coming years, the international energy agency expects that water injection for oil facilities in the south region will increase with an expected demand that ranges from (12 to 16 mb/day) (IEA 2012).

Other water issues related to climate change could be characterised under high increased temperature that is likely to increase droughts and reduce the quantity of rainfall in the future (Al-Ansari et al. 2014). Figure 3.5 shows the current rainfall projection under different future scenarios.

(b)

Figure 3.5 Rainfall projections for Iraq under scenario (a) and (b) in future compared with baseline (Al-Ansari et al. 2014)

Within the same context, Al-Saidi et al. (2016) showed that Iraq was within the list of top countries that were vulnerable to water stress issues in the Middle East. The country recorded a high vulnerability of 0.6 on a scale of (0-1), where 0 shows no vulnerability and 1 indicates the maximum level of vulnerability. Figure 3.6 shows that water vulnerability in Iraq could cause further social disability, violence, food shortage and economic impairment. Therefore, water management should be considered and planned by the Iraqi planning authorities to secure this resource for the present and future generations. Water conservation and sustainable drainage systems should be an important part of any sustainability assessment framework.

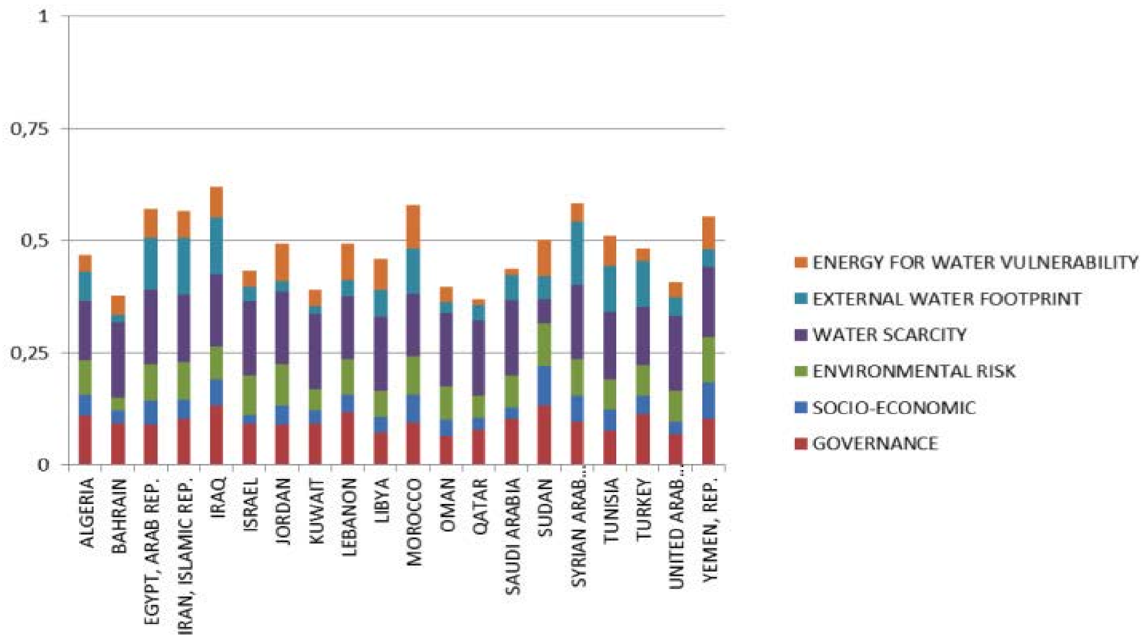

Figure 3.6 Iraq's future water vulnerability score index compared to MENA countries

3.6 Building morphology in Iraq

Many factors were attributed to the form of traditional Arabic cities in the Middle East, such as Baghdad. Environmental factors are the main reason behind the formation of the urban fabric, followed by political, religious and cultural factors.

Strategies responding to environmental issues were targeted through two stages. The first stage was on the urban scale as demonstrated in Figure 3.7, through the design of the compacted neighbourhood and the narrow alleyways to maximise the shaded areas during the day. The façade facing these alleyways normally has small openings with projected features called 'shanashel', which are balconies with openings that provide privacy for residents and allow for daylight to penetrate inside the buildings at the same time.

Figure 3.7 Aerial view of alleyways and compacted neighbourhood in old Kadima, Iraq

The second level was represented by implementing the passive cooling strategies, as these were the main characteristics that underpinned the traditional courtyard houses in Iraq. In this sense, the internal courtyard acted as a microclimate moderator to cool down the residential unit and enhance ventilation. Various studies in the literature (Almhafdy et al. 2013; Soflaei et al. 2017) have concluded that the courtyard design must consider orientation and material properties to maximise the thermal comfort of the occupants.

Figure 3.8 Double glazing in Iraqi courtyard house (Warren and Fathi 1982)

Work by Warren and Fathi (1982) showed that in most of the traditional houses the courtyard design was related to the plot area of the house and, since no front or back garden exists, the courtyards acted as recreation space with many advantages such as: enhancing circulation, ventilation, and daylight.

The glazing type used in buildings was mainly single glazing except in very rare cases, double glazing was used in traditional houses. This was demonstrated in some internal rooms that face onto the courtyard, in which the internal glazing contained ornaments, as shown in Figure 3.8.

3.7 Ventilation strategies

Various ventilation strategies are utilised in vernacular buildings. Ragette (2003) showed that natural ventilation was incorporated into the design of traditional houses:

- The building was oriented toward the prevailing winds, as well as the cross-sectional of buildings being distributed horizontally rather than vertically to enhance the natural ventilation, as shown in Figure 3.9;

Figure 3.9 Cross sectional shows the horizontal distribution of residential building (Ragette 2003)

- Use of wind catchers which are directed toward the prevailing winds that are normally located in the roof, allowed the air to cool down once it passes through the inlet, until it reached the basement, and through the courtyard as it enhanced its ventilation (Konya 2013). The cooling of the air was using evaporative cooling pads sprayed with water as shown in Figure 3.10. However, water scarcity may be a major disadvantage of these types of systems.

- Evaporative cooling was used, by placing water jugs at the window or at the end outlet of wind catchers to humidify the air and enhance cooling and ventilation (Konya 2013).
- Use of water bodies, like a fountain, was installed in the courtyard to improve the micro-climatic conditions by lowering the temperature of local ambient air temperature.

Figure 3.10 Sketch explains the use of wind catchers in Iraq (Konya 2013)

3.8 Seasonal design strategies

The traditional courtyard houses were designed with seasonal migration in mind, which means that each traditional house had two types of space: one for summer use and the other for winter use. During summer days, occupants used to inhabit the ground floor and basement, as the roof and the first-floor acted as a thermal barrier, while occupants moved to the roof during the night as ambient temperature began to gradually cool down

(Suleiman and Himmo 2012) as shown in Figure 3.11. The courtyard also acted as a vertical ventilation element with a difference in temperature of about 20°C between the ground floor and the roof. Hence, it was logical to use the basement during the day with an average temperature of 30°C, as the temperature on top floors and roof was around 50°C (Warren and Fathi 1982).

Figure 3.11 Occupant's seasonal migration in typical traditional house adapted from (Suleiman and Himmo 2012)

3.9 Current issues in housing market

UN-Habitat (2006) provided some insight into the current and potential issues facing the housing market showing that management and planning were insufficient in Iraq. For example, most of the land sub-divisions occurred in 1990 which was lopsided in favour of the main ruling party at that time, and therefore the policy proved to be inefficient because of the influence of political patronage.

Hired labours and supervised by owner/client   Self built   Private contractor

Figure 3.12 Construction of houses in Iraq (UN-Habitat 2006)

Another important issue was the lack of building standards and codes that regulated the building design and construction, as most of the new construction does not follow a proper construction practise. This issue was further exacerbated by the lack of trained construction labourers and the fact that most of the houses built in the country were supervised by the owners to reduce the cost of construction. Figure 3.12 shows the distribution of housing construction by type of contracting organisation.

Zebari and Ibrahim (2016) reported that owners and private contractors tended to spend more on the physical attributes of buildings such as a façade that shows luxury or wealth status and spent less or decided not to invest in more important elements (i.e. insulations, maximising solar potential, use of traditional passive techniques).

Furthermore, the majority of houses built in Iraq were financed by occupants themselves with either a loan from relatives or personal savings. Mortgages and borrowing from commercial banks was very minimal or absent (UN-Habitat 2006). According to UN-Habit Survey (2006) the majority of surveyed houses in Iraq, about 43% were in fair condition—which meant that they needed little maintenance, while 18 % were in very poor condition. Within the same report the surveyed households expressed their dissatisfaction with both the quality of the infrastructure and by the approximate distance of the buildings to needed social services. This can be seen in Figure 3.13 which shows the dissatisfaction of occupants within their neighbourhood. Finally, the quality of the infrastructure was the most cited problem on the residential unit's scale, as most of the houses expected to expand in size in the future because of the growth in the families of the occupants. Figure 3.14

Figure 3.13 Occupants' dissatisfaction on neighbourhood scale (UN-Habitat 2006)

Figure 3.14 Occupants' dissatisfaction on residential unit scale (UN-Habitat 2006)

3.10 Concluding remarks of current issues for residential buildings in Iraq

In summary, residential buildings in Iraq suffered greatly from many issues such as the lack of proper planning owing to the absence of, or weakness in, planning policy and controls. There is also evidence of a lack of guidance for construction practitioners, such as building regulations and sustainable building standards. The modern houses in Iraq neglect the traditional passive strategies for buildings and focus on the outer appearance of the building to reflect social status rather than focusing on functional matters. The high usage of air-conditioning owing to cooling demand leads to high electricity demand which leads which leads to peak demand exceeding the current generation capacity.

Because of this high electricity consumption, nowadays in Iraq, many buildings rely on private generators for electricity which compensate for blackout hours in the national grid electricity supply. Using private generators adds more CO_2 to the already high air pollution that is driven by oil extraction and production processes in Iraq. There is significant evidence that these anthropogenic activities will lead to significant climate change that may affect several aspects of life in the future. On the other hand, poor infrastructure was cited as the largest obstacle by the residents where poor water quality and sanitation were mentioned as the most important issues that need to be addressed. Other problems that were associated with poor planning were the distances involved in travelling to work or to access social services owing to the lack of provision for public transport and the locating of the properties in isolated neighbourhoods. Figure 3.15 summarises all the current and expected future issues affecting housing in Iraq.

There is a growing need to tackle these issues by developing a sustainability assessment framework for residential buildings, as it could bring the following benefits to residential buildings:

- Improve the overall sustainability of buildings.
- Improve the health and wellbeing of the occupants.
- Set a benchmark for buildings to be used as a measure for improving sustainability in the future
- Reduce the natural non-renewable resources used in buildings;
- Make cost savings in the design, construction, operation and demolition for buildings;
- Decentralise the construction market and stimulate the growth of investment in buildings;

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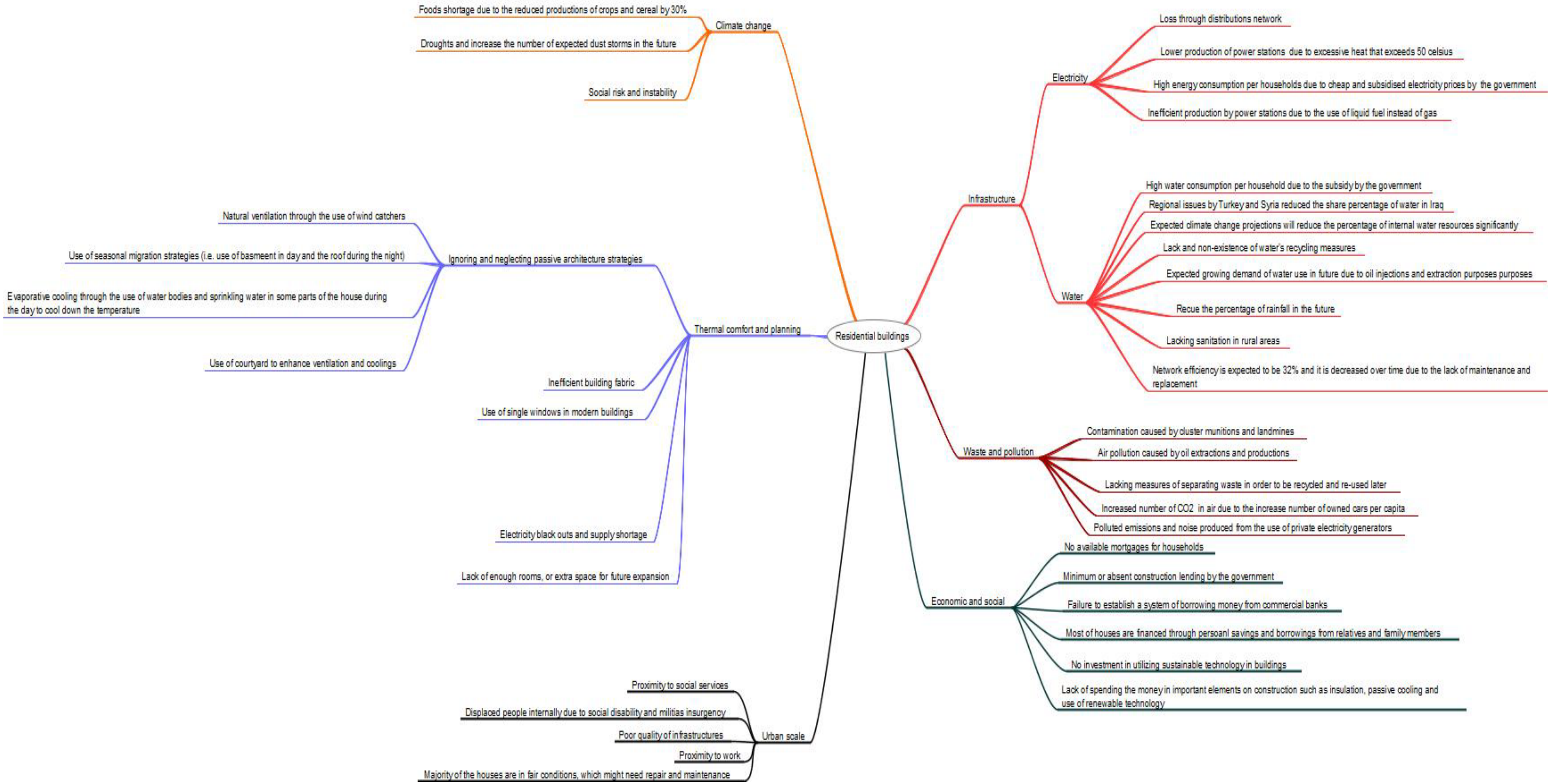


Figure 3.15 Summarised factors affecting the built environment in Iraq

3.11 Summary

This chapter provided a comprehensive review on various aspects related to the economy, environment and architecture of Iraq. This chapter showed that because the climate is hot and arid there is an expected demand for cooling in the future, adding more pressure on the generators that currently cannot supply enough electricity to the households during peak hours in summer. Furthermore, Iraq relies on fossil fuel to supply electricity as more than 80% of its energy mix is based on oil, while 0% of energy is obtained from renewable sources. Iraq does have a great potential for the use of renewable energy that ranges from (1800-2390) kWh/m^2.year, therefore, considering solar energy by incorporating solar panels and PVs on top of roofs while increasing the efficiency envelope of buildings will ensure enough electricity is provided during peak hours.

It is also worth mentioning that lack of building regulations and planning policies for residential buildings increased the degradation of infrastructure and environment. For example, based on UN-Habit report (2006), most occupants expressed their dissatisfaction with the infrastructure as well as the distance they had to travel to work and social services, which encouraged the residents to use cars instead of using greener options such as walking. Hence, the incorporation of a sustainable building assessment framework presents an opportunity for the future, to regulate the sustainability performance of residential buildings while curbing carbon emissions.

Chapter 4: Methodology

4.1 Introduction

This chapter is focused on demonstrating the philosophical assumptions applied to this research alongside describing the methodological approach selected to achieve the aim and objectives. This chapter also presents the research design and use of the quantitative approach through the employment of a longitudinal design survey. The Delphi technique, which was selected for data collection, implementation, and sampling, is discussed in detail. Following the discussion of Delphi, the analytical hierarchy process (AHP) is also discussed with a commentary elaborating why it was selected and how it fits within the research design.

4.2 Research Theory, Epistemological and Ontology Considerations

According to Bryman and Bell (2013) the term theory is expresses many things; but, mainly it is commonly used to explain an observed regularity. Researchers should explain research regularities through the collection of data. The main two approaches are deductive and inductive. The former is concerned with testing existing theory; whereas the latter is focused on developing a new theory. These two approaches are influenced by research philosophies such as epistemological and ontological considerations.

Dainty (2007) described ontological philosophy as a perception of reality comprised of objectivism and constructionism. Bryman and Bell (2013) suggested that objectivism refers to social phenomena as well as external realities being either independent entities or social actors. They defined constructionism as a social phenomenon that is associated with social actors, which keeps changing depending on the interactions with social actors. On the other hand, epistemological philosophy is concerned with what is considered an acceptable knowledge, and how this knowledge can be conveyed to others (Saunders et al. 2016). Epistemology is categorised into positivism, realism and Interpretivism (Bryman and Bell 2013). Positivism referred to using existing theory to reach a conclusion that can be generalised which follows scientific structured methods to analyse the data (Saunders et al. 2016). While realism denotes objects as being independent of the human mind, interpretivism advocates the understanding of humans as social entities without relying on existing theories to reach generalisation like positivism (Saunders et al. 2016). The understanding of these paradigms reflects the type of contribution to knowledge that is added to the field of study. Indeed, Knight and Ruddock (2008) stated that without identifying the use of epistemological and ontological considerations in research, the contribution of knowledge cannot clearly be explained. Table 4.1 explains the characteristics of research philosophies and their data collection techniques. According to the aim and objectives of this research, the type of data gathered in this research focused on studying the phenomenon of a sustainability assessment framework for residential buildings and it follows an epistemological philosophical stance which best fit the description in Table 4.1 for epistemology under the positivism column. The collection of the data used multiple quantitative rounds, therefore it followed a positivist assumption to verify and objectify the findings of the research. This included generalising the results obtained from the new developed assessments categories and their indicators to other assessments in different countries in the world.

Table 4.1 Research philosophies and their data collections (Saunders et al. 2016)

After deciding the research philosophy and approach, it is also important to identify the research purpose as well. Three types of research purposes are discussed in the literature (Crossman 2016; Saunders et al. 2016). These are:

- **Exploratory:** This research seeks new insights through studying a phenomenon or clarifying an understanding of a certain problem. It might include elements such as: literature reviews, interviews, and focus groups;
- **Descriptive:** This research seeks to clarify some events or phenomena-- often it comes after exploratory research and its final remarks should be a means to an end but not an end in itself. An example might include a survey of an entire population by statistical analysis that shows the causality of the results tested through correlations (Grimes and Schulz 2002);
- **Explanatory:** This research focuses on studying a phenomenon or situation and test the relationships between variables within that phenomena or situation;

The purpose of this research is firstly exploratory, which seeks to explore the sustainability assessment frameworks through the literature review secondly, this is followed by descriptive research as the study seeks to develop a new sustainability assessment framework for residential buildings using a survey. Finally, the study is going to discuss the results by establishing relationships and correlations that aim to generalise the final outcomes.

The different types of research purposes normally follow either qualitative, quantitative or both approaches for analysing the data. The main distinction between qualitative and quantitative is that quantitative research is typically related to natural science in that it is intended to investigate natural phenomena; whereas, the qualitative approach is more concerned with perceiving and exploring the human experience. Overall, matching the research philosophies and approaches above with the aims and objectives of the current research, this research is epistemological and follows a positivist approach that seeks to analyse the data quantitatively while using a cross sectional time horizon, see Figure 4.1.

Figure 4.1 Research onion modified to explain the philosophies and approaches used in this research (Saunders et al. 2016)

4.3 Research Strategies

Research strategies can be employed by the researcher for exploratory, descriptive and explanatory research. Robson (2013) argued that the essence of using research strategies is mainly to answer research questions. The research strategy can either be quantitative, qualitative or both. In this regard, Saunders et al (2016) clearly distinguished between these strategies by claiming that quantitative strategies are positivist, normally following a deductive approach, incorporating natural science. While qualitative strategies are more inductive, rejecting conventional norms and considering social reality as continuously emerging and changing.

4.4 Research Design

Research design is a framework that determines the process for collecting and analysing the data while choosing research methods that fit the purpose of the study (Walliman 2006). According to Bryman and Bell (2013) research designs are categorised into: (1) experimental design; (2) case study design; and (4) survey.

4.5 Experimental studies

Experimental studies are applied to study the influence of, and relationship between variables in a controlled setting. In this sense, experimental research quite often manipulates the independent variables to measure corresponding changes in the dependent variables (Leavy 2017). Experimental design is quantitative and relies on testing the cause and effect after introducing an intervention to the experiment. There are different settings within which to conduct an experiment (e.g. lab-based or field-based, etc.) (Leavy 2017). The results generated from experimental design are often considered a benchmark compared to other designs owing to the robustness of the findings. However, Saunders et al (2016) argued that generalisation of the findings for experimental design is very difficult to prove since the experiment is conducted to test an effect on a specific group and the settings are limited to either lab-based or field-based.

4.5.1 Case study

Case studies are one of the most common strategies that has been used in studies by various disciplines. Case studies are empirical inquiries that explore the phenomena within its real-life context, which are used when the boundaries between the phenomena and its context are not clear or well defined (Yin 2011). A case study can answer questions such as “why?”, “what?” and “how?” therefore, it is most often employed in exploratory and explanatory research (Saunders et al. 2016).

The data collection can be qualitative and quantitative or both, and may use: observation; semi-structured interviews; documents analysis and questionnaires. Yin (2011) classifies the case study into: single case; multiple cases; holistic and embedded. Multiple case studies are preferred as the findings from one case study can be analysed and compared with findings of other cases to be generalised which is harder to achieve with a single case. A holistic case study analyses one case study or entity. Conversely, an embedded case study is concerned with analysing the sub-units of a particular case, hence, final analysis will include multiple layers or elements. Case study can be a very effective research design to challenge an existing theory with new research questions.

4.5.2 Survey Studies

Survey studies usually follow a deductive approach, and quite often they seek to answer questions such as "who?"; "what?" or "how many?", therefore, they fit in with exploratory and descriptive research (Saunders et al. 2016). Surveys allow an easy way to collect and analyse data quantitatively using inferential statistics. In essence, they allow for an easy way of comparing variables and drawing a conclusion that can be generalised to a whole population. Surveys can take many forms such as: structured observation; structured interviews and questionnaires (Leavy 2017). Survey research can fall into two categories, which are cross sectional and longitudinal.

4.5.2.1 Cross sectional

Cross sectional is part of survey design which includes questionnaires, structured interviews, structured observations and diaries (Bryman and Bell 2013). This research design seeks to identify variations in data, which are established when the researcher collects the data through using more than one case (i.e. organisation, nations, populations). This is very different to experimental research, as the survey is only collected once from the sample, rather than many times in long time frame, to check the results before and after the test (Bryman and Bell 2013). Surveys are a quick method to collect the data compared to other research design approaches, however careful attention should be taken to select a representative sample.

4.5.2.2 Longitudinal design

The main features of longitudinal design are the study of change and development of variables that are collected through the cross-sectional design. This research design seeks to collect the data at least twice from the cross-sectional case. Bryman and Bell (2013) suggested that longitudinal design was used less than other methods because of the cost, however, it can be a very effective approach to gain a special insight by analysing a phenomenon from different contextual viewpoints. The main advantage of using this approach is the ability to draw inferences among tested variables for long time frame usually more than one year of data collection, which cannot be achieved if a cross sectional approach was employed. There are two types of studies for this research design:

1- Panel studies: which relies on collecting data from a random sample on multiple occasions.

2- Cohort studies: which include selecting a sample that often shares the same characteristics.

4.6 Data Collection

4.6.1 Overview of the Delphi technique

This study adopted Delphi as the main research data collection method. Delphi's meaning is derived from a place in Greece where Priests used to discuss and consult personal affairs, public policies and war issues; therefore, the name is associated with having good judgement on issues (Keeney et al. 2011).

The Delphi technique was developed first by the US military during the 1950s, to evaluate the impact of technologies on warfare and consequently reach a convergence of opinions on possible policies that related to that matter (Keeney et al. 2011). The technique has been used in various types of research and defined as a tool managed by the facilitator to seek a specific goal/purpose, investigate policy and to predict the occurrence of future events (Hsu and Sandford 2007).

The process of collecting information through the Delphi technique requires managing the survey and controlling the flow of information by the researcher. Basically, the researcher conducts many anonymous discussions and debates by circulating questions to the panel engaged in the subject of the study. Obtaining the relevant information from the panel requires remoteness and anonymity of the process as this helps to reduce the issue of conflicts and disagreements among the panel. The final step of the process requires the facilitator to analyse and tone down the obtained feedback and responses through various cycles to reach a robust finding. With regards to the research philosophy and approach, Keeney et al (2011) suggested that the Delphi technique follows survey research design by the utilisation of questionnaires to collect the data; it also applies a deductive and positivist research philosophy. Conversely, in very rare cases it can also be identified as a qualitative method to collect data through interviews while following, for example, an interpretivist research philosophy.

The fundamental concept of Delphi relies on using the maxim that "two heads are better than one" when it comes to making decisions. Delphi is a method aimed to reach the consensus of panel on an issue/target and to subsequently develop a set of solutions or decisions based on the feedback (Silva 2012). Delphi has been employed as it is in line with the aim and objectives of this study. According to (Hsu and Sandford 2007) and (Keeney et al. 2011), the characteristics of the Delphi technique are classified as follows:

Anonymity

The first step requires the distribution of the questions privately to each individual member of the panel, and by contacting these individuals through email or post. The advantages of doing this is to allow the individuals to express their opinions freely, as well as eliminating the influence of respondents upon each other during the data collection, therefore, giving the chance for the panel to review the answers, evaluate and adjust their final responses accordingly.

Iteration

This step is a multi-stage process which will require the researcher to distribute many question to the panel several times, as this will enable the researcher to extract and tabulate the responses of the panel accordingly.

Panel judgment

This feature represents the extraction of responses in the form of statistical indicators such as the mean and median. For instance, the judgements will express the opinion of the panel for a question thus all the answers will then be reflected in a statistical form.

Controlled Feedback

The exchange of information among the members of the panel is subject to filtration and control. Ideally, the coordinator will receive the reviewed answers, and only then will they be able to analyse these responses and use them as feedback in the development of the next round. The merits within this stage are; eliminating any heated arguments between the members of the panel and facilitating the smooth development for the research. Finally, the nature of the questionnaires varies in the Delphi technique: the first round of questionnaires is unstructured to allow for the gathering of as much data as possible that is related to the subject; while the second round of questions are based on its predecessor stage and employs a more structured form. After each round the facilitator will analyse and summarise responses statistically. The subsequent rounds of questionnaire processing will continue until stability and consensus has been established. Ideally this could be achieved through two to three rounds.

4.6.2 Justification of using Delphi technique as a main methodology

Although there were many methodological approaches in the literature considered for the development of a sustainability assessment frameworks for residential buildings in Iraq, the Delphi technique was the most appropriate choice. This was because the use of Delphi fitted the aim and objectives of the study, but also:

- Allowed a consensus to be reached by experts in the field.
- Facilitated the evaluation of factors or criteria based on their level of influence and importance on the topic.

Within this context, ecological and sustainability assessment frameworks are usually identified as multi-dimensional subjects **(**Ding 2008). Asli et al (2016) recommended the implementation of methodological techniques based on the consensus of panel to explore these multi-dimensional subjects and evaluate them accordingly. Therefore, Delphi was selected in this research as it fitted the purpose of the research, as well as seeking consensus on complicated multi-dimensional issues similar to the sustainability assessment frameworks for buildings. The technique consisted of an anonymous and iterative-survey; responses being gathered in rounds, with the intention of increasing these rounds until stability is achieved. There are different types of Delphi methods as illustrated in Table 4.2 (Gnatzy et al. 2011).

Table 4.2 Various Delphi methods and their characteristics (Gnatzy et al. 2011; Keeney et al. 2011)

Classical Delphi is more appropriate for this research because it aims to reach a consensus of the panel by iterative rounds. The method relies mainly on repetitive consultation and summarised feedback that has been gathered from professionals during the processing of the questionnaires. The members of the panel are given the necessary anonymity and confidentiality and are provided with an opportunity to complete the survey within their own free time and any distractions that might occur during the evaluation process for the questionnaires are minimised.

4.6.3 Research Process

This research employed questionnaires as the main instrument to collect the data, being distributed in multiple rounds using the Delphi technique.

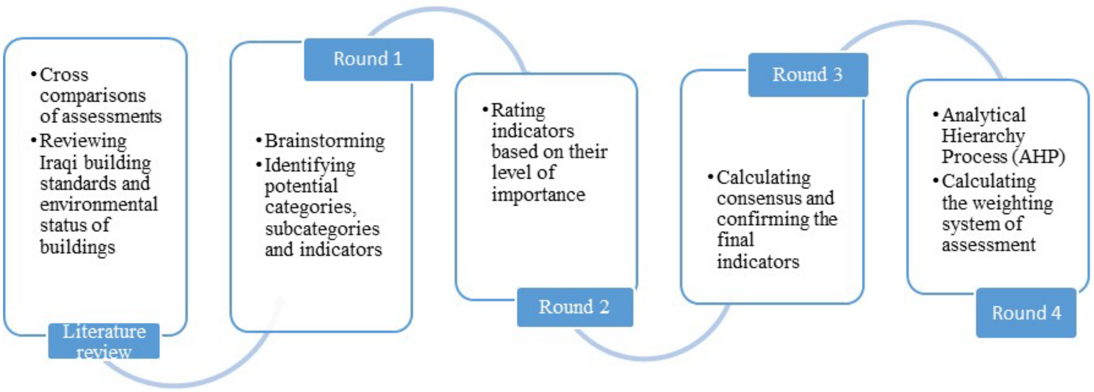


Figure 4.2 Stages of research

The multiple stages of this research, are illustrated in Figure 4.2 and are broken up into the following stages:

Literature Review: A comparison between the most common sustainability assessment frameworks for residential buildings used worldwide, reviewing the current state of residential buildings in Iraq, to identify applicable categories and potential indicators appropriate for the new assessment.

Round 1: selection of a panel of experts who, by using the Delphi technique, and open-ended questionnaires identify the initial categories, subcategories and indicators for the subsequent rounds of questionnaires;

Round 2: evaluation of the indicators based on their level of importance in accordance to the categories and subcategories as determined in round 1.

Round 3: confirming the final categories, subcategories and indicators by achieving consensus.

Round 4: conducting a pairwise comparison to evaluate the importance and calculate the weighting of the final categories, subcategories and indicators through use of analytical hierarchy process (AHP).

4.6.4 Sampling - Selection of Delphi Panel

The selection of the panel is a critical element that affects the success of the Delphi method (Linstone and Turoff 1975; Nworie 2011). There is no precise method for selecting the Delphi panel that has been articulated in the literature. However, there were recommendations in the literature to ensure the verification of the selection process that were followed in this research (Linstone and Turoff 1975; Hsu and Sandford 2007). Hsu and Sandford (2007) argued that investigators must make sure that the panel are trained well and are willing to reach a final judgement on the output.

Also, there is no precise guidance in the literature which specifies the number of panel members. (Okoli and Pawlowski 2004) showed that the number of members could vary from 10 to 50 but that it should be large enough to allow patterns of responses to be identified, and not so large that it complicates feedback and analysis. Loo (2002) argued that researchers should not focus on the number of members, but instead should focus on the criteria for selecting the members, such as: knowledge, capability, relevant experience and professional qualification that relate to the subject of study.

The sampling chosen for this research was non-probability sampling, which relied on the judgement of the researcher to identify cases and individuals, to answer the research questions and to subsequently meet the research objectives. Hence, the research should be careful to include or exclude cases when selecting the sample.

Purposive sampling uses judgement to provide the maximum variation possible in data collection. It enables the researcher to identify and explain various key themes that can be observed through the data collection stage. The sample might include cases that are different, and this could be considered as a weak sample; however, Patton (2009) advocates this type of sampling and considered it to be strong and representative. As such, heterogeneous sampling will help the researcher to gain an insight into a particular topic from different perspectives owing to the nature of the research. To eliminate the bias in the sample, it was important take the following steps to ensure representation of a comprehensive sample, as recommended by Okoli and Pawlowski (2004) and these steps were:

1- Identifying individuals based on their experience, skills, academic background and knowledge of buildings.

2- Creating a list of names for potential panel members and assigning them to their organisation, institution and groups.

3- Contacting individuals and asking them to nominate other potential members of the panel.

4- Ranking the members of the panel based on their experience and knowledge.

5- Contacting and inviting the final list of members on the panel to participate in the study.

6- Terminating the selection process after recruiting the target size of the panel.

Owing to the limits in the knowledge regarding sustainable buildings in Iraq, the sample that was chosen include the following members of panel:

- Professionals comprised of: 3 architects, 3 Mechanical, 2 Electrical, 3 structural engineers, 3 certified sustainability assessors) with 2 years of experience at least in buildings and construction.
- Academics: lecturers and researchers with academic publications for sustainable buildings and materials which included academics from the following universities in Iraq: 6 participants from The University of Baghdad; 3 participants from University of Mosul and 1 the University of Basra. In addition, the panel members include 3 academics from Coventry University as the University was actively engaged in holding a competition for architectural students in Iraq under the name of the Tamayouz award. Therefore, the study selected academics from Tamayouz owing to their knowledge in Iraqi buildings and architecture.
- Decision makers: (6 construction project managers, 7 planers based in ministry of construction and ministry of water in Iraq)

To ensure a high response rate and commitment by the panel, it was important to explain the purpose as well as engaging them with every step of the study as recommended by Keeney et al. (2011). Therefore, the importance and impact of the study was explained to the panel members, as well as increasing their sense of ownership and engagement by making regular contact keeping them updated with current research development. Table 4.3 shows the total number of the panel who agreed to enrol and complete the subsequent questionnaires. It is worth mentioning also that the total duration of data collection lasted for seven months, in which the responses were analysed and sent to the member of the panel after the completion of each round of questionnaires. Following each round of questionnaires, the answers were summarised using statistical methods to show each individual response as well as the total responses by the panel. This allowed the panel to re-evaluate their answers and comparing them with their colleages, so they can decide whether they keep their responses or they change them. After obtaining all responses from each round the consensus was calculated and the indicators that achieved the consensus criteria was kept and the one that did qualify for such condition was disregarded.

Table 4.3 Delphi Panel

Panel speciality	Contacted participants	Round 1 participants (open ended questions)	Round 2 participants (evaluation of assessments indicators)	Round 3 participants (evaluation of assessment indicators)	Round 4 participants (pair-wise comparisons)
Building professionals	70	14 (34.14 %)	14 (34.14 %)	14 (34.14 %)	14 (34.14 %)
Academics	75	13 (31.70%)	13 (31.70%)	13 (31.70%)	13 (31.70%)
Decision makers (governmental bodies, planning authorities)	60	14 (34.14%)	14 (34.14%)	14 (34.14%)	14 (34.14%)

4.6.5 Comparison of the most famous sustainability assessment frameworks across the world

The first and most important step used to develop a new sustainability assessment framework was the cross comparisons and analysis of the well-established and most common assessments across the world (Cole 2005). Therefore, the selection of these methods through the literature was based on certain factors including: applicability to the regional context; building type applicability and the credibility of the framework developers. Moreover, the analysis of the frameworks was based mainly on the reviewing of certain documents, including: technical-manuals, and the recent literature review. This helped the researcher to identify the main similarities and differences between the categories and indicators used in various assessments from countries with similar weather conditions to Iraq.

4.6.6 Round 1: seeking Panel opinions/consultation (brainstorming stage)

This stage involves the use of the Delphi technique which seeks to gather and consolidate information from the panel by asking them open ended questions in order to gain a general overview for subject of study. The stage includes:

(A) Brainstorming by asking the panel open ended questions to gather more information about the subject and comparing the gathered information with the criteria and indicators that have been gathered.

(B) Narrowing down the factors and consolidating the information from the literature.

4.6.7 Round 2

The questionnaires distributed in the second round consisted of extracted indicators from the first round alongside indicators extracted from the literature. These indicators were re-classified according to the categories and subcategories of their intended purpose. In total there were 10 categories and 15 subcategories with 131 indicators that were structured into statements. A Likert rating scale of 1-5 was selected for this study since the nature of questions were based on rating the indicators (Saunders et al. 2016).

The scoring scale included the following rating levels: (1) not applicable; (2) not important; (3) important; (4) very important; (5) extremely important. A mixed mode of data collection was used including online and manually distributed questionnaires. This increased the flexibility of the survey and allowed more time for respondents to fill in the questionnaires. This round focused on filtering down the indicators removing those that were not applicable from the study after calculating the consensus of the respondents from round 3.

4.6.8 Round 3 calculating the consensus

Round 3 of the questionnaire were developed to confirm the indicators selected from round 2 with the same questions being redistributed to participants in round 3 to seek a consensus. Following the achievement of a consensus, all relevant indicators were retained, and average rating values were calculated. The Delphi studies used various methods to arrive at a consensus, some of them relying on statistical descriptive criteria while others used subjective non-statistical criteria as shown in Table 4.4. The first study listed in the table relying on Kendell's W, a non-parametric test, which achieved consensus with 31 participants. (It is worth noting that this qualified the number of members selected for this study, which also used 31 participants for conducting the same test). Other studies used the interquartile range as a filter for consensus. Being a statistical measurement that divided the set of data into four quartiles and calculated the value of the third quartile, which was then subtracted from the first quartile. Rayens and Hahn (2000) used the interquartile range to assess consensus with accepted values that fell between 0 and 1 on a Likert scale of 1-4. They also concluded in their study that there was no clear justification for the use of 0-1 as the interquartile range to achieve consensus. The interquartile range could be a suitable measure to achieve consensus on issues that are to be filtered down by participants. The problems associated with using the interquartile range are: (1) the interquartile range might not be the same over two consecutive rounds and (2) it might not be an ideal option for studies that includes the ranking and ordering of issues and is more applicable to filtering issues.

On the one hand, researchers used various statistical measures for consensus such as the mean (Carrera and Mack 2010), while others used the standard deviation together with the mean to highlight areas of high convergence (Rogers and Lopez 2002). The standard deviation is a measure to quantify the degree of variation in a set of data. A low value of standard deviation shows that there is little difference between the obtained values, thus there is a good level of consensus. Other measures used to assess the degree of convergence in Delphi studies might include the coefficient of variance, which is calculated by dividing the standard deviation by the mean. Using this method, to achieve consensus, the calculated value should not exceed 0.5 (Sharma et al. 2003).

The final group of researchers used subjective non-statistical criteria to decide the point to terminate the number of rounds of questionnaire distribution in order to achieve consensus whereas Fan and Cheng (2006) used a pre-defined number of rounds, justifying using this approach because exceeding three rounds could put more pressure on the participants having a negative influence on the results, as well as encouraging some of the researchers to withdraw from the study because it was taking too long.

Table 4.4 Reviewed studies that used various consensus measurements for Delphi

Reference	Aim of the study	No. of Rounds	No. of Participants	Consensus measurement	Scale or Ranking	Reason for selecting consensus
(Rayens and Hahn 2000)	To identify policy measures that moderate the use and control of tobacco in Kentucky	Two rounds with structured questions	115	Interquartile range (0-1)	Scale (1-4)	Based on a similar study in the literature that used same consensus measurement
(Carrera and Mack 2010)	Identify the sustainable energy indicators that have an impact on social issues	2 rounds followed by a workshop	39 participants	Use of thee Mean followed by group workshop to confirm consensus	Scale (1-5)	The author sought to achieve consensus through holding a workshop
(Erffmeyer and Lane 1984)	Post-group consensus	One round/ session	Un-specified	Post-group consensus obtained through meeting	None	The consensus measure was tested as part of some broad comparisons of different measures used to achieve consensus among participants
(Rogers and Lopez 2002)	Identify various psychological characteristics ’ competencies	Two rounds: first with open-ended and structured questions, followed by a final round	24	Standard deviation and mean	Scale (1-5)	By considering the results of a similar study in the literature that used the same consensus measurement

		with structured questions				
(Ray and Sahu 1990)	To identify productivity management indicators and measures	Three rounds: first round was open ended followed by structured questions for second and third rounds respectively	34	Relative interquartile range; where 0 and 1 refer to the accepted level of convergence/consensus	Scale (1-4)	The author sought that the calculated mean with relative interquartile range could be used as a consensus and ranking measurement; thus items were ranked in accordance with their mean and interquartile relative range.
(Sharma et al. 2003)	To identify issues that impact the future of energy use in India	Two rounds with structured questions	44	Coefficient of variation	Scale (1-5)	No justification but this measurement is suitable for parametric analysis which might be suitable for this study
(Fan and Cheng 2006)	To identify the training competency measures of sales representative that increase productivity in Taiwan	Three rounds of structured questions	10	Pre-defined number of rounds, which was (3)	Scale (1-5)	author considered three rounds was enough to achieve consensus on issues ranked according to their scale

According to the studies reviewed the best method for quantifying consensus was found based on the following criteria:

1- A standard deviation that is equal or less than 1.64;

2- A coefficient of variance with a value that is equal or less than 0.5;

3- A stipulated number of round, which in this case will be three, as any study that seeks to execute further rounds will put pressure on participants, and could be biased.

4.6.9 Validation

Questionnaire validity could be achieved through internal validity; which represents the ability of questionnaires to measure the items that it actually intends to measure (Saunders et al. 2016). In another word, the responses from the questionnaires should reflect the reality of what the research wants to measure through the questionnaires. Therefore, there is no point in collecting data from questionnaires unless it provides answers to the research questions and ultimately achieves the research objectives. According to (Litwin 1995; Cooper and Schindler 2008) validity is classified into three types and these are:

- **Content Validity:** This represents the accuracy of the measurement that is used by the researcher to collect the data. Certain conditions need to be met for the content to be valid: the sample must be representative in order to ensure the quality of the context are essential for the study. For example, the questions must cover the topic that is identified in the study. In this research validity is achieved by the choice of method used by the researcher to collect it, relying on the judgement of the panel. They will then assess the questions by choosing them based on three criteria: essential; useful but not essential and not necessary. After that, all the questions that have been rated as essential will be further assessed by calculating the content validity ratio and the items that meet the minimum statistical threshold for the test will be kept and the rest disregarded.

- **Criterion related validity:** This refers to a measure of how well the research instrument correlates with another well-established instrument. It can be divided into two types: (1) concurrent validity: which requires the instrument to be tested against an accepted standard or index well established in the literature. Normally this method is tested through correlation. The drawback of using this method is the problem of identifying a benchmark from the literature that can be compared with the outcome of the questionnaires to draw a correlation. (2) Predictive validity: which is very similar to concurrent validity except that it requires having a significant correlation between the result of the study and a well-established outcome that could occur in the future.

- **Construct validity:** this type of validity measures how meaningful the survey instrument in practical use and includes two types: (1) convergent validity: which implies that multiple methods for obtaining the same information about a given idea should produce similar results; (2) Divergent validity: which requires the instrument survey to have a low correlation value to show the differences between the two measured scales or data. Both types are hard to achieve because they require a lot of effort and a great deal of experience in designing the survey.

Following consideration if the validation types discussed above, it was decided to select the most relevant technique to suit the Delphi process used in this study. The content validity test was selected as the most relevant technique to be used, as the Delphi process already provided an opportunity for testing validity through its panel of experts. To meet the content validity requirements, the selected sampling type was non-probability purposive sampling; this ensured that the data gathered will be valid, as the panel were selected based on their experience and knowledge of sustainable buildings. Furthermore, the output from stage one and two of the Delphi process were sent to five members of the panel to assess using the content validity test. The calculated content validity ratio used assured a good level of validation for the questionnaire content.

4.6.10 Round 4 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) was originally developed by Thomas Saaty in the 1970's. AHP is a multi-criteria decision-making approach enabling the researcher to design and structure a complex problem in a hierarchical order (Saaty 1994). The first step of AHP subdivides a research problem into smaller inter-related components which are then extracted and combined into a comprehensive framework. AHP breaks down a research problem into: (1) goal; (2) categories; and (3) sub-categories. The goal represents the central issue that comprises the scope of the study. The lower hierarchical levels of categories and sub-categories are components that allow the evaluation of the problem (Satty 1994).

AHP focuses its attention on reducing subjectivity by incorporating a mathematical and statistical form. In this sense, the importance of the categories and sub-categories are analysed and then interpreted into a weighting scale. To generate the weighting scale, pair-wise comparisons determine the level of importance of each category to the main goal and sub-categories to the respective categories. Therefore, round 4 consisted of questionnaires that require the respondents to rate each category and sub-category by a scale of 1-9 as suggested by Saaty (1994).

4.6.11 Rationale for selecting AHP in this study

The area of sustainable buildings and its influence on the surrounding ecology is still considered as a disputed subject. Up to the current time, no single approach has been selected to comprehensively tackle the ecological and environmental research area (Ding 2008). Therefore, the concept of sustainable development has come to be established as a standard to assess the best practise in human interaction with ecology viewed from different perspectives such as: multi-criteria, social, economic and ecological.
Environmental assessment of buildings promotes sustainability and its inherent values (Cole and Jose Valdebenito 2013). In this regard, promoting the best construction practise in the industry is one of the key elements that is embedded within the sustainable values (Berardi 2012). To develop any sustainability assessment framework for buildings, a structured weighting system should be planned and established to encompass a wide variety of desired sustainable construction principles (Ali and Al Nsairat 2009). Hence, there are various numbers of methods created from the current available construction appraisal systems (Kajikawa et al. 2011). These methods were influenced by numerous factors such as: climatic conditions, geographical locations and economic and social aspects. According to (Gou and Lau 2014) every country and nation requires its own framework, to make sure that the construction practice adheres to sustainable standards.

The AHP method is one of the multi criteria dimension methods (MCDA) which provides an applicable weighting system for assessing the importance of issues for categories and sub-categories of data involving many different criteria which need to be considered. For example, a study conducted by Ali and Al Nsairat (2009) to formulate an ecological instrument for assessing the sustainability performance of buildings in Jordan, incorporated the following steps in their methodology: first, reviewing all building assessments and second, evaluating and appraising the selection of categories and their relative indicators by using the AHP technique. This technique has also been used to develop other assessments (e.g. CASBEE SBtool, Estidama, etc.), which shows that AHP is the most common technique used to evaluate categories and sub-categories for the sustainability assessment frameworks for buildings. Another important reason of selecting AHP is that most of the sustainability assessments implemented this technique for their development of the weighting system **(**Villarinhorosa and Haddad 2013).

4.6.12 Hierarchical structure of sustainability assessment

The AHP technique seeks to break down complex problems into structured elements. This, process established many hierarchical levels including: goal, category, sub-category and indicators (Saaty 1994). Hence, the first level within the hierarchical structure identifies the central issue which is the goal that underlines the subject of the work, followed by the lower levels (categories and sub-categories), by which the new sustainability assessment framework for residential buildings can be evaluated, as shown in Figure 4.3.

Figure 4.3 Illustrates the graphical representation of AHP hierarchical-levels (Saaty 1994)

Statistically, the three levels of the problem are solved by conducting pair-wise comparisons between the categories and the sub-categories to calculate their relevant statistical priority. The pair-wise comparisons will help to examine the consistency level extracting relevant information from the judgementally assigned numbers which will be within a ratio scale of (1-9) as outlined in Table 4.5, thus simplifying the qualitative information into quantitative information to be better assessed and interpreted.

Table 4.5 Saaty's pairwise comparisons scale (Saaty 1994)

According to (Saaty 1994) the pairwise comparisons are obtained from the matrix:

$$A = \begin{bmatrix} a11 & a12 & a1n \\ \vdots & \ddots & \vdots \\ an1 & \cdots & anm \end{bmatrix} \qquad \text{(Equation 4.2)}$$

a11 represents a ratio of two weights based on the judgement assigned by the member of the panel. To calculate the weight for each category and subcategory a geometrical mean must be calculated to obtain the collective judgements of answers. Saaty (1994) suggested checking the consistency of each individual judgement through the following equation:

$$\mathrm{C.I} = \frac{(\lambda\max - n)}{(n - 1)} \qquad \text{(Equation 4.2)}$$

Which;
λmax represents the maximum eigenvalue of matrix A

n= the number of matrix

$$CR = \frac{C.I}{RI} \qquad \text{(Equation 4.3)}$$

CR represents the consistency ratio;

RI represents the ratio index which is a fixed value obtained from Saaty (1994).

CR must equal or be less than 10%; if CR was more than 10% then the judgement would need to be revised and repeated to ensure the reliability of the responses. The calculated weight of AHP was discussed in Chapter five. Overall the use of AHP enabled the researcher to calculate the weight for categories and subcategories of the newly developed sustainability assessment framework for Iraq, as well as providing a basis for comparing the outcome of new assessments with other assessments developed in the Middle East region and the rest of the world.

4.7 Summary

This chapter presented an overview of the methodology that was employed to meet the aim of the research. Sustainability assessment frameworks for residential buildings deal with a wide range of categories and subcategories, thus, the research design consisted of: (1) comparing the assessments for residential buildings worldwide; (2) selecting a panel of experts in the research and managing the data collection using the Delphi technique and; (3) employing the analytic hierarchy process to obtain the weighting scale for the new assessment in Iraq.

The first stage required the identification, key similarities and differences between various sustainability assessment frameworks, for residential buildings worldwide and demonstrating their applicability to the Iraqi context. The second stage focused on selecting a panel of experts to participate in the Delphi technique by narrowing down and selecting the most applicable indicators that were relevant to Iraqi residential buildings. The third stage was conducting a pair-wise comparison of categories and subcategories to obtain their relative weight.

The next chapter presents the analysis and discussion of categories, subcategories and indicators developed for the new sustainability assessment framework for residential buildings in Iraq.

Chapter 5: Result and Analysis

5.1 Introduction

This chapter aims to identify the main categories, sub-categories and indicators for a sustainability assessment framework and explains why these indicators are relevant to the Iraqi residential buildings context. This chapter presents the analyses of data through subsequent stages of questionnaires until consensus and stability of responses was achieved. 41 members of the panel from different disciplines were selected including academia, industry, and governmental bodies.

Following the development of indicators, the analyses of the final round of questionnaires are discussed in detail including final categories and sub-categories with their weighting values. Finally, a summary is presented to conclude with the final remarks and findings developed through this chapter.

5.2 Round 1: Brainstorming

As explained in the previous chapter under section 4.6.6, the first round seeks to identify the main indicators for assessment by mining the ideas of the panel. After identifying the main categories of the assessment from the comparative analysis in the literature review, the questionnaire was structured to seek the opinions of the panel on which indicators would be associated with the categories. The indicators selected and the questions to be answered for the gathering of data from the brainstorming were:

1- Management Plan—This category promotes the integration between stakeholders during the design and construction stage, and ensures the long-life performance in the operation and maintenance of the building. The question to be answered for the gathering of data was: '*Could you please list the main management plan factors or strategies that must be taken into consideration during the design and construction of the building'?*

2- Indoor Environmental Quality—This category is concerned with the factors that affect the health and wellbeing and satisfaction of the occupants which might include for example, the level of noise or illumination. The question to be answered for the gathering of data was: '*Could you please list the main factors or strategies that affect the indoor environmental quality?'*

3- Energy Optimisation—This category is focused on the factors and strategies that could improve energy consumption in buildings which might include for example, passive design strategies, and the use of renewable energies. The question to be answered for the gathering of data was: '*Could you please list the main factors or strategies that affect the use of energy in residential buildings?'*

4- Water Efficiency—This category includes factors and strategies that associated with efficient consumption of water in buildings. This may include the following criteria: water recycling for instance. The question to be answered for the gathering of data was: '*Could you please list the main factors and strategies that affect the water-efficiency in residential buildings?'*

5- Waste Management—This category is concerned with factors that are related to pollution from waste generation. This might include: recycling facilities and the re-use of structure or materials. The question to be answered for the gathering of data was: *'Could you please list the main factors or strategies that affect the waste management in residential buildings?'*

6- Materials and Resource Use—This category is concerned with issues that are related to the efficient utilisation of materials during various construction stages in the building, this might include: the use of environmentally friendly or recycled materials. The question to be answered for the gathering of data was: *'Could you please list the main factors or strategies that concerned with the utilisation of materials and natural resources in residential buildings?'*

7- Site and Microclimate—This category is concerned with issues that relate to the selection of the site and the influence of the microclimate influence on the buildings. This might include, for example, outdoor thermal comfort and biodiversity. The question to be answered for the gathering of data was: '*Could you please list the main site and the microclimate factors or strategies that influence the design and the construction of residential buildings?'*

8-Transportation—This category is concerned with the implementation of measures that encourage sustainable transportation during the design and construction of the building. The question to be answered for the gathering of data was: '*Could you please list the main factors or strategies that affect the utilisation of measures in buildings?* '

9-Social and cultural— This category is concerned with issues that are related to the selection of traditional cultural or social aspects, such as local architectural features or specific local codes, that enforce a certain type of design or use of materials. The question to be answered for the gathering data was: *'Could you please list the main the social and cultural factors or strategies that must be considered in the design or construction of the building?'*

10- Economic Efficiency— this category is concerned with issues that are related to the cost of the building. This might include certain procedures for construction, incentive schemes promoted by the government, or any codes/ design legislation that contribute to reducing the cost of the building. The question to be answered for the gathering of data was: '*Could you please list the main factors or strategies that affect the economic-efficiency in residential buildings?* '

The answers from the questionnaires were analysed and the suggestions for indicators were listed. Indicators that would achieve the same purpose were combined into one and replicated or reduntant indicators discarded. The main indicators identified in the first stage are illustrated in Figure 5.1 and discussed briefly in this section, further analysis being provided in Round 3, after obtaining a consensus of answers from the the panel.

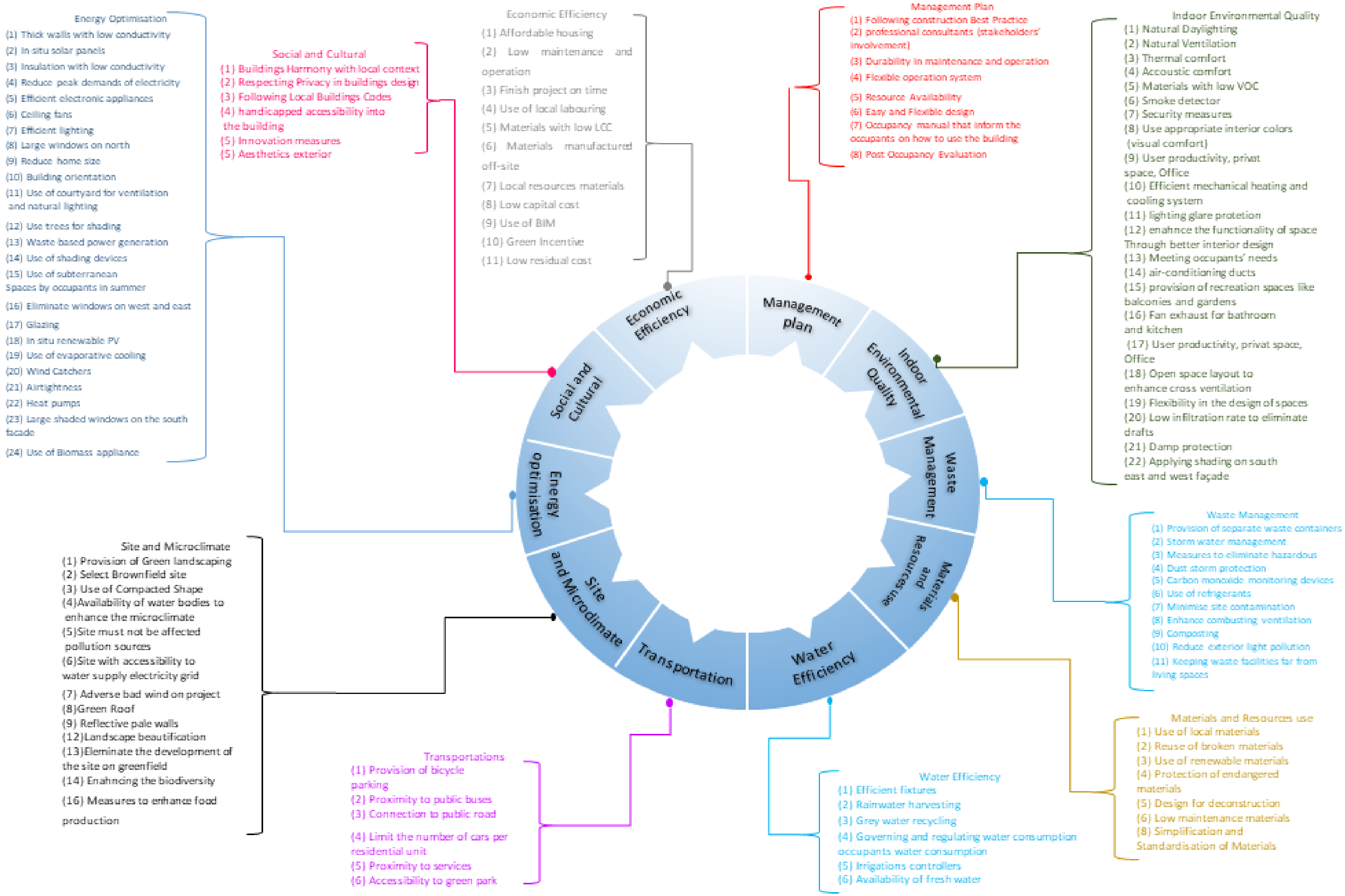


Figure 5.1 Categories and their corresponding indicators identified from Round 1 (brainstorming)

5.2.1 Management Plan

Most of the respondents highlighted the inclusion of construction best practice to deliver a building with optimum sustainability performance. Owing to a lack of information there hasn't been any benchmarks established for buildings that have achieved high quality in construction and sustainability in Iraq.

Other indicators included within this category focus on managing resources and operation systems for buildings. Following the categorisation of these indicators, it was decided to include subcategories for this category for the next rounds of questionnaires. These sub-categories were: (a) Building Management and (b) Building Occupant management.

5.2.2 Indoor Environmental Quality

The respondents listed 15 items within this category as demonstrated in Table 4.2. The items in descending order of frequency were; natural daylighting, natural ventilation, acoustic comfort and thermal comfort. Following the analysis of this stage, the listed indicators were re-ordered and re-grouped under three sub-categories: (a) Controllability (items that trigger the indoor environmental quality); (b) Indoor services and (c) Interior qualities and functions.

5.2.3 Energy Optimisation

The indicators listed in this category focused on issues such as improving the building envelope efficiencies; increasing the airtightness; optimising passive house strategies; the utilisation of renewable energy and the use of efficient lighting and appliances. Therefore, the sub-categorisation of these indicators are: (a) Building envelope; (b) Efficient indoor appliances, heating and cooling; (c) Efficient designs and strategies and (d) Renewables.

5.2.4 Water Management

The indicators for this category focused on measures that reduce water consumption by: indoor & outdoor controllers; rainwater harvesting and regulating the social behaviour of the occupant.

5.2.5 Waste Management

The panel placed emphasis on issues such as provision of separate waste containers for recycling; hazards reductions; reducing impacts that affect global warming and other issues that are associated with eliminating waste from buildings. Hence the sub-categorisation of indicators under this category were: (a) indoor waste and (b) outdoor waste.

5.2.6 Materials and Resource Use

The panel listed indicators that aimed to reduce the wastage of materials during construction and encourage the use of materials which were either broken or with little operational cost. The indicators obtained from this round were categorised into: (a) resources sourcing and (b) environmental impact of materials.

5.2.7 Site and Microclimate

Some of the indicators listed in this category such as the availability of water bodies or those associated with landscape, that reduce the heat wave island effect were not considered in the international sustainability assessment frameworks. Their main function was to reduce the high temperature surrounding the building during the hot summer season and to prevent the building using too much energy for cooling during the hot summer season. The indicators were further divided into two sub-categories for the subsequent rounds, and these were: (a) heat wave islands and (b) biodiversity and infrastructure.

5.2.8 Transportation

It is obvious from responses gathered within this category that the member of the panel encouraged the use of alternative public transportation accompanied with the provision of public facilities within walking distance from residential buildings.

5.2.9 Social and Cultural

The answers gathered from this category placed emphasis on the inclusion of building standards and the cohesion of the appearance of the building with its context. It is also worth mentioning that some novel indicators were highlighted by the panel within this category such as accessibility for the handicapped; the exterior aesthetics and consideration for of privacy in the design and construction of building.

5.2.10 Economic Efficiency

The most indicators listed by members of the panel in descending order of frequency were: low rental cost, low maintenance, followed by operation cost and finishing the project on time. The panel mentioned other indicators that will contribute to the reduction of the cost of buildings in future, such as: the use of BIM in the design and construction of the building and following green initiatives.

5.3 Round 2

Questions for the second round were based on the answers obtained from the first round, together with indicators from other sustainability assessment frameworks to ensure the most applicable indicators were considered within their associated category. Unlike the first round of questions which were open-ended, the second round of questions were structured, and respondents were asked to answer questions using a Likert scale from (1-5). Both round two and three sought to obtain and evaluate the level of importance of indicators and subsequently measure the degree of consensus among respondents to decide which indicators should be kept and which were removed. Therefore, after collecting the responses from round 2, the answers were analysed, and statistical values were send to the panel, which offered them a chance to change their answers after seeing the responses from the other members. The final consensus was calculated after two subsequent rounds to determine the stability of the responses and whether subsequent rounds were required or whether to terminate at that point.

5.4 Delphi Round 3

As discussed in Chapter four, see section 4.6.8, round 3 is concerned with determining and calculating the consensus from the responses. Therefore, the questionnaire from round 3 was identical to the questionnaire from round 2 to confirm the answers from the previous stage. Another conditional requirement for indicators to be included within the final sustainability assessment framework was to achieve a mean value above 2.5, since any value less than that was considered to be not important and not applicable to the assessment. The following sections discussed the final indicators obtained from this round.

5.4.1 Management Plan

The indicators within this category were divided into sub-categories that best represent them, and these subcategorises were:

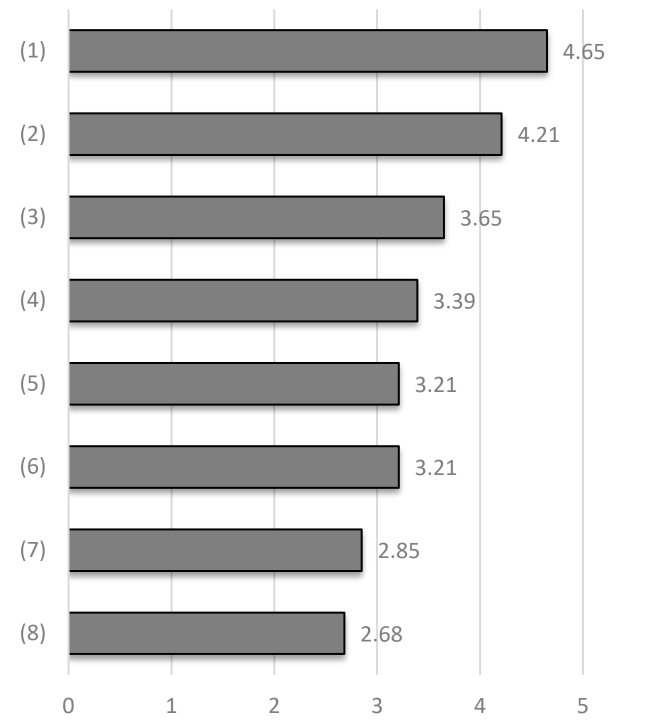
5.4.1.1 SUB-CATEGORY A (Building Management)

Eight indicators were selected for this sub-category, as shown in Table 5.1. Construction best practice and project team integration was selected as the most important indicators with a mean of 4.65 and 4.21 respectively. This could be due to the failure of the government to implement and enforce a building code as suggested in recent studies by Al-Taie et al. (2014) and Haykal (2016). The need for a buildings code is to ensure that buildings follow best practice in the selection of mechanical, plumbing and sanitary equipment, as well as health and safety concerns. Moreover, project team integration was selected as the second most important indicator. This indicator should be considered during design and construction stages, as it encourages the participation of involved parties early in the project to share their ideas and apply them from start to finish.

It is worth mentioning that an evacuation plan was highlighted as the lowest indicator with a mean of 2.73. The reasons behind listing this indicator could be due to the lack of security in Iraq and its impact on the occupants of the building. Another reason for selecting this indicator could be to assist older and disabled occupants to evacuate the building by creating links to all the necessary official departments within the city such as: local health centre; police, and fire station in the event of an emergency.

Table 5.1 Sub-category (A) building management indicators

Indicators	Round 3		
	Mean	St.Dev	CV
(1) Following construction best practice	4.65	0.57	0.12
(2) Project team integration	4.21	0.68	0.16
(3) Resource availability	3.65	0.76	0.20
(4) Durability: maintenance and operation	3.39	0.91	0.26
(5) Flexible and adaptable design (easy to construct and change)	3.21	0.82	0.25
(6) Flexible operation of building systems	3.21	0.82	0.25
(7) Commissioning plan	2.85	0.79	0.26
(8) Evacuation Plan	2.68	0.68	0.25

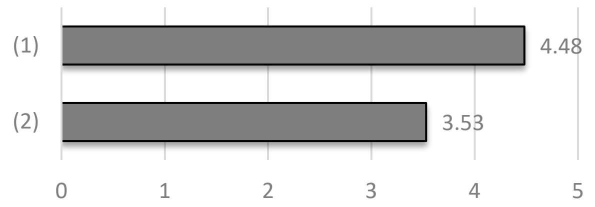


5.4.1.2 SUB-CATEGORY B (Occupants Management):

According to Table 5.2, two indicators were assigned under this sub-category. The panel identified that post-occupancy evaluation was the most important indicator as it focused on monitoring the performance of buildings during post-construction stage when occupants were using the buildings. This procedure is important to ensure that the design matches the actual performance as built (RIBA 2017). The provision of a user manual was also listed by the panel, as it aims to guide occupants on how to use the building wisely by providing a procedure for reporting a problem and describing the operation and maintenance of the building within the project. The user manual should be easy to understand for occupants, and should be available as printed copy, on CD or online.

Table 5.2 Indicators of sub-category (B) occupants' management

Indicators	Round3		
	Mean	St.Dev	CV
(1) Post occupancy evaluation	3.53	0.89	0.25
(2) User manual	4.48	0.71	0.15



5.4.2 Indoor Environmental Quality

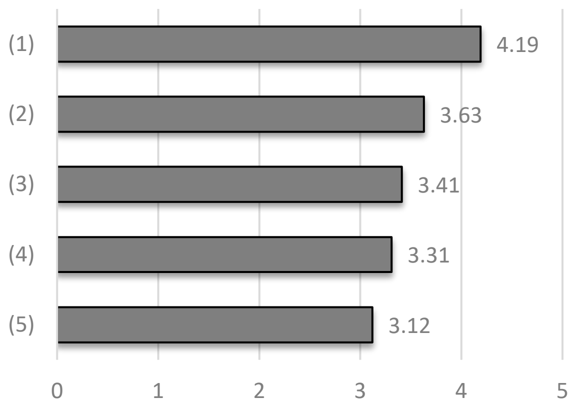
This category was subdivided into the following sub-categories:

5.4.2.1 SUB-CATEGORY A (Controllability)

This sub-category focused on issues related to elements that influence the indoor environment and can be controlled by the occupants. According to the responses of the panel, as shown in Table 5.3, an efficient mechanical heating and cooling system was preferred to natural ventilation, as the external temperature for a typical hot summer in Iraq exceeds the indoor comfort levels, so, external air inflow should be kept to a minimum in the day and maximized at night owing to the high diurnal temperatures that would involve. On the other hand, the indicator of roof shading devices was given the lowest rating in this category owing to its limited influence and usability in terms of the indoor environment as compared to its counterparts within same sub-category

Table 5.3 Indicators of sub-category (A) controllability

Indicators	Round3		
	Mean	St.Dev	CV
(1) Efficient mechanical heating and cooling system	4.19	0.78	0.18
(2) Natural ventilation	3.63	0.91	0.25
(3) Daylighting glare controllability	3.41	0.74	0.21
(4) Lighting glare controllability	3.31	0.90	0.27
(5) Roof shading devices	3.12	0.84	0.26



5.4.2.2 SUB-CATEGORY B (Indoor Services)

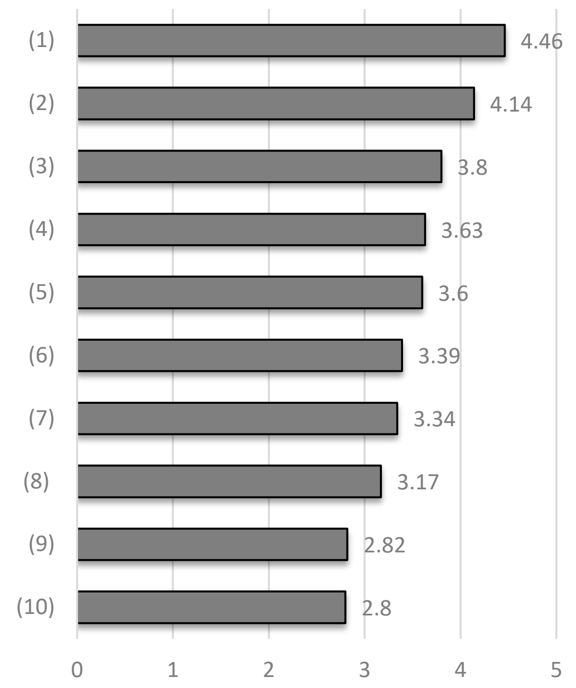
This sub-category was concerned with indoor services that control the indoor environmental quality. It is clear from the ratings in Table 5.4, that thermal comfort was selected as the most important factor, as temperatures in Iraq during summer months can reach up to 50°C, see section 3.2. Therefore, reducing the indoor temperature to achieve healthy comfort levels indoors is critical for buildings in such a climate. Similarly, balancing the indoor temperature in winter is challenging, where ambient temperature in northern region such as Mosul can be as low as -3.8°C.

The defined thermal comfort temperature as defined by (Bateson 2016) is 28°C for living areas. The overheating period should not exceed this temperature for an annual occupied hour of 1%; whereas, 26°C for bedrooms, with no more than 1% of annual occupied hours exceeds this temperature.

These defined temperatures can vary depending on internal gains, activity level and metabolic rate of the occupants in the spaces. Furthermore, the panel listed issues that impact the indoor health of occupants such as, materials with low VOC and damp protection. For the former, these materials can be found in paintings and adhesive materials, thus designers must select materials with low VOC to mitigate the pollutions emitted from these chemical compounds (EPA 2017). As for the latter, special types of moisture control can be applied to building construction to prevent the occurrence of such damage in buildings.

Table 5.4 Indicators of sub-category (B) indoor services

Indicators	Round3		
	Mean	**St.Dev**	**CV**
(1) Thermal Comfort	4.46	0.73	0.25
(2) Natural daylighting accessibility to functional spaces	4.14	0.69	0.16
(3) Acoustic comfort	3.80	0.84	0.22
(4) Security and protection measures	3.63	0.96	0.26
(5) Fan exhaust for bathroom and kitchen	3.60	0.84	0.22
(6) Airtight air-conditioning ducts and opening	3.39	0.83	0.24
(7) Accessibility to internet services	3.34	0.93	0.27
(8) Smoke detector	3.17	0.77	0.24
(9) Materials with low VOC	2.82	0.73	0.25
(10) Damp Protection	2.80	0.67	0.23

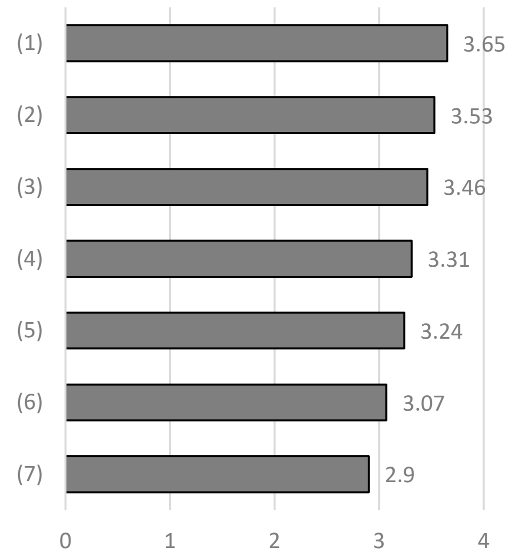


5.4.2.3 SUB-CATEGORY C (Interior Qualities and Functions)

Seven indicators were listed by the panel in this category as shown in Table 5.5. Distinctive indicators were found in this sub-category that were not mentioned in other international sustainability assessment frameworks such as; functionality of spaces and open space layout to enhance ventilation. Another important indicator highly rated by the panel was the use of interior colours to enhance the mood of occupants and the function of buildings. The influence of colours on boosting the mood of residents has been supported by studies in literature (Yildirim et al. 2011; Kurt and Osueke 2014). Finally, according to the opinion of the panel, the provision of a recreational spaces was the least important indicator compared to similar indicators within this sub-category.

Table 5.5 indicators of sub-category (C) interior qualities and functions

Indicators	Round3		
	Mean	**St.Dev**	**CV**
(1) Functionality of the spaces through interior space orientation	3.65	0.72	0.19
(3) Open space layout to enhance cross ventilation	3.53	0.71	0.20
(3) Interior colours that have a positive impact on occupants' visual comfort	3.46	0.80	0.23
(4) Flexibility and durability in the design of spaces	3.31	0.78	0.23
(5) Interior design quality	3.24	0.73	0.22
(6) Meetings occupants needs (room size)	3.07	0.75	0.24
(7) Provision of recreation spaces like balconies and gardens	2.90	0.66	0.22



5.4.3 Energy Optimisation category:

This category is divided into four sub-categories:

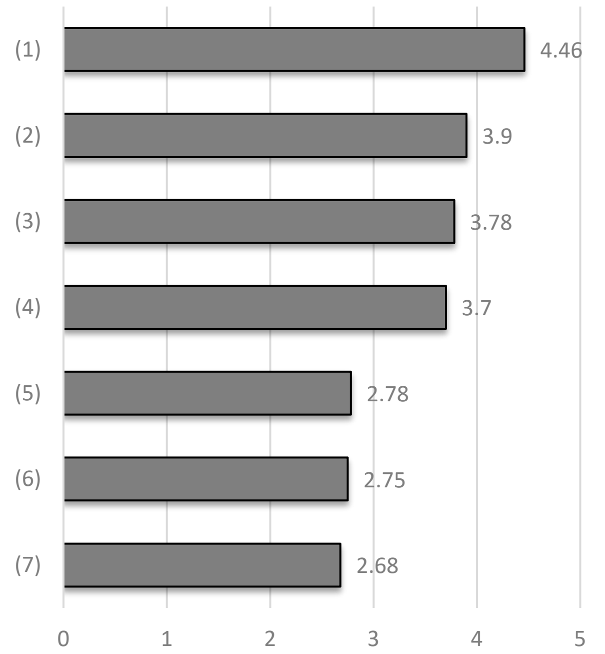
5.4.3.1 SUB-CATEGORY A (Building Envelope)

The building envelope is an extremely important factor that influences energy consumption in buildings in a hot-arid climate, and it has been strongly recommended as an effective strategy by the panel in this study. As it shown in Table 5.6, the panellists suggested using thick external walls with low heat conductivity (u-value). This was followed by having a very low airtightness together with double or triple glazing that ensures the building is kept warm in winter and cool in summer. As far as the roof design was concerned, the panel suggested the use of domed roof, which has proved its effectiveness in reducing energy consumptions in a similar climate. According to Lavafpour and Surat (2011) using a domed roof in a hot-arid climate can boost radiant cooling at night by having a larger exposure surface to the sky and less solar heat gains during the day, since only part of the dome will be exposed to the sun.

The panel supported the use of roof ponds as a strategy to reduce the indoor temperature of the building. The use of roof ponds, as suggested by the panel, was supported by an earlier study conducted by Kharrufa and Adil (2008) in which this strategy was tested in Baghdad and which concluded that using a roof pond reduced the average indoor temperature by 3.36°C in a typical hot day in summer. On the other hand, minimising the home size was less favoured compared with other indicators in this sub-category. This might be due to social reasons as most of the home owners in Iraq prefer homes of a large size.

Table 5.6 Indicators of sub-category (A) building envelope

`Indicators	Round3		
	Mean	St.Dev	CV
(1) Use of external thick walls with low heat thermal conductivity	4.46	0.63	0.14
(2) Great air tightness fabric, (less air infiltration	3.90	0.66	0.16
(3) Use materials with thermal insulation for walls and roofs	3.78	0.75	0.19
(4) Efficient glazing (i.e. double or triple)	3.70	0.78	0.21
(5) Use dome-shaped roof on whole or part of the building	2.78	0.90	0.32
(6) Use roof pond (Skytherm) on whole or part of the building	2.75	0.69	0.25
(7) Minimise home size	2.68	0.90	0.33

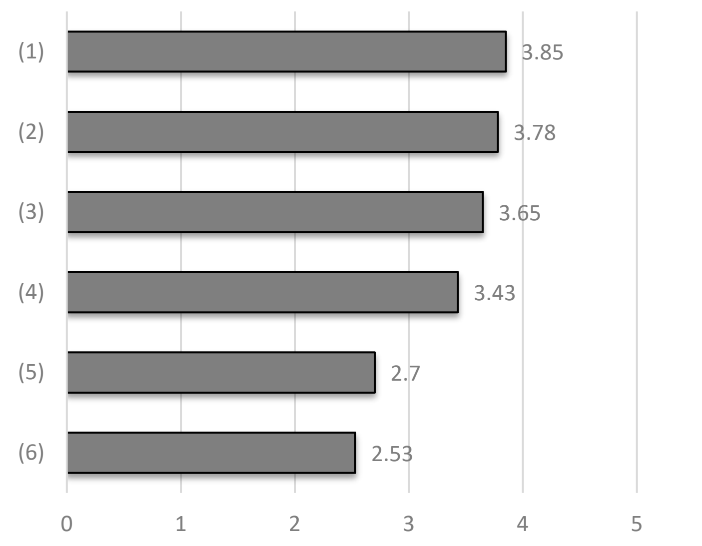


5.4.3.2 SUB-CATEGORY B (Efficient Indoor Appliances, Heating and Cooling)

Heating and cooling are extremely important for energy consumption in Iraq as they account for 46% and 26% of total energy consumption in buildings respectively; while 28% was used for indoor appliances and lightings purposes (Hasan 2012). This has been reflected on the rating of indicators. The highest rated indicators selected in this subcategory were related to cooling, followed by managing indoor appliances and heating energy consumption respectively, as shown in Table 5.7. Within this context, the use of evaporative cooling was highly favoured by the panel due to its effectiveness as a cooling strategy in a hot-arid climate as well as reducing the energy consumption compared with other cooling alternatives such as mechanical air conditioning. The evaporative coolers work by reducing and moisturising air ambient dry bulb temperature inside buildings. This strategy has shown to be effective in a hot-dry climate such as Iraq (Harvey 2006; Konya 2014).

Table 5.7 Indicators of sub-category (B) efficient indoor appliances, heating and cooling

Indicators	**Round3**		
	Mean	**St.Dev**	**Cv**
(1) Use of evaporative coolers	3.85	0.79	0.20
(2) Use of ceiling Fans	3.78	0.85	0.22
(3) Use of efficient electronic appliances	3.65	0.88	0.24
(4) Use of efficient lighting appliances	3.43	0.77	0.22
(5) Heat pumps	2.70	0.74	0.27
(6) Cooling the bed instead of the whole room	2.53	0.83	0.32



Use of ceiling fans can also be an effective strategy to use, particularly at night, if coupled with night purge ventilation to enhance the circulation of air inside the occupied room, as recommended by the panel. As an attempt to curb the 28% of energy consumed by domestic indoor appliances and lighting, the panel suggested the use of efficient indoor appliances and lighting which can have a green label such as; energy start lightings and appliances that are available on the market nowadays.

Moreover, heat pumps were suggested as a heating strategy by the panel as they can use ambient air or any waste heat and transform it into hot air for heating which can be used in buildings during the cold season. One member of the panel proposed a novel strategy to reduce the energy consumption in the bedroom during the sleeping period in summer. The strategy implied downsizing the thermal zone of the bedroom to include the bed zone area, by surrounding it with fabric or any similar alternative material to cool only the bed instead of the whole room during peak energy consumption at night in Iraq.

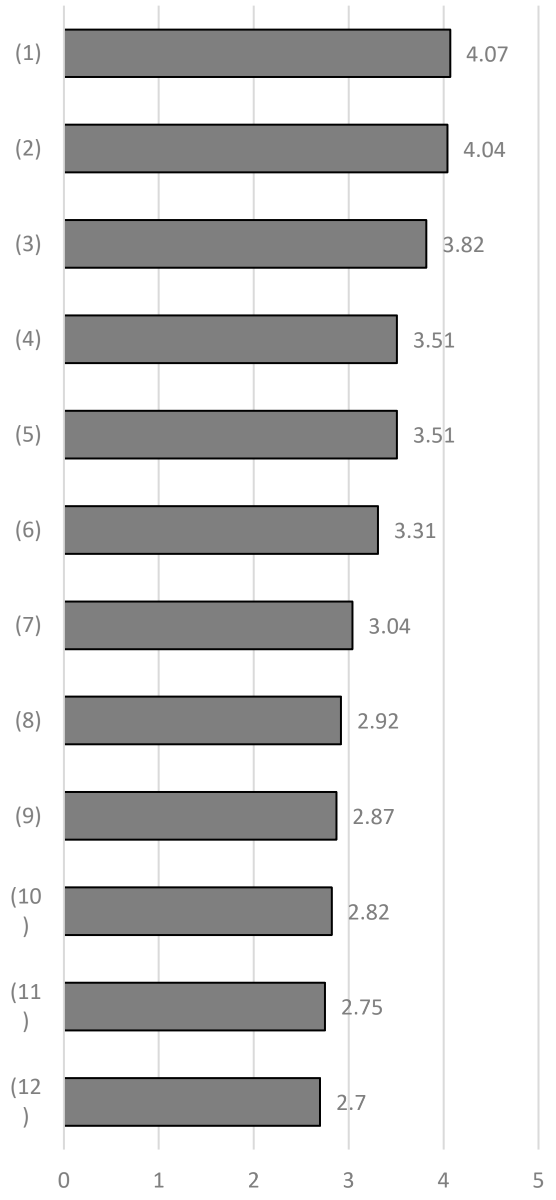
5.4.3.3 SUB-CATEGORY C (Efficient Design and Strategies):

This subsection is mainly focused on the overall design and strategies that help to reduce energy consumption in domestic buildings. According to Table 5.8, building orientation was selected as the most important strategy owing to its influence in significantly reducing the energy consumption. To maximise the benefits of building orientation, the panel proposed locating all the windows areas on the south and north façade while eliminating any glazing surface on the west and east façade to maximise solar gains in winter and preventing overheating in summer. Another way of reducing the energy consumption in summer in a hot-arid climate is to use wind catchers, as suggested by the panel. Wind catchers have shown a great potential to reduce indoor temperature during summer in the Middle East region. For instance, Kalantar (2009) tested the performance of a wind catcher combined with a solar chimney in Iran, and concluded that using wind catchers in summer enhanced cooling by creating a difference of 15°C between the ambient air and the indoor temperature.

The panel also proposed a couple of strategies to alter the behaviour of occupants while simultaneously reducing energy consumption. The panel suggested the use of the basement as a shelter for occupants in the hot summer, a feature which has been used in Middle Eastern countries like Iraq, Egypt and Iran. The influence of this bioclimatic strategy was measured numerically by Hazbei et al. (2015) in the southeast region of Iran which has an average temperature of 7°C in winter and more than 50°C in summer, which is similar to the middle and southern regions of Iraq. Based on their study, the recorded temperature in the basement was 17°C in January and 25°C in July, while the above ground temperature in the living room was 7°C in January and 35°C in July; thereby, including this element in buildings can save huge amounts of energy by maintaining a thermal comfort level for occupants.

Table 5.8 Indicators of sub-category (C) efficient design and strategies

Indicators	Round3		
	Mean	St.Dev	CV
(1) Building Orientation	4.07	0.98	0.24
(2) Large shaded windows on the south facade	4.04	0.72	0.17
(3) Wind Catchers	3.82	0.89	0.23
(4) Use of courtyards for ventilation and natural lighting	3.51	0.71	0.20
(5) Large windows on the north facade	3.51	0.86	0.24
(6) Drying Space	3.31	0.78	0.23
(7) Linking living rooms with recreational outdoor spaces	3.04	0.72	0.23
(8) Use of subterranean spaces during summer	2.92	0.75	0.25
(9) Dividing window openings into vertical strips	2.87	0.78	0.27
(10) Eliminate windows on west and east facade	2.82	0.80	0.28
(11) Provision of safe outdoor sleeping facilities	2.75	0.89	0.32
(12) Inclusion of private space (i.e. Office)	2.75	0.85	0.30
(13) Outdoor cooking facility	2.70	0.74	0.27



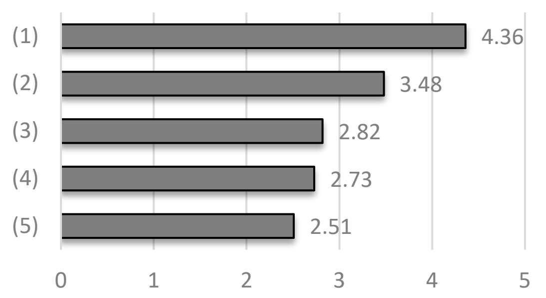
Another novel adaptive strategy that was highly rated by the panel was the use of outdoor sleeping facilities to reduce the use of energy for cooling purposes. This habit has been used by home occupants in Middle Eastern regions like Iraq, Iran and Egypt as the outdoor temperature cools down at night (Hazbei et al. 2015; Maftouni and Bagheri 2016). Furthermore, the respondents pointed out that outdoor cooking during good weather is a means of cutting energy consumption associated with constant use of the kitchen. Finally, the panel recommended using solar cooking, as it has shown some promise in the hot region such as part of the United States of America and the Middle East owing to the potential for high solar radiation during the day (Cantinawest 2016).

5.4.3.4 SUB-CATEGORY D (Renewables):

This deals with the utilisation of renewable energy as an alternative to relying on fossil fuel consumptions in buildings. Due to the high solar potential in Iraq which can reach an average of 2000 kWh/m^2 yearly (Solargis 2016), the utilisation of photovoltaics (PV) and solar panels were highly recommended by the panel with a mean value of 4.36 and 3.48 respectively, as shown in Table 5.9. Another interesting indicator highlighted in this section is the utilisation of district heating and cooling which have shown great potential in reducing energy consumption for a group of buildings. Within the same context, Gang et al. (2016) pointed out that recent projects that used district cooling extracted cool water from rivers and then redistributed cool air to the buildings through heat pumps. The same strategy can be used in Iraq since the country has two main rivers that pass through its territory, as well a small coast on the Persian Gulf located in the south of Iraq. Use of biomass was less emphasised in this section owing to its limited capabilities in saving energy compared to similar solar alternatives (Kazem and Chaichan 2012).

Table 5.9 Indicators of sub-category (D) Renewables

Indicators	**Round3**		
	Mean	**St.Dev**	**CV**
(1) In-situ renewable PV	4.36	0.68	0.15
(2) In-situ renewable solar panels	3.48	0.74	0.21
(3) District heating and cooling	2.82	0.73	0.25
(4) Use of biomass appliances (i.e. stove, boiler, fireplace)	2.73	0.93	0.33
(5) Waste-based power generation	2.51	0.74	0.29



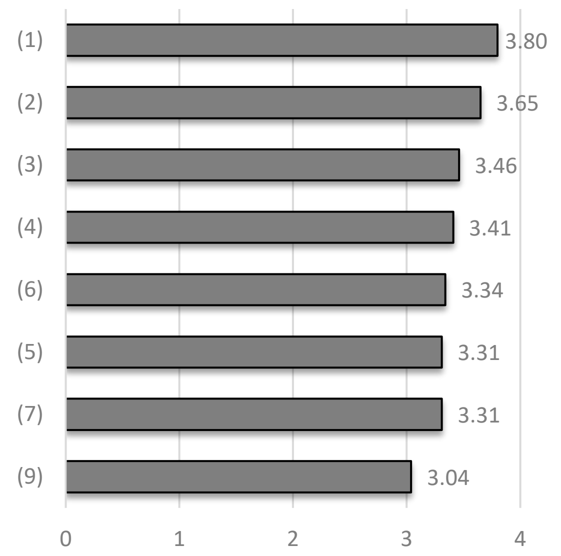
5.4.4 Water Efficiency

Water efficiency is vital to maintain life and a healthy environment. Iraq has two rivers however according to the world resources institutes: Iraq is ranked number 21 out of 33 countries that is predicted to suffer from water supply shortage in 2040 (World Resources Institute 2015). In addition, Iraq has very limited rainfall during the year which is estimated to be 216 mm (World Bank 2016). Thereby, the panel considered indicators for indoor savings more important than the outdoor savings, as shown in Table 5.10. Efficient fixtures were the most important indicator in this category due to their contribution in significantly reducing water consumption. For example, the United States of America Environmental Produce Agency pointed out that if 1 out of 100 homes in the United States of America were retrofitted with high water-efficient fixtures, 100,000,000 kWh of electricity will be saved annually. This could also hold true in Iraq, if the same fixtures are implemented and used within the residential buildings.

Other methods for reducing water consumption outdoors or through construction was stressed by the panel. For example, irrigation controls were recommended by the panel to eliminate excessive water use in gardening and landscape work. Another interesting indicator listed in this category was a measure to reduce the use of embodied water in construction owing to the lack of availability of such practice or guidance in Iraq. In this sense, embodied water is believed to account for 8% of total water consumption throughout the whole life cycle of a building (Bardhan 2011). As far as outdoor water consumption is concerned, using native plants was also mentioned within this section mainly owing to their capability to use less water and withstand drought during extreme temperatures in summer.

Table 5.10 Indicators of water efficiency

Indicators	Round3		
	Mean	St.Dev	CV
(1) Efficient fixtures	3.80	0.90	0.23
(2) Regulating occupants water consumption litre/per day	3.65	0.85	0.23
(3) Availability of fresh water	3.46	0.89	0.25
(4) Irrigation controllers	3.41	0.99	0.29
(5) Grey water recycling	3.34	0.91	0.27
(6) Reduce the use of embodied water	3.31	0.93	0.28
(7) Rainwater harvesting	3.31	0.90	0.27
(8) Automatically boiler switch control for summer use	3.04	0.70	0.23
(9) Use of native plants	2.92	0.75	0.25



5.4.5 Waste and Pollution Management

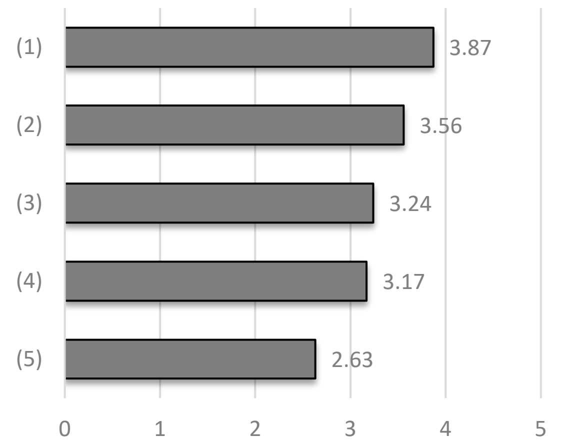
This category was subdivided into two sub-categories:

5.4.5.1 SUB-CATEGORY A (Indoor Waste):

This section focuses on a measure that reduces indoor waste and pollution, as shown in Table 5.11. The panel prioritised measures that eliminate hazards generated by materials indoors. These materials can pose significant risk to the health of occupants and may increase the risk of cancer and respiratory problems. Normally these materials are found in insulation, and some specific types of paint. The risk associated with these materials must be assessed and then followed up with measures to manage the risks. Furthermore, a carbon monoxide monitoring indicator was suggested by the panel—this measure is achieved by mounting a carbo monoxide detector on a wall or ceiling to detect the levels of carbon monoxide in the room. Therefore, the panel also suggested tackling this by compartmentalisation, together with ventilation, whilst limiting NO_x emission from boilers or any similar appliances that might increase the level of this gas in buildings.

Table 5.11 Indicators of sub-category (A) indoor waste

Indicators	Round3		
	Mean	St.Dev	CV
(1) Limits NO_x emission	2.70	1.16	0.42
(2) Measures to enhance the ventilations of (stoves, ovens, fireplaces, boilers)	3.19	1.24	0.38
(3) Compartmentalisation	3.21	0.90	0.28
(4) Carbon mono-oxide monitoring devices in kitchens and around fireplaces	3.68	0.98	0.26
(5) Measures to eliminate the hazards generated by the materials used indoor	4.00	1.24	0.38



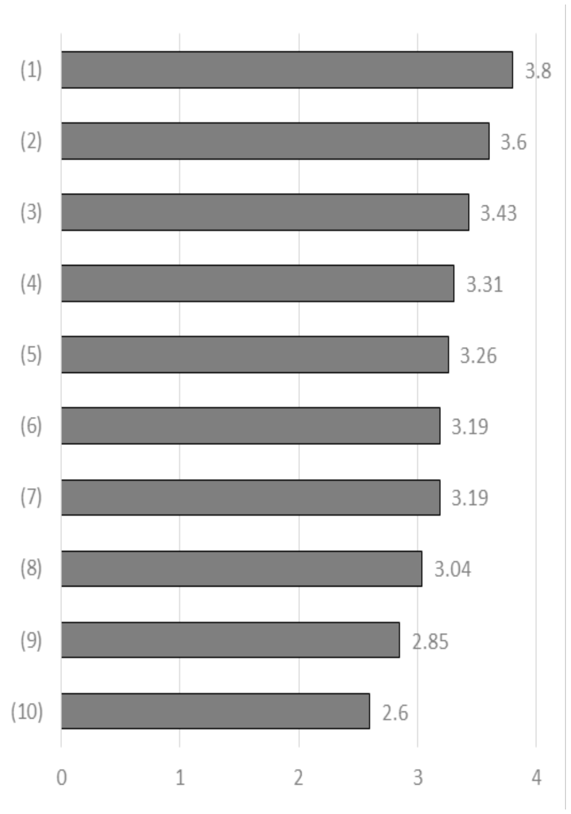
5.4.5.2 SUB-CATEGORY B (Outdoor Waste)

This category is focused on indicators that mitigate the negative impact on the atmosphere generated by buildings. As shown in Table 5.12, the panel prioritised indicators such as the provision of separate waste containers as this measure had not been implemented by building regulations or any other planning authority in Iraq. This was followed by other measures to control soil erosion as well as eliminating the hazards generated from building material in construction. According to a report published by the United Nations Environmental Program, Iraq has a high level of soil contamination owing to metal being left from old military munitions as well as contamination generated from bad oil extraction practice (UNEP 2005).

Apart from soil contamination issues, Iraq has dusty dry weather. The Iraqi government recorded 283 dust days and 122 dust storms in one single year (UNEP 2016). The same report predicted that Iraq will encounter 300 dust storms every year within the next 10 years, which is almost 82% of days which have dust storms every year. There was a consensus on the panel regarding the importance of this issue. Measures to combat the dust contamination issue could include sealing doors and windows, as well as considering greenery around the buildings as this will reduce the impact of the dust storms in the future. It is worth mentioning that another unique measure highlighted by the respondents in this group was composting. Composting is using any green, food waste and reusing this to enhance the fertilisation of the soil, which was first discovered by the Akkadian people around 2320 BC who lived in Mesopotamia at that time (Bardhan 2011).

Table 5.12 Sub-category (B) Outdoor waste's indicators

Indicators	**Round3**		
	Mean	**St.Dev**	**CV**
(1) Provision of separate waste containers	3.80	0.84	0.22
(2) Minimise site Contamination	3.60	0.94	0.26
(3) Dust storm Protection	3.43	1.00	0.29
(4) Keeping waste facilities far from living spaces	3.31	0.84	0.25
(5) Use of refrigerants system with zero ozone depletion	3.26	0.59	0.18
(6) Mitigate the un-wanted wind	3.19	0.84	0.26
(7) Composting	3.19	0.67	0.21
(8) Reduce exterior light pollution	3.04	0.70	0.23
(9) Reduce the impacts on solar energy potential of adjacent property	2.85	0.79	0.27
(10) Pest control	2.60	0.97	0.37



5.4.6 Materials

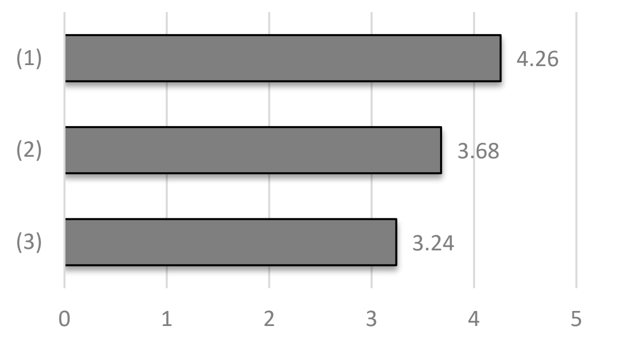
This category was further was classified into two sub-categories:

5.4.6.1 SUB-CATEGORY A (Resources-Sourcing)

This sub-category is focused on the sourcing and extraction of materials utilised for construction, as shown in Table 5.13. Using local materials was highly recommended by the panel, for example cement and clay blocks. The use of local materials within 100 miles of the construction site curbs the carbon emission as it significantly reduces the distance travelled from the manufacturer to the construction site. This was coupled with promoting the use of renewable materials that have less impact on the atmosphere and environment. Lastly, protecting the endangered materials in buildings or using materials that are non-renewable, such as cork and milky latex was listed as the least important indicator in this group.

Table 5.13 Indicators of sub-category (A) resources-sourcing

Indicators	**Round3**		
	Mean	**St.Dev**	**CV**
(1) Use of local materials (i.e. local Cement, clay blocks, etc.)	4.26	0.74	0.17
(2) Use of renewable materials	3.68	0.87	0.23
(3) Protection of endangered materials	3.24	0.83	0.25

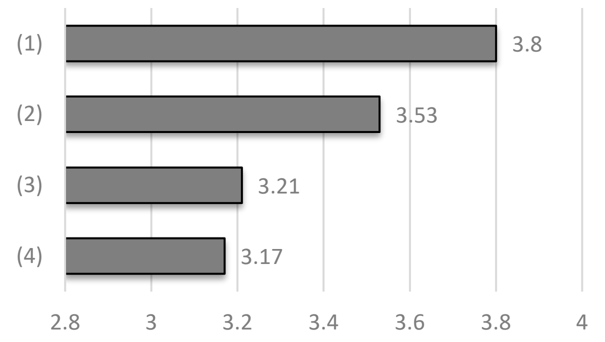


5.4.6.2 SUB-CATEGORY B (Materials Environmental Impacts):

This emphasis in this sub-category is on reducing the negative impact of materials on the environment during all phases of construction. Re-using broken materials was highlighted as the most important measure, as shown in Table 5.14 .Moreover, using materials with a low maintenance cost was also suggested by the panel as an important strategy to reduce the cost of building and to ultimately make affordable housing accessible to the middle-income residents. Material and building elements should also be selected with the flexibility that allows for reuse in construction such as stairs, windows, doors, roof, and floors. Lastly, simplifying and standardising materials was the least important among the indicators listed in this section, yet, this can also minimise the waste in materials by matching the design and construction of the building with the standardised material.

Table 5.14 Indicators of sub-category (B) materials environmental impacts

Indicators	Round3		
	Mean	St.Dev	CV
(1) Re-use of broken materials	3.80	0.90	0.23
(2) Use of materials with low maintenance and replacement cost	3.53	0.8	0.22
(3) Design for deconstruction	3.21	0.88	0.27
(4) Simplification and standardization of materials	3.17	0.77	0.24



5.4.7 Site and microclimate:

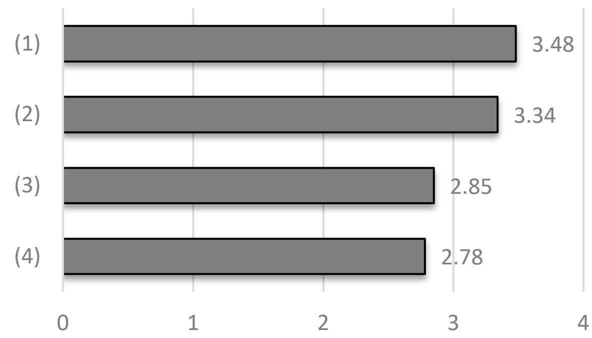
This category is concerned with issues related to the selection of the site and the impact of the microclimate on the building located within the site. This category is divided into two sub-categories:

5.4.7.1 Sub-category A (Heat Wave Island):

This sub-category considers measures that reduce the impact of the Heat Wave Island effect and the subsequent high-temperature rises in summer. According to Table 5.15, reflective walls or those with white paint were prioritised owing to their impact on the reflection of heat radiation and tendency to absorb less radiation compared to coloured walls. The availability of water bodies in the microclimate was also important in mitigating the urban heat island through the evaporative cooling effect as this will reduce the overall temperature around the building thereby reducing cooling demand and CO_2 emissions. Furthermore, the panel mentioned using green roofs to lower the temperature of the ambient air surrounding around the building owing to evapotranspiration. Lastly, the aesthetics of the landscape was voted by the panel as the least indicator in this sub-category, as it only enhances visual comfort.

Table 5.15 Indicators of sub-category (A) heat wave island

Indicators	Round3		
	Mean	**St.Dev**	**CV**
(1) Reflective pale walls	3.48	0.97	0.27
(2) Availability of water bodies to enhance the micro climate	3.34	0.85	0.25
(3) Green roofs	2.85	0.82	0.28
(4) Landscape beautification	2.78	0.79	0.28

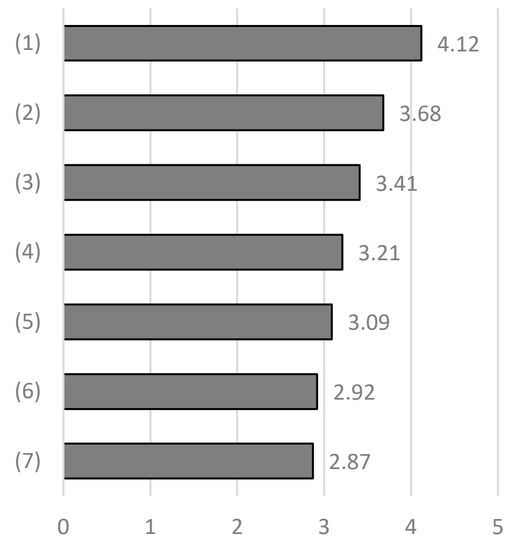


5.4.7.2 SUB-CATEGORY B (Biodiversity and Infrastructure):

This sub-category focuses on enhancing biodiversity and making sure that main infrastructure links are well established within the building's construction site. The panel thought that constructing a building on a brownfield site was the most important issue as shown in Table 5.16. A brownfield site is industrial or commercial land that has been abandoned; thereby re-using this land will enhance the re-creation of communities and create affordable housing. This was followed by other measures such as: mitigating the site pollution; ensuring the site is connected to both the main electricity grid as well as electricity and infrastructure services; reducing the building's footprint on green areas and protecting any monumental building or landmark within the boundary of the site. The respondents also highlighted a very distinctive indicator within this list, which was enhancing food production. Encouraging food production by household has certain advantages such as; enhancing the security of food as well as reducing unemployment rate, as highlighted in the literature by Poulsen et al (2015) and Growing Green Guide (2016).

Table 5.16 Indicators of sub-category (B) biodiversity and infrastructure

Indicators	Round3		
	Mean	St.Dev	CV
(1) Select brownfield site	4.12	0.67	0.16
(2) Mitigate site's pollution	3.68	0.64	0.17
(3) Site with accessibility to water supply and electricity grid	3.41	0.70	0.20
(4) Reduce development of the site on greenfield sites	3.21	0.79	0.24
(5) Protection of any heritage and historical monument	3,09	0.7	0.22
(6) Measures to enhance food production	2.92	0.72	0.24
(7) Enhancing the biodiversity	2.87	0.71	0.24

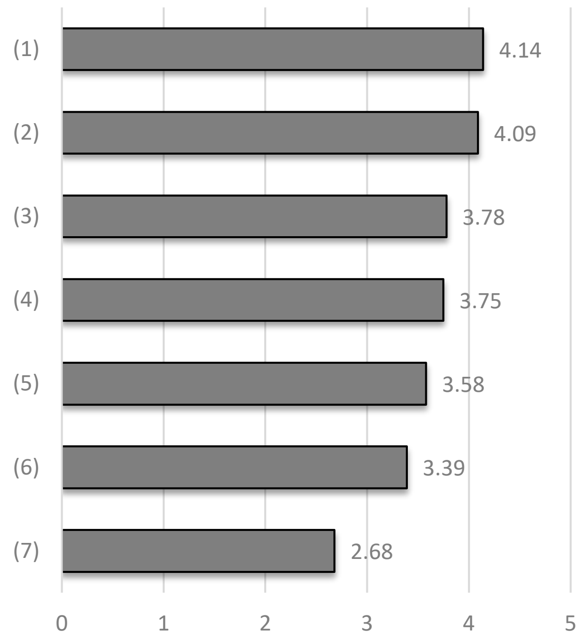


5.4.8 Transportation

This category focuses on issues that are related to transportation systems and services that are required by building occupants. Table 5.17 shows that the proximity to public services was considered by the panel to be the most important indicator in this category. There are many possible reasons for this, including: (1) It ensures that the basic resources and needs of local residents are close at hand in the event of a disaster or disruptive event and (2) it reduces the total energy consumption of residents encouraging them to walk instead of using a less environmentally friendly means of transportation. Preferably, the services should be within walking distance from residential units. Reducing the usage of private vehicles by households was also targeted by providing a bicycle parking space or storage area for each residential unit. Passengers light duty vehicles (PLDV) ownership in Iraq is estimated to be 100 for each 1000 inhabitants, which is double the number in China and 9 times higher than India. The number of PLDVs in Iraq is predicted to double by 2035 owing to, both, the limited availability of transportation, as well as a 7% expected growth in GDP (IEA 2012). Therefore, encouraging the use of bicycles and public transportation is vital to reduce energy consumption and ease traffic congestion. Also, accessibility to green parks and proximity to recreational places for building occupants was also mentioned in this sub-category as it contributes to a better environment by reducing dust storm events, as well as ensuring residents have a smaller carbon footprint by only travelling small distances.

Table 5.17 Transportation indicators

Indicators	**Round3**		
	Mean	**St.Dev**	**CV**
(1) Proximity to services (i.e. shops, hospital, schools)	4.14	0.76	0.18
(2) Proximity to public buses transport	4.09	0.73	0.18
(3) Provision of bicycle parking	3.78	0.79	0.20
(4) Connection to public main road	3.75	0.94	0.25
(5) Accessibility to green park or recreational space	3.58	0.80	0.22
(6) Limit/regulate the use of private cars per residential unit	3.39	0.99	0.29
(7) Provision of bicycle lane or network linked with the street	2.68	0.64	0.23



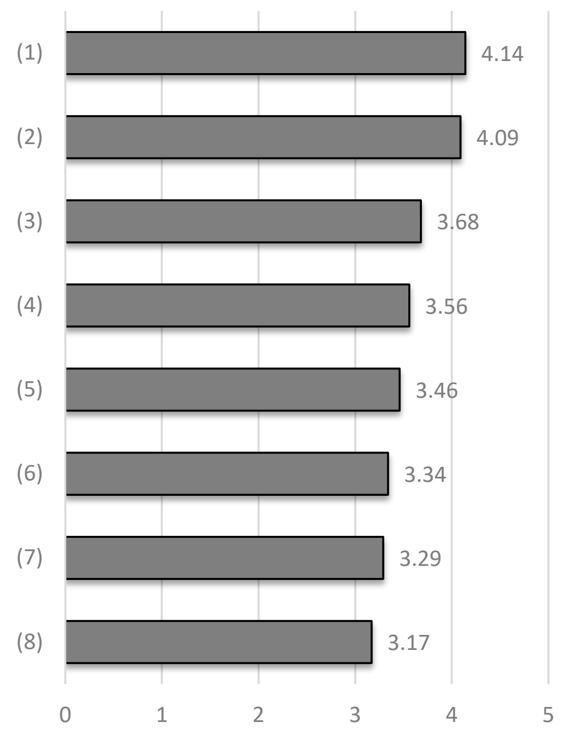
5.4.9 Social and Cultural

This category includes indicators that respect the regional cultural characteristics of buildings in Iraq, as shown in Table 5.18. The most important factor in this category was maintaining cultural and architectural values through the exterior design of the residential units. To maximise the benefits of this indicator the panel suggested that municipal authorities should maintain and enforce building regulations for residential buildings within their city or region.

Three unique indicators were included within this section and these were: providing accessibility into buildings for the handicapped; providing access to exterior natural views from the interior and respecting privacy in design. Lastly, the panel agreed to include innovation measures which could be any design solution that aimed to improve the performance beyond the currently benchmarked levels.

Table 5.18 Social and Cultural indicators

Indicators	Round3		
	Mean	**St.Dev**	**CV**
(1) Maintaining and keeping the cultural architectural value features of the building through the exterior design	4.14	0.61	0.14
(2) Compliance with local buildings codes	4.09	0.66	0.16
(3) Handicapped accessibility into the building	3.68	0.78	0.21
(4) Access to exterior natural views from the interior	3.56	0.80	0.22
(5) Harmony with the neighbouring buildings	3.46	1.00	0.28
(6) Respecting privacy in design	3.34	0.76	0.22
(7) Innovation measures	3.29	0.90	0.27
(8) Designing an aesthetic exterior	3.17	0.8	0.25



5.4.10 Economic Efficiency

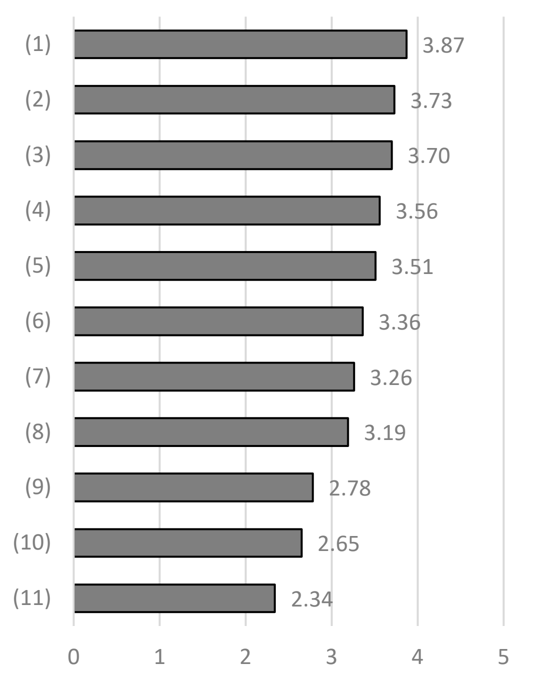
This category aims to boost and add value to the local economy, as presented in Table 5.19. Indicators included measures for ensuring that the rental cost of a building is within an affordable range and contributes to a better quality of life. Another important measure that has an impact on the cost of construction projects was completion on time. Various studies in developing countries summarised the reasons for construction delay including: weather, materials replacement and design modification (Assaf et al. 1995; Mezher and Tawil 1998; Odeh and Battaineh 2002). Managing and controlling these issues as early as possible reduces the project cost overrun significantly and saves unnecessary expenditure for the project.

The panel considered reducing the embodied construction cost by: using materials with a low emissions rate; using local labouring and resources; lower capital cost by using materials manufactured off-site and also by the implementation of building integrated modeling (BIM) that simultaneously reduces the construction and operational costs.

Moreover, the panel was in favour of following green building initiatives, by third party installation of renewable solutions for homes spreading the cost over a period acceptable to the owner. This is usually calculated by determining a fixed interest rate set by the provider to the owner. These measures encourage residents to implement green solutions that reduce the cost of energy bills in the future.

Table 5.19 Economic Efficiency indicators

Indicators	Round 3		
	Mean	St.Dev	CV
(1) Low rental cost	3.87	0.74	0.19
(2) Materials with low LCC	3.73	0.83	0.22
(3) Finishing construction within time	2.82	0.99	0.35
(4) Local labouring	3.56	0.89	0.25
(5) Low cost of maintenance and operation	3.51	0.81	0.23
(7) Low capital cost	3.26	0.89	0.27
(8) Materials manufactured off-site	3.19	0.81	0.25
(9) Use of BIM in design and construction	2.78	0.90	0.30
(10) Following green Incentive	2.65	0.88	0.33
(11) Residual cost	2.34	0.96	0.41



5.5 Delphi’s Rounds termination and stability test

There are multiple tests to measure stability of the responses when using the Delphi technique. Applying these measures depends on the size of the sample and whether the test will be parametric or non-parametric (Kalaian and Kasim 2012). If the sample size is equal to or less than 30 and the distribution of the data is not normal, then the applied tests will be non-parametric. If the sample is more than 30 together with a normal distribution of the data then the applied tests must be parametric. Parametric tests include the following: (1) pearson’s correlation; (2) coefficient of variation; (3) f-ratio test and (4) paired t-tests. Whereas, non-parametric tests encompass the following: (1) spearman’s correlation; (2) Mcnemar change and (3) Wilcoxon paired t-test. To decide the type of test needed to test the stability of the Delphi technique from round 2 and 3, the normality of the responses was tested using SPSS software packages. The responses were skewed asymmetrically, and therefore only non-parametric tests were applicable. Therfore the spearman correlation was selected to determine the termination of Delphi rounds as the correlation of coefficient (R) was between +1 and -1, with +1 representing positive correlation and stability in the responses from the two consecutive rounds, whereas -1 showed disagreement in the responses from the last two consecutive rounds. Table 5.20. Shows the reported correlation of coefficient (R) for the indicators from the last two consecutive rounds.

Table 5.20 Delphi’s stability test

Indicators	Correlation Coefficient	Stability status
Following construction best practice	0.87	✓ Achieved
Project team integration	0.93	✓ Achieved
Durability: maintenance and operation	0.94	✓ Achieved
Flexible operation of building systems	0.97	✓ Achieved
Resource availability	0.88	✓ Achieved
Flexible and adaptable design (easy to construct and change)	0.91	✓ Achieved
Commissioning plan	0.88	✓ Achieved
Evacuation plan for emergencies	0.93	✓ Achieved
Post occupancy evaluation	0.82	✓ Achieved
User manual: that informs occupants in the way of using the buildings efficiently	0.84	✓ Achieved
Natural ventilation	0.94	✓ Achieved
Efficient mechanical heating and cooling system	0.88	✓ Achieved
Lighting glare controllability	0.97	✓ Achieved
Daylighting glare controllability	1.00	✓ Achieved
Roof shading devices	0.89	✓ Achieved
Natural daylighting accessibility to functional spaces	0.87	✓ Achieved
Acoustic comfort	0.93	✓ Achieved

Thermal comfort	0.85	✓ Achieved
Materials with low VOC	0.97	✓ Achieved
Smoke detector	0.97	✓ Achieved
Airtight air-conditioning ducts and opening	0.98	✓ Achieved
Security and protection measures	0.97	✓ Achieved
Fan exhaust for bathroom and kitchen	0.90	✓ Achieved
Damp protection	0.94	✓ Achieved
Accessibility to Internet services	0.93	✓ Achieved
Functionality of the spaces through interior space orientation	0.90	✓ Achieved
Provision of recreation spaces like balconies and gardens	0.93	✓ Achieved
Flexibility and durability in the design of spaces	0.89	✓ Achieved
Open space layout to enhance cross ventilation	0.90	✓ Achieved
Meetings occupants needs (room size)	0.78	✓ Achieved
Interior design quality	0.96	✓ Achieved
Interior colours that have a positive impact on occupant's visual comfort	0.91	✓ Achieved
Use of external thick walls with low heat thermal conductivity	0.96	✓ Achieved
Use materials with thermal insulation for walls and roofs	0.96	✓ Achieved
Minimise home size	1.00	✓ Achieved
Great air-tightness fabric, (less air infiltration)	0.77	✓ Achieved
Efficient glazing (i.e. double or triple)	0.96	✓ Achieved
Use roof pond (Skytherm) on the whole or part of the building	0.93	✓ Achieved
Use dome-shaped roof on whole or part of the building	0.96	✓ Achieved
Use of efficient lighting appliances	0.95	✓ Achieved
Use of ceiling fans	0.89	✓ Achieved
Use of efficient electronic appliances	0.91	✓ Achieved
Use of evaporative coolers	0.95	✓ Achieved
Heat pumps	0.89	✓ Achieved
Cooling the bed cubing only instead of the whole room	0.91	✓ Achieved
Wind catchers	0.83	✓ Achieved
Large windows on the north facade	0.92	✓ Achieved

Building orientation	1.00	✓ Achieved
Dividing window openings into vertical strips within the same area designated for conventional shape	0.84	✓ Achieved
Occupants migrations through summer and winter (i.e. use of subterranean spaces during for summer use; to reduce demand on cooling)	0.80	✓ Achieved
Reduce/eliminate windows on west and east facade	0.57	✓ Achieved
Large shaded windows on the south facade	0.76	✓ Achieved
Use of courtyards and intermediate open spaces; for ventilation and natural lighting	0.75	✓ Achieved
Linking living rooms with outdoor recreational spaces like gardens (that could be used in summer)	0.64	✓ Achieved
Drying space	0.58	✓ Achieved
Inclusion of private space (i.e. office)	0.91	✓ Achieved
Outdoor cooking	0.97	✓ Achieved
Provision of safe outdoor sleeping facilities to be used by occupants in summer	0.98	✓ Achieved
In-situ renewable PV	0.95	✓ Achieved
In-situ renewable solar panels	0.96	✓ Achieved
District heating and cooling	0.87	✓ Achieved
Use of biomass appliances (i.e. stove, boiler, fireplace)	0.81	✓ Achieved
Waste-based power generation	0.86	✓ Achieved
Measures to eliminate the hazards generated by the materials used indoor	0.65	✓ Achieved
Carbon mono-oxide monitoring devices in kitchens and around fireplaces	0.85	✓ Achieved
Compartmentalisation	0.97	✓ Achieved
Measures to enhance the ventilations of (stoves, ovens, fireplaces, boilers) through an exhaust fan	0.74	✓ Achieved
Limits NO_x emission	0.86	✓ Achieved
Use of refrigerants system with zero or low impact on ozone depletion	0.91	✓ Achieved
Composting	0.94	✓ Achieved
Provision of separate waste containers	0.84	✓ Achieved
Minimise site contamination (i.e. topsoil erosion)	0.94	✓ Achieved
Keeping waste facilities far from living spaces	0.97	✓ Achieved

Reduce exterior light pollution	0.69	✓ Achieved
Pest control	0.98	✓ Achieved
Dust storm protection	0.88	✓ Achieved
Reduce the impact on solar energy potential of the adjacent property	0.77	✓ Achieved
Mitigate the unwanted wind influence on building	0.86	✓ Achieved
Rainwater harvesting	0.82	✓ Achieved
Efficient fixtures	0.86	✓ Achieved
Grey water recycling	0.93	✓ Achieved
Regulating occupants water consumption liter/per day	0.90	✓ Achieved
Irrigation controllers	0.96	✓ Achieved
Availability of fresh water	0.99	✓ Achieved
Automatically boiler control switch for summer	0.72	✓ Achieved
Reduce the use of embodied water	0.93	✓ Achieved
Use of native plants	0.90	✓ Achieved
Reflective pale walls	0.90	✓ Achieved
Landscape beautification	0.76	✓ Achieved
Green roofs	0.85	✓ Achieved
Select Brownfield site or pre-developed land	0.99	✓ Achieved
Mitigate site's pollution (e.g. noise, particles and emissions from factories)	0.83	✓ Achieved
Site with accessibility to water supply and electricity grid	0.78	✓ Achieved
Reduce development of the site on greenfield sites	0.87	✓ Achieved
Enhancing the biodiversity by protecting the endangered species	0.53	✓ Achieved
Protection of any heritage and historical monument located within the site	0.72	✓ Achieved
Measures to enhance food production	0.54	✓ Achieved
Use of local materials (i.e. Local Cement, clay blocks, etc.)	0.94	✓ Achieved
Use of renewable materials	0.91	✓ Achieved
Protection of endangered materials	0.88	✓ Achieved
Re-use of broken/faulty materials during construction	0.87	✓ Achieved
Design for deconstruction	0.95	✓ Achieved
Use of materials with low maintenance and replacement cost	0.80	✓ Achieved

Simplification and standardization of materials	0.64	✓ Achieved
Provision of bicycle parking	0.71	✓ Achieved
Proximity to public buses transport	0.72	✓ Achieved
Limit/regulate the use of private cars per residential unit	0.79	✓ Achieved
Proximity to services (i.e. shops, hospital, schools)	0.91	✓ Achieved
Connection to the public main road	0.99	✓ Achieved
Accessibility to green park or recreational spaces	1.00	✓ Achieved
Provision of bicycle lane or network linked with the street	0.56	✓ Achieved
Maintaining and keeping the cultural, architectural value features of the building through the exterior design	0.89	✓ Achieved
Harmony with the neighing buildings or context	0.89	✓ Achieved
Respecting privacy in design	0.97	✓ Achieved
Compliance with local buildings codes	0.92	✓ Achieved
Handicapped accessibility into the building	0.81	✓ Achieved
Innovation measures	0.95	✓ Achieved
Designing an aesthetic exterior	0.82	✓ Achieved
Access to exterior natural views from the interior	0.76	✓ Achieved
Low rental cost	0.61	✓ Achieved
Low cost of maintenance and operation	0.85	✓ Achieved
Finishing construction within time	0.67	✓ Achieved
Materials with low LCC	0.62	✓ Achieved
Materials manufactured off-site	0.86	✓ Achieved
Local resources materials	0.82	✓ Achieved
Low capital cost	0.93	✓ Achieved
Use of BIM in construction	0.99	✓ Achieved
Following green Incentive	0.88	✓ Achieved
Residual cost	0.97	✓ Achieved

5.6 Justification for developing weighting system for the sustainability assessment frameworks for residential buildings

Due to the variations and differences among regions and countries worldwide, it is impractical for one sustainability assessment framework for residential buildings to fit all countries. Thereby, customising and adjusting these assessments is essential to meet the contextual social, economic and environmental needs. Medineckiene et al (2015) argued that sustainability assessment frameworks include multiple dimensions and owing to their complexity it is better to address those dimensions during the early stages of the development of the assessment.

Wu et al (2007) developed an accessibility assessment framework for construction in UK using the Analytical Hierarchy Process (AHP). He identified the accessibility indicators from literature sources and building construction codes which were categorised and then evaluated by a panel of experts who assessed their weighting and level of importance within the assessment.

Khalil et al (2016) conducted four stages of survey to identify parameters that enhance the performance of buildings in Malaysia, while reducing any associated risk to occupants at the same time. The 26 parameters were sub-categorised under three categories: functional performance; technical performance and indoor environmental performance. The AHP was an important instrument to assess the performance of these categories and their parameters.

Yu et al. (2015) developed a sustainable rating framework for store buildings in China by the implementation of AHP. 31 experts evaluated 7 categories that assessed the design and operation stages of the building. The overall scores obtained from the categories and indicators were accumulated and then final rating was assigned to the building.

Banani et al. (2016) developed a sustainable building assessment framework for non-residential buildings in Saudi Arabia. They identified 9 criteria and 36 sub-criteria for the Saudi context. Firstly, these were verified through conducting semi-structured interviews followed by a questionnaire. The weighting system was assessed by utilising AHP and pairwise comparisons. It is clear from the mentioned examples above that AHP was used as a facilitating tool to solve any research problem with multiple criteria decision analysis.

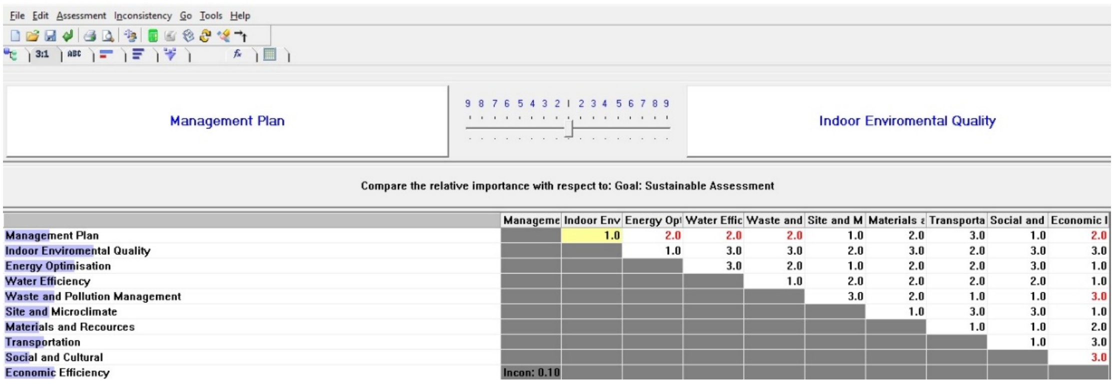
That might include the development of assessment criteria or the evaluation of a problem with many alternative solutions. Hence, AHP was chosen in this research to solve the multiple criteria issue and to rank the criteria based on an evaluation by experts of their relative importance.

5.7 Weighting system suggested for residential buildings in Iraq

The sustainability assessment framework is underpinned by their categories which have been developed based on the grounds of consensus. This was accomplished through consultations with panel of experts to yield comprehensive responses. The following sections break down the structure of the weighting system followed by an explanation of the proposed scoring system for the new sustainability assessment framework for residential buildings in Iraq.

5.7.1 Expert choice results

The weighting system was achieved by the implementation of AHP as explained earlier in Chapter four, see section 4.6.12. Expert Choice was selected as the main software to calculate the aggregated responses of the 41 members of the panel. Through the final stage of the questionnaire, the panel were asked to prioritise the categories and the sub-categories based on their importance within the Iraqi context, as shown in Figure 5.2.



	Manageme	Indoor Env	Energy Opt	Water Effic	Waste and	Site and M	Materials a	Transporta	Social and	Economic I
Management Plan		1.0	2.0	2.0	2.0	1.0	2.0	3.0	1.0	2.0
Indoor Enviromental Quality			1.0	3.0	3.0	2.0	3.0	2.0	3.0	3.0
Energy Optimisation				3.0	2.0	1.0	2.0	2.0	3.0	1.0
Water Efficiency					1.0	2.0	2.0	2.0	2.0	1.0
Waste and Pollution Management						3.0	2.0	1.0	1.0	3.0
Site and Microclimate							1.0	3.0	3.0	1.0
Materials and Recources								1.0	1.0	2.0
Transportation									1.0	3.0
Social and Cultural										3.0
Economic Efficiency	Incon: 0.10									

Figure 5.2 Aggregated pairwise comparisons of 10 categories and their reciprocal matrix of (10x10)

Expert Choice was selected in this research based on its use and wide recognition by scholars in the literature (Ali and Al Nsairat, 2009; Alyami et al. 2013; Banani et al. 2016) and the results obtained from the software show reliable judgements and results. The aggregated judgements for all categories are demonstrated in Figure 5.3. The results obtained showed water efficiency and energy optimisations were selected as the most important categories with a percentage of 0.196 and 0.184 respectively because of their relative importance to the Iraqi building context.

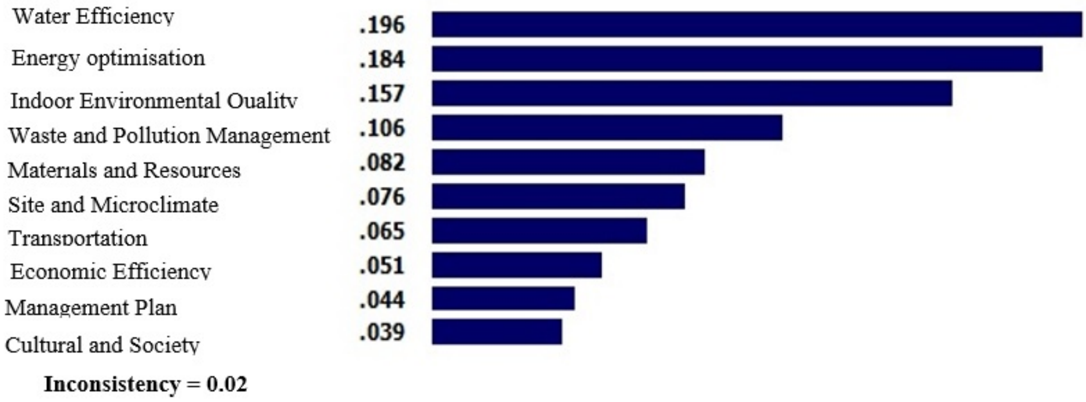


Figure 5.3 The ranking of assessment's categories based on their relative levels of importance

While management and cultural society were selected as the least important issues compared to their counterparts within the assessment.

5.7.2 Sub-category prioritisation

The sub-categories were also compared within each category. Figure 5.4 shows the weighting of the sub-categories embedded within the management category. Sub-category A (building management) was slightly favoured with 57.1% compared to sub-category B (occupants Management) with 42.9%.

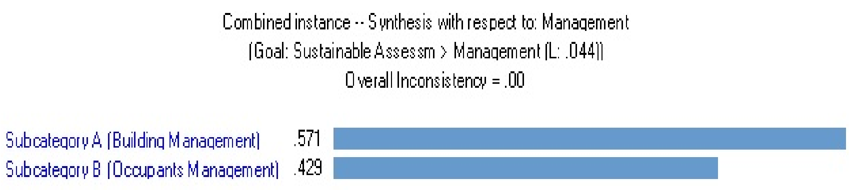


Figure 5.4 Pairwise comparisons of Management's sub-categories

As far as the indoor environmental quality was concerned, controllability scored the highest ranking with 43.6%, as shown in Figure 5.5. The reason behind the high ranking by the panel could be due to the embedded indicators such as mechanical heating and cooling systems owing to their influence on the indoor environmental quality in the hot-arid climate of Iraq, where the mean temperature in summer is around 50°C**.** These sub-categories were then followed by indoor services together with interior qualities and functions with 35.8% and 20.6% respectively.

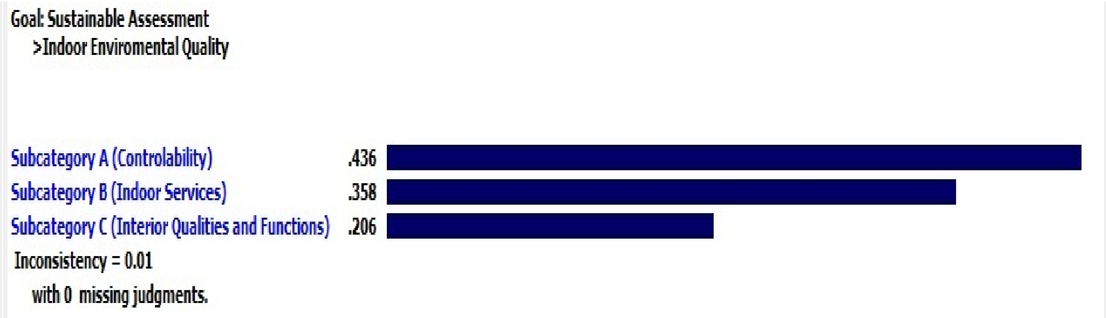


Figure 5.5 Pairwise comparisons of Indoor Environmental Quality's sub-categories

From the materials and resources perspective, the environmental impacts of materials were given a slightly higher score by the panel with 50.2% compared to 49.8% given to resources, as shown in Figure 5.6. The reasons behind this could be its high environmental impact, alongside its capability to substantially reduce carbon emissions by recycling, as well as minimising the cost by using low cost materials.

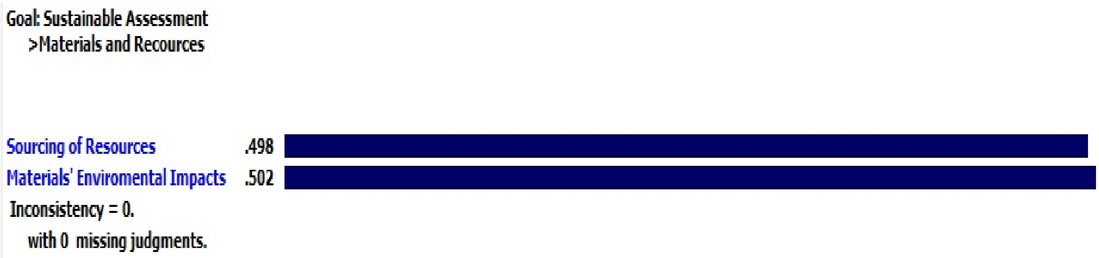


Figure 5.6 Pairwise comparisons of Materials and Resources' sub-categories

Within the site and microclimate category the heat wave island sub-category was given a slightly higher score than biodiversity and infrastructure, as shown in Figure 5.7. This could be due to the increased level of urbanisation in Iraqi's main cities, like Baghdad, which has led to a dramatic increase in ambient temperature compared with rural areas. Curbing the heat wave island effect could be considered as a measure to reduce droughts by increasing green areas around the compacted building in cities in Iraq.

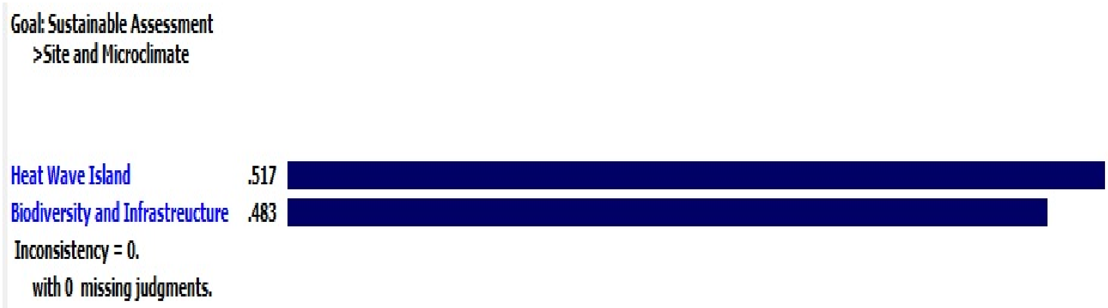


Figure 5.7 Pairwise comparisons of Site and Microclimate' sub-categories

In the waste and pollution category, indoor waste was prioritised by the panel with 56.9 % with 43.1% for outdoor waste, as shown in Figure 5.8. Therefore, indoor waste was considered by the panel to be a high risk for the health and wellbeing of occupants and curbing this pollution should be a priority for the designer and stakeholders of the building.

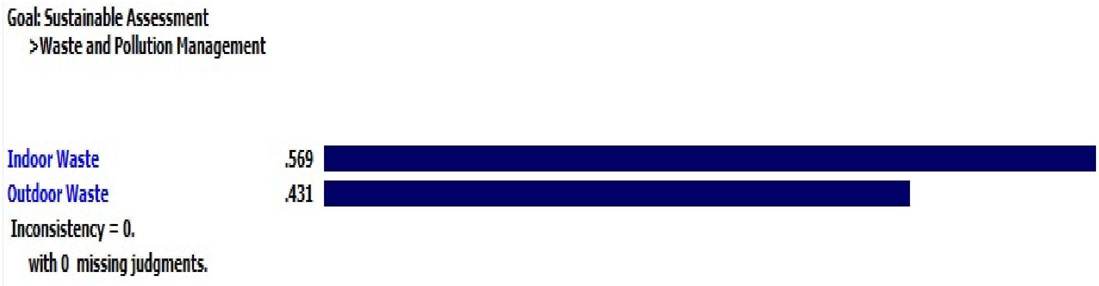


Figure 5.8 Pairwise comparisons of Waste and Pollution Management's sub-categories

Finally, the building envelope and the efficient indoor heating and cooling strategies were selected as the most important groups with 0.35% and 0.26% respectively, as shown in Figure 5.9. This could be due to the significant savings in energy that might occur through an airtight building with efficient indoor appliances and an HVAC system.

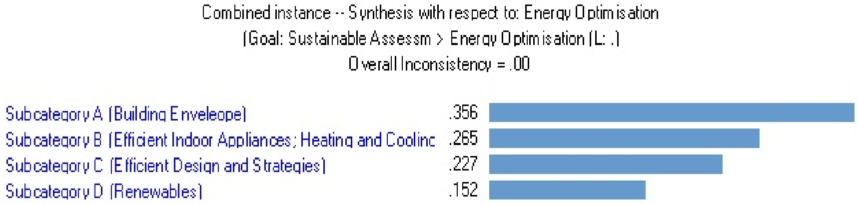


Figure 5.9 Pairwise comparisons of energy optimisation's subcategories

5.8 Summary

This chapter detailed the process of developing a sustainability assessment framework for residential buildings in Iraq by analysing the data using the Delphi technique. 126 indicators achieved consensus and were given confirmation by the panel. Following the process of consolidating and confirming the indicators, the weighting for the categories and sub-categories was calculated. The analytical hierarchy process (AHP) was selected as the method to compare and evaluate the judgements of the panel in order to calculate the final weighting for each category and sub-category. Water was highly prioritised having been given a weight of 19.6%, due to water scarcity in the Middle East and Iraq, followed by energy optimisation with a weight of 18.4% compared to the weights of other categories in the assessment. The energy optimisation category was the second most important category within the framework due to the lack of any guidance for improving the energy overconsumption within the buildings sector in Iraq and the negative impact on the environment from the carbon emissions consequently. The next chapter compares the weighting system discussed in this chapter with the weighting systems developed for other Middle East regions and the rest of the world. The overall impact of the study is also discussed.

Chapter 6: Discussion

6.1 Introduction

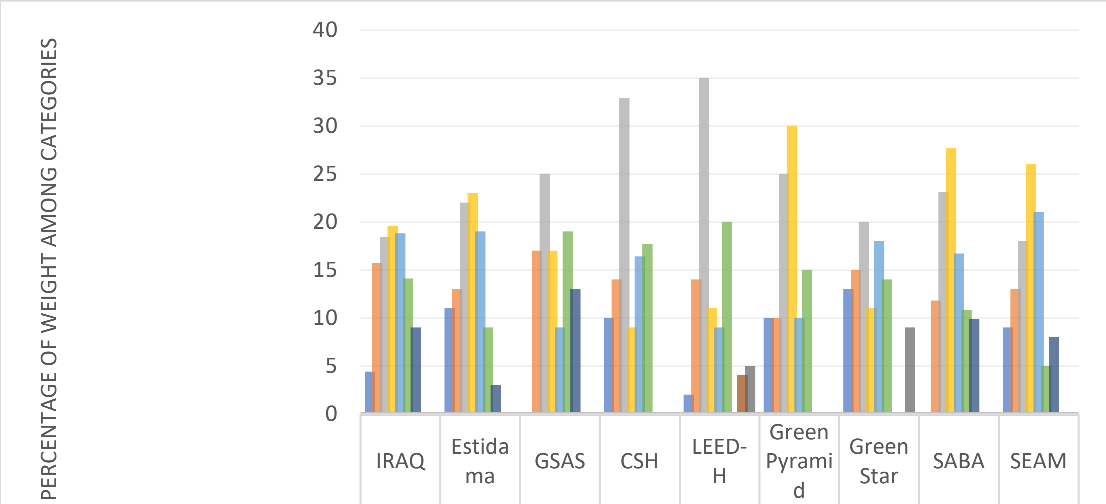
This chapter discusses the various research stages and results for developing a sustainability assessment framework for residential buildings in Iraq. The development of indicators for the framework are discussed highlighting the key similarities and differences for the new Iraqi assessment when compared with assessments developed for the Middle East and the rest of the world. This chapter also presents the scoring systems, labelling for the certification system and the testing of performance indicators for the current and future climate scenarios of three cities in Iraq. Finally, the chapter highlights and presents the impact of indicators in the assessment that are unique to Iraq.

6.2 The case of developing sustainable assessment for residential buildings in Iraq

Buildings consume 40% of the energy resources, 25% of the water resources, release a third of greenhouse gas emission into the atmosphere and are responsible for causing global warming (UNEP 2016). Yet, they provide a great opportunity to reduce resource consumption as well as optimising the thermal comfort of occupants. Most developed countries have created their own sustainability assessment frameworks for buildings as a means of reducing the consumption of natural resources as well as promoting a healthy and comfortable environment for occupants. Following the establishment of the first generation of sustainability assessment frameworks for buildings (i.e. BREEAM, LEED, CASBEE) in developed countries, a second generation of assessments are starting to appear in other countries such as; SABA in Jordan, ESTIDAMA in United Arab Emirates, GSAS in Qatar and SEAM in Saudi Arabia (Banani et al. 2016). Iraq on the other hand, does not have any sustainability standards for buildings. Furthermore, the Ministry of Housing and Construction in Iraq is falling short on the delivery of housing as it can only provide 10% of the current housing needs (Un-Habitat 2006). The government of the country also promised to cut greenhouse gas emissions by 15 % under the Paris Climate Change agreement (Abu Zeed 2017). To deliver this goal, Iraq needs to implement a policy that regulates emissions, promotes building sustainability and develops a sustainability assessment for buildings. The assessment should consider: the climate, availability of natural resources and government regulation and policy, as discussed in Chapter one section 1.2.

6.3 Results of the weighting for the sustainability assessment framework

A comparison was established to show the similarities and differences between the various sustainability assessment frameworks, as illustrated in Figure 6.1. It can be seen from the comparison that assessments in the Middle East, as well as the new assessment for Iraq, place a high emphasis on issues related to water. This is due to its scarcity in the region compared to other countries such as Australia, the United States of America and the United Kingdom. On the other hand, energy consumption is given a higher emphasis in the Western assessments such as CSH and LEED, compared to those in the Middle East. This could be due to the need for Western countries to meet targets set by the government of these countries to curb energy consumption and carbon emissions in the future. The following sub-sections discuss the significance of the results for each category and corresponding indicators for the new assessment in Iraq.



	IRAQ	Estidama	GSAS	CSH	LEED-H	Green Pyramid	Green Star	SABA	SEAM
Management	4.4	11	0	10	2	10	13	0	9
Indoor Enviormental Quality	15.7	13	17	14	14	10	15	11.8	13
Energy	18.4	22	25	32.89	35	25	20	23.1	18
Water	19.6	23	17	9	11	30	11	27.7	26
Materials, Waste & Pollution	18.8	19	9	16.4	9	10	18	16.7	21
Tranportation, Site & Microclimate	14.1	9	19	17.71	20	15	14	10.8	5
Economics & Cultural	9	3	13	0	0	0	0	9.9	8
regional priority					4				
innovation					5		9		

Figure 6.1 Comparison of categories weights among various assessment

6.3.1 WATER

The results obtained from this category showed that the panel prioritised internal fixtures over external ones as discussed in Chapter five section 5.4.4 due to the nature of the climate in Iraq. Water scarcity in Iraq has been escalated as a problem due to the limited rainfall and reduction in Iraq's share of water from Turkey and Syria as a result of the construction of multiple dams in those countries (Al-Ansari 2013; Abu Zeed 2017). As such, water was highlighted as the most important category within the Iraqi sustainability assessment framework with 19.6 % of the total weighting given to all categories. Figure 6.2 shows a correlation between the various worldwide sustainability assessments frameworks; where the X-axis represents annual freshwater withdrawals obtained from the literature (World Bank 2017), while the Y-axis represents the weight given to water.

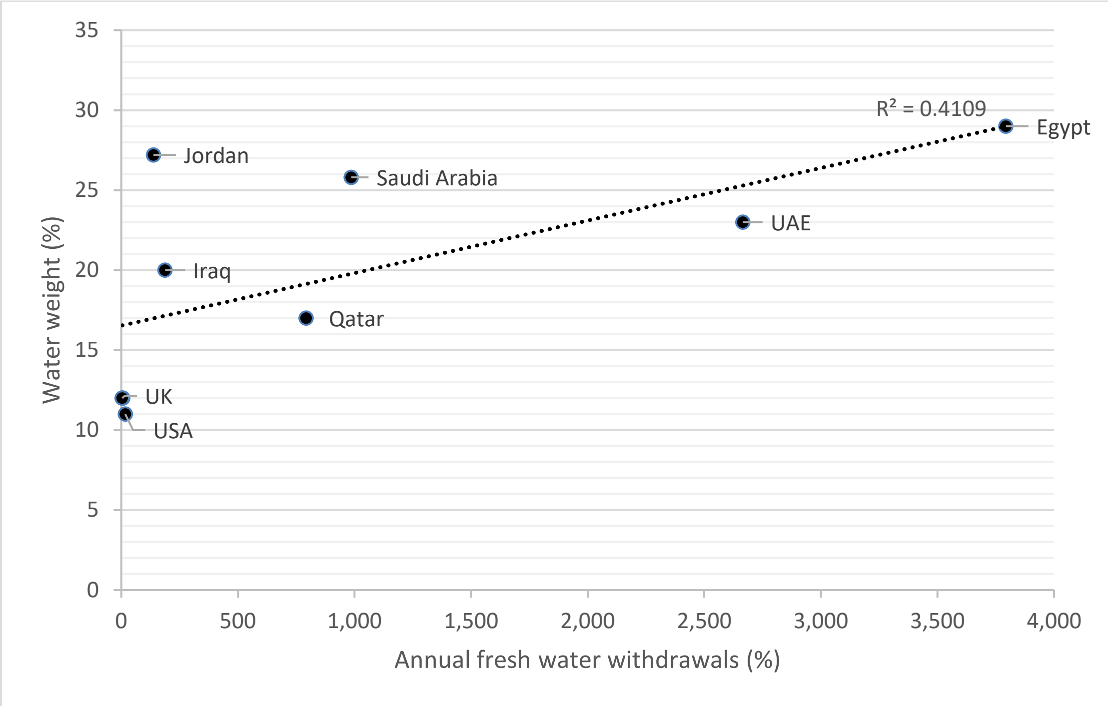


Figure 6.2 Correlation comparisons between water category and annual fresh water among various countries

Figure 6.2 shows a medium correlation of 0.41 between the internal water resource withdrawal and the corresponding weight allocated for the water category. The weighting of water for the Iraqi sustainability assessment framework was similar to other frameworks in the Middle East such as; SABA in Jordan, ESTIDAMA in the United Arab Emirates, SEAM in Saudi Arabia and Green Pyramid in Egypt. While, countries like the United States of America, United Kingdom and Australia had placed less emphasis on the weighting of water in their assessments due to the abundance of this resource in their region. The Iraqi sustainability assessment frameworks included three measures that were not identified in previous assessments which are: (1) the availability of fresh water due to the country's infrastructure being old and only one in four Iraqis having access to fresh water, as demonstrated by the Iraqi national statistics (Cosit 2017); (2) the use of native plants to reduce outdoor water consumption; (3) the turning off of boilers during the summer as the water moving through the pipes is already moderately warm due to its exposure to extreme heat. To sum up, the sustainability assessment framework for residential buildings in Iraq aims to reduce water stress on households in the future because of the expected changes in the climate and environment.

6.3.2 Energy

Energy consumption was the second most important category within the sustainability assessment framework for residential buildings in Iraq with an allocated weight of 18.4% of the total weight given to the category. Regarding the weight and importance level given to this category, Iraq's electricity consumption per capita for 2013 was 1781 kWh which is considered moderate consumption by other countries (World Bank 2017). Energy weight and electricity consumption demonstrates a positive correlation when compared with other assessments and countries, as shown in Figure 6.3. The obtained coefficient of determination (R^2) = 0.85, shows a strong relationship between the weight given for energy in the assessments and the corresponding electricity consumption in kWh per capita. Gulf cooperation countries (e.g. Saudi Arabia, Qatar, and United Arab Emirates) and Australia were excluded from the comparisons as they were considered as outliers.

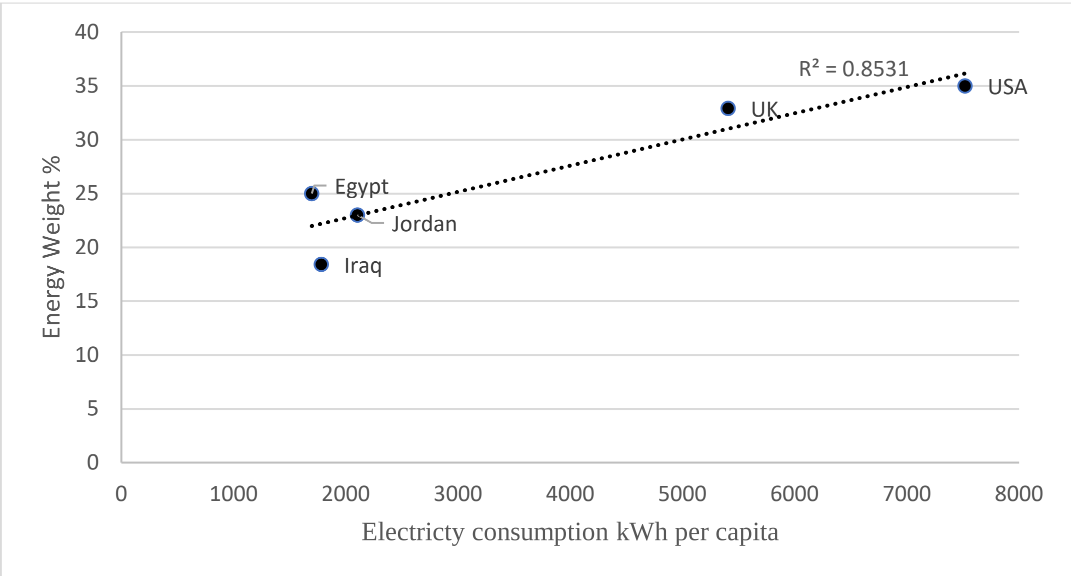


Figure 6.3 Correlation between energy weight and the electricity consumption

The reasons behind excluding these countries were: (1) high electricity consumption per capita due to the cheap prices of fuel compared to other countries and (2) an increased number and size of the dwellings (Abs 2006; Chandratilake and Dias 2013; Gulf Intelligence 2015). It was noted from Figure 6.3 that energy in Middle Eastern countries, including Iraq, tend to place less weight on energy compared to developed countries like the United Kingdom and the United States of America. Developed countries consume higher energy compared to developing countries, including those in the Middle East.

As far as indicators are concerned, the strategies obtained were clustered within four groups which reflect the major issues related to energy. These were; the building envelope, use of efficient indoor appliances and efficient design. The energy indicators that are used in most sustainability assessment frameworks (i.e. LEED, GREEN STAR, and ESTIDAMA) followed one of two paths: (1) a prescriptive pathway which allows for indicators to be assessed individually; or (2) a performance simulated pathway which is based solely on simulation. The Iraqi sustainability assessment framework followed the former option, as it rewards improvements to the design of the building with the indicators rather than achieving the same aim through building energy simulation. The unique indicators that were highlighted within this category were:

1- Use of a Skytherm on the roof, which can reduce indoor temperature by 3.36°C in summer, as discussed in Chapter five section 5.4.3.1;

2- Use of heat pumps for cooling and heating, which can be used for heating or cooling purposes and can reduce energy consumption by 30%-60% in hot climates (DOE 2017);

3- A cooling bed area, creating a small thermal zone that only surrounds the bed as this requires less energy;

4- Use of evaporative coolers and ceiling fans in hot climates help to reduce energy, consumption compared to conventional air conditioning units, while moisturizing dry air inside the building;

5- Use of the basement for living purposes during hot summer days helps to reduce energy consumption needed for cooling as the ground temperature is cooler and within an accepted comfort level compared to above ground temperature inside building;

6- Use of outdoor facilities for sleeping and cooking, alongside wind catchers as these strategies are useful for Iraq’s climate due to great diurnal temperature between day and night;

7- Use of courtyards as it helps to bring cooler air into the building and reduce the total energy consumption used for cooling;

8- Use of district heating and cooling which can minimise energy consumption and carbon emissions per household.

Overall, the above strategies have shown their effectiveness in hot climates, such as Iraq, therefore implementing these within the sustainability assessment frameworks will improve building energy consumption and simultaneously curb harmful emissions.

6.3.3 Indoor Environmental Quality

Iraq suffers from extreme hot temperatures in summer, particularly during July and August as the temperature is expected to reach 50°C. Therefore, in summer, occupants spent most of their days inside buildings, preventing exposure to the sun. In addition, there have been studies in the literature (EPA 1991) and (Norhidayah et al. 2013) to highlight the risks of spending significant amount of time inside including the associated "sick building syndrome" caused by contaminated air and inadequate ventilation. As such, indoor environmental quality was selected as the third most important category following water and energy, with a 15.7 % level of importance. To tackle indoor environmental quality issues, indicators were sub-categorised into three components: (a) controllability; (b) indoor services and (c) interior qualities and functions. With regards to the sub-categories (a) and (b), thermal comfort and efficient mechanical heating and cooling were prioritised, as occupants cannot achieve thermal comfort by using passive cooling per se, without relying on mechanical methods. Nevertheless, there were some distinctive indicators which emerged from these sub-categories which were not mentioned by other sustainability assessment frameworks. These were: (1) accessibility to the internet as the country has the lowest percentage of internet accessibility among other developing countries; only 21.2% of population have access to internet service (CIA 2017) and (2) roof shading devices that are controlled by occupants in summer to cast shading on the façade. Furthermore, indicators from sub-category (c) were novel indicators that emerged within the indoor environmental quality category, which focused on enhancing the functionality and design of the interior, while having a positive impact on the psychology and productivity of the occupant.

6.3.4 Waste and pollution management

The allocated weight for the waste category was 10.6%, which was divided between 5.69% and 4.31% for indoor and outdoor waste sub-categories respectively. The findings showed that indicators obtained from the indoor waste sub-category were similar to other sustainability assessment frameworks which aim to reduce contamination from carbon and nitrogen oxide gases inside the residential building. There were two novel indicators which emerged from the use of the Delphi technique, and these were: (1) provision of separate waste containers for different types of waste, as this measure encourages occupants to recycle waste and (2) keeping waste facilities away from buildings to reduce the risk of contaminated waste streams entering the buildings. The indicators obtained for the outdoor waste sub-category highlighted two important measures which included: dust storm protection (which was mentioned in GSAS) and composting (which was implicitly described within ESTIDAMA). For the former, this indicator was meant to reduce dust through the use of shrubs as a barrier, whereas its inclusion in the Iraqi sustainability assessment framework was to protect buildings from sandstorms. Achieving this measure can take many forms including: airtightness; use of a high external fence; sealing the corners around windows and doors before incoming storm, or it can even be a natural or site-specific barrier specified on the building site plan.

It is also worth mentioning that reducing impact on solar energy potential of adjacent buildings was an indicator which is only mentioned in the SBtool sustainability assessment framework as shown in Appendix E. This was adopted in the Iraqi framework due to the lack of both the defined heights for buildings as well as the permitted solar accessibility for each residential unit within a neighborhood district. All other indicators within the outdoor waste sub-categories were similar to the compared sustainability assessment frameworks as they focused on general issues such as: site contamination; mitigation of the negative impacts of the wind on site; use of refrigerants with a low or zero impact on ozone; reduction of exterior light pollution and pest control.

6.3.5 Materials and Resource Use

The assigned weight for this category was 8.20 %, which was divided into two sub-categories: 50.2 % for the environmental impact of materials (sub-category A) and 49.80 % for the sourcing of materials (sub-category B). As discussed in Chapter two section 2.5.22.4, all sustainability assessment frameworks including ESTIDAMA, GSAS and GPRS lacked indicators specifying types of available regional materials while they did include indicators specifying the travelling distance for obtaining regional materials. However, the results obtained from the Iraqi framework encouraged the use of local materials (e.g. cement, clay and blocks) for sub-category B for the, as these materials were classified as local materials in Iraq (Un-Habitat 2006). Although, encouraging the use of renewable materials was included in GPRS and was similarly adopted within the Iraqi framework as Iraq and Egypt both use similar organic materials (e.g. straw, natural stone and reeds) for construction, all of which have less environmental impact through their extraction and use.

The protection of endangered materials within the same sub-category was mentioned in SBtool and LEED to protect non-renewable materials such as tropical wood extracted from non-renewable rainforest sources. This same indicator was included within the Iraqi sustainability assessment framework. However, rainforest wood sources are not readily available in Iraq, so other endangered non-renewable materials in Iraq (e.g. natural stones, local granite and marble) should be used with caution and in minimum quantities, compared with the more permanent materials used in the construction of residential buildings.

As far as sub-category A is concerned, the only distinctive and novel strategy that was included within the Iraqi framework, and not included in any other, was the simplification and standardisation of materials by architects and planning authorities during the design stage of buildings. As such, research in the literature (Osmani et al. 2008; Wang et al. 2014) showed that a third of the waste generated in projects can be reduced during the design stage by the simplification and standardisation of the design and construction materials. So, the inclusion of this indicator is important to minimise waste during the design stage of construction in Iraq as such a strategy is not currently followed by building practitioners.

6.3.6 Transportation

The transportation category was responsible for reducing energy consumption per resident through design and planning measures, and this category accounted for 6.5% of the total weight given for the sustainability assessment framework. Iraq is a member of non-OECD developing countries which are expected to have a growth of 61% of total energy consumption by 2040. OECD countries are projected to decrease their transportation energy consumptions by 2040 through the implementation of transportation with less reliance on fossil fuels (EIA 2016). Furthermore, due to economic growth, the ownership of cars per capita in Iraq had increased so much that the transportation sector accounted for 60% of the total energy consumption by 2010 and ownership of private cars are considered high in Iraq (IEA 2012). To understand the effect of transportation on energy consumption in Iraq, a correlation was created to compare the weight assigned for the transportation category for each sustainability assessment framework with the corresponding weight for energy intensity for transportation, extracted from the literature (Data Market 2012). As shown in Figure 6.4. GCC countries including (Saudi Arabia, Qatar and United Arab Emirates) and their associated sustainability assessment frameworks were considered outliers as their transportation energy intensity was high due to their subsidised low fuel energy prices compared with the international and regional average prices (IMF 2015).

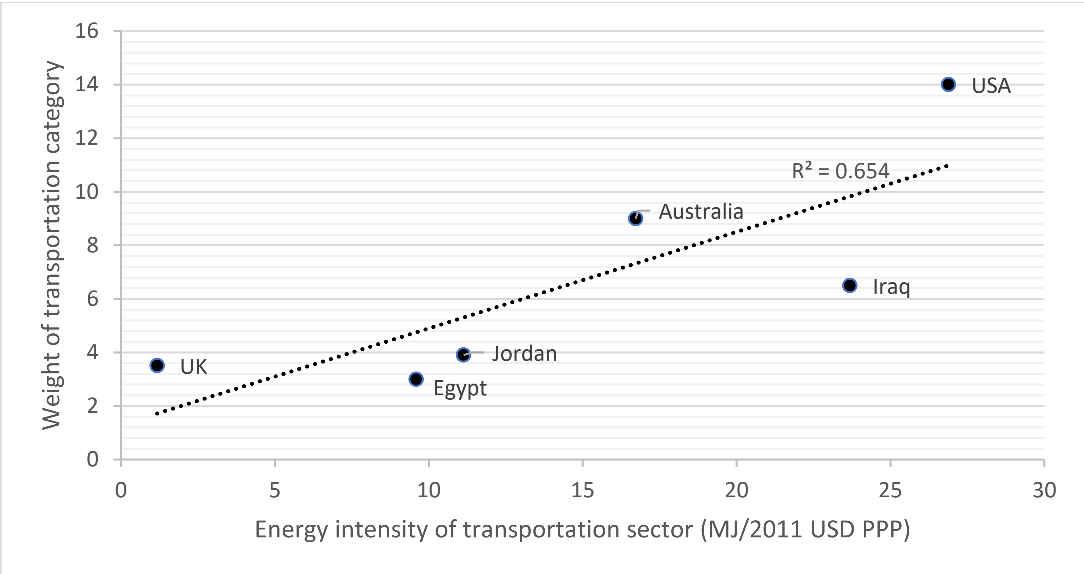


Figure 6.4 Correlation between transportation weight and energy intensity for transportation by various countries

The graph at Figure 6.4 showed the coefficient of determination (R^2) which was 0.65, which showed a strong correlation between the weight given for the transportation category for each country and the associated energy intensity. Considering the weights given in the sustainability assessment frameworks for the transportation category in comparison to the energy intensity, Iraq has a relatively high energy intensity, therefore, the assigned weight was 6.5%. Within the same graph, the USA was assigned the highest weight due to its high energy intensity, while the United Kingdom was assigned the lowest weight for all countries because of its low energy intensity.

The transportation category included two important indicators that were not discussed in other frameworks. These were; the provision of public main roads and regulating the use of private cars. By encouraging the provision of public main roads, the first indicator aims to enhance connectivity within the community, thus reducing travel distance required over time for residents. Coupled with regulating the use of private cars as both indicators will help to curb the overall energy consumption per residential unit simultaneously.

6.3.7 Site

The site and microclimate category were given a weight of 7.6%, divided into 5.17% for the Heat Wave Island effect and 4.83% biodiversity & infrastructure. To justify the weight obtained for this category a comparison was established that consisted of Y-axis percentage of weight assigned for the site category shown on the Y-axis and the urban density (population per square kilometre) for capital of each country shown on the x-axis obtained from the literature (Demographia 2016), as shown in Figure 6.5. According to the same figure, the USA, Australia and United Arab Emirates where among the countries with the lowest density and weight for the site category. However, countries like Jordan with a population of 7,200 people per square km and Iraq with a population of 10,100 people per square km, have been allocated weights of 10.8 and 7.6 percent respectively. The highest urban density was in Egypt with 16,300 and its corresponding weight was 15%.

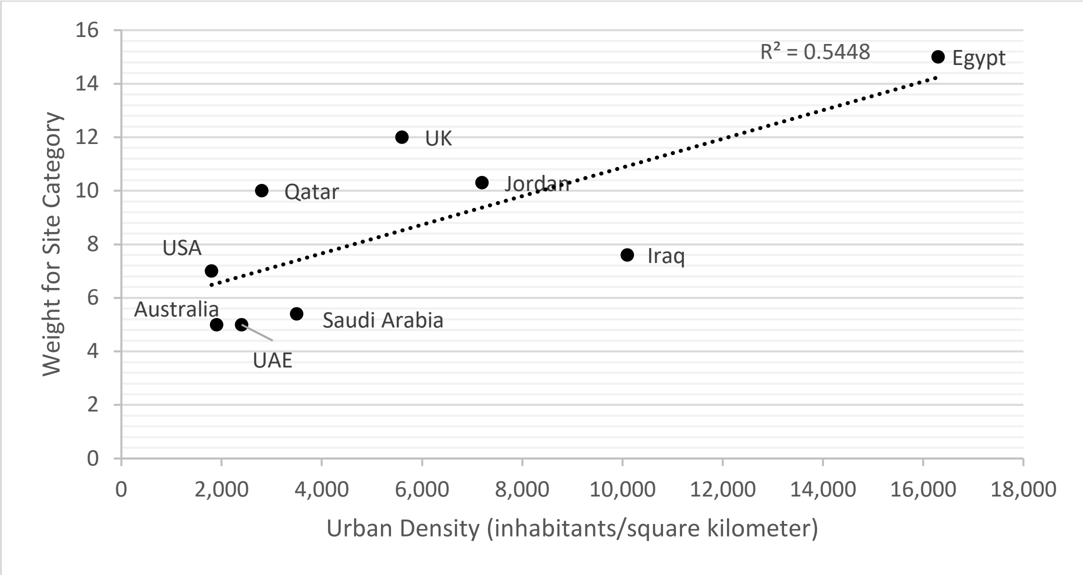


Figure 6.5 Correlation between site's weight and urban density by various countries

The obtained correlation of coefficient (R^2) was 0.54, which is a moderately positive correlation that shows that an increase in urban population density is associated with a corresponding increase in the weight allocated for the category. The reasons behind this could be the availability of land is lower in cities with a high population density and value of sites for buildings increases. Therefore, indicators within the biodiversity and infrastructure sub-category were given a higher priority to encourage the re-use of land for buildings. Measures included: the selection of brownfield sites; the preventing site pollution; reducing development on green field sites and protection of any heritage and historical monuments within the construction site.

Moreover, there were novel indicators that emerged within this sub-category for Iraq which aimed to enhance food production as well as to protect historical and monumental buildings. For the former indicator, it was concurrent with recent studies in the literature (Specht et al. 2015; Benis et al. 2017) that supported the integration of buildings and farm land to reduce carbon emissions and to mitigate the impact of climate change. The country experienced continuous conflicts which impacted wildlife and caused destruction of historical buildings and monuments, as demonstrated in the literature (British Council 2015). Therefore, provisions for protecting endangered species and monumental buildings was a necessity.

The heat wave island effect sub-category included indicators that were not explicitly discussed within other sustainability assessment frameworks such as; use of water bodies features to enhance microclimate and the use of green roofs. The latter was believed to be first found in Iraq in the hanging gardens that were built by the Sumerians in 600 BC (Dastjerdi 2014). Both green roofs and the inclusion of water bodies, have shown a positive impact on the reduction of the heat wave island effect and the surrounding temperature for buildings by 2-3 Kelvin, as demonstrated in the literature (Ambrosini et al. 2014; Sodoudi et al. 2014). Hence, the inclusion of both measures within the Iraqi framework could encourage planners to improve the urban microclimate for residential buildings.

6.3.8 Economic Efficiency

The economic category was assigned 5.6% among other ranked categories within the Iraqi sustainability assessment framework. Iraq is falling short on the delivery of 1.27 million residential units to cope with housing demands, and financing these was one of the main issues that caused such a problem as highlighted by the literature (Un-Habitat 2006). According to the same report the cheapest affordable housing for low income households in Iraq was in Hilla province with a size of 60m2 and took three years to purchase, whereas the most expensive housing for the same sample population was in Mosul province with an area of 105 m2 which took seven years to purchase. Therefore, the Iraqi framework emphasised the importance of providing low capital cost housing units. The former indicator was also coupled with other complementary indicators such as: low rental cost; materials with low life cycle cost and low maintenance /operating costs that help to alleviate the shortages of housing by curbing the overall cost of the building. The panel also suggested the implementation of building information modelling (BIM) which was not listed by previous assessments, as studies over the last few years showed the use of BIM in construction can reduce the overall cost and amount of waste significantly (Bryde et al. 2013; Ahuja et el. 2016).

6.3.9 Management

The weight assigned for this category was 4 %, the second lowest weighting among all categories within the Iraqi sustainability assessment framework. Two novel indicators were highlighted within this category and these were: (1) evacuation plan; and (2) post occupancy evaluation. The evacuation plan is used for getting the affected people out of the disaster-prone area as fast as possible. There are numerous studies within the literature that support such a measure as part of disaster management (Gan et al. 2016; Pillac et al. 2016; Boyce 2017). This measure is highly important for Iraq since the country is still under threat of terrorist attacks. This particular indicator was not listed in the other assessments which were located in relatively safe countries compared to Iraq.

The post occupancy evaluation focuses on gathering feedback from occupants on building performance. Although this measure was not included in the other assessments, it has been included within the Iraqi assessment to ensure that buildings perform as designed.

6.3.10 Cultural

The cultural aspects category was allocated a weight of 3.9%, which was lowest percentage weight for all the categories of the Iraqi sustainability assessment framework. All the other frameworks as presented in Appendix H showed a lack of emphasis on cultural issues except GSAS Estidama and SBtool which acknowledged these issues through two main indicators which were intended to achieve both interior to exterior visual accessibility and also neighbourhood harmony. However, the Iraqi framework does include these two indicators as well as further indicators, not mentioned in the other frameworks, which were, maintaining and keeping cultural architectural features of the building through exterior design and compliance with local codes.

The Iraqi sustainability assessment framework also placed emphasis on issues such as demonstrating an entrance for handicapped; harmony with neighbouring surroundings and finally designing an aesthetic exterior for the building.

6.4 Scoring system

Due to the Delphi technique used in this research, the panel reached a consensus on determining the importance level of each indicator on a scale of 1-5. This evaluation was used to calculate the total score for the assessment. Different scoring systems have been implemented by various sustainability assessment frameworks. In Jordan, Ali and Al Nsairat (2009) adopted a scoring system that assigned 0, 0.5 and 1 points for each parameter, while the final accumulated results of assessments were calculated through the following equations:

Parameter result = weight of parameter x parameters assigned score (Equation 5.1)

Result of indicator = weight of indicator x Parameter result (Equation 5.2)

Result of category = weight of category x total result of all indicators located for a particular category (Equation 5.3)

Total assessment rating= $\sum$ result of category (Equation 5.4)

Estidama, follows the same scoring system in LEED, CSH and Green Star which are based on the points/credits allocated for each indicator within the categories and a final score is calculated by summing up the points/credits for all categories. SBtool, on the other hand, assigned four ranking scores for each indicator from -1 to 5. Only three scores were accepted for positive performance which were: 0 for minimum performance, 3 for good performance and 5 for best performance.

The GSAS sustainability assessment framework in Qatar used a different scoring approach that assigns points for each indicator from -1 to 3, in which -1 and 0 indicates a poor performance.

In Saudi Arabia, Alyami et al. (2014) used points from 1 to 3 for each indicator to determine the level of importance within each category.

It is apparent that most sustainability assessment frameworks analysed in this study assigned three scoring points that ranged from (-1 to 5) for their indicators. Therefore, this study followed a similar approach for the Iraqi framework by assigning points for each indicator based on its mean value achieved through the rating of questionnaires. As shown in Figure 6.6, the mean value for each indicator are rounded to the nearest integer value. For example, an indicator with a mean value of 2.5 to 2.49 was assigned 3 points, while indicators with 3.5 to 4.49 were assigned 4 points and finally indicators with 4.5 to 5 mean value were assigned 5 points.

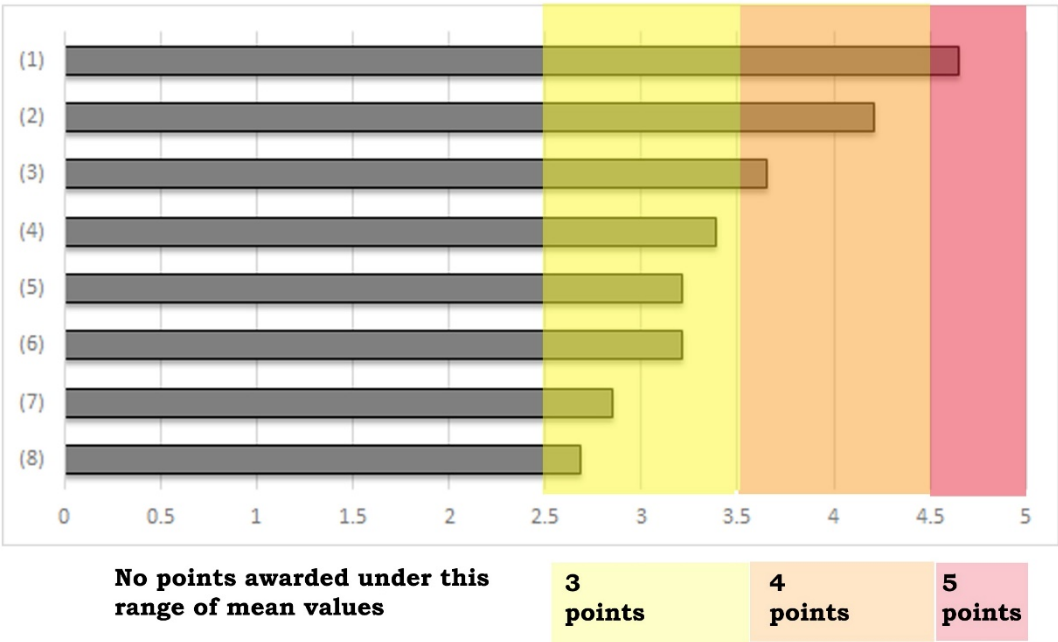


Figure 6.6 Shows sample of scoring distribution allocated for assessment's indicators

6.5 Assessment's Ratings

The implementation of AHP helped to provide a relative weight for each category and sub-category within the Iraqi sustainability assessment framework. A score was assigned to each indicator and the final result from the calculation was obtained by: (A) identifying the final score for each category; (b) calculating the aggregated final score for by the summation of the weights given for all categories and subcategories:

$$\text{Subcategory final score} = \frac{\text{Indicators points achieved}}{\text{Total points available for subcategory}} X \text{ subcategory weight} \qquad \text{(Equation 5.5)}$$

$$\text{Category score} = \text{Subcategory 1 final score} + \text{Subcategory 2 final score} + \cdots + \text{Subcategory n} \quad \text{(Equation 5.6)}$$

$$\text{Category final score} = \text{Category 1 final score} + \text{Category 2 final score} + \cdots + \text{Category n} \quad \text{(Equation 5.7)}$$

The final rating score is determined by calculating the final score of the category, as this will reflect the level of sustainability for the residential building evaluated through the sustainability assessment framework.

6.6 The assessment Certification Levels

The final output for most of sustainability assessment frameworks was expressed through a descriptive label or a grade that reflected the level of sustainability achieved for a building. A comparison graph was created to compare the level of certification between seven frameworks and these were: CSH, LEED-H, ESTIDAMA, GPRS, SEAM in Saudi Arabia, Green Star and SABA in Jordan. An average line was established to define the certification level within these frameworks, as shown in Figure 6.7. In this sense, the code of sustainable homes has six levels of certification. In order to achieve level 1 the building needs to score at least 36 out of 107 total points available; scoring 90 points will eventually help the building to get a level 6 which is the highest level of certification. Level 3 is required as a minimum by some planning authorities in the United Kingdom (GOV 2010). While LEED has four paths for certification which are: certified (40-49 points); silver (50-59); gold (60-79) and platinum (80+). Furthermore, the literature (Estidama 2010) showed that Estidama had a total of 93 credits available including innovation with 5 levels of certification, which were: all mandatory credits (1 pearl); all mandatory+30 points (2 pearl); all mandatory+44 points (3 pearl); all mandatory+57 points (4 pearl) and all mandatory+70 points (5 pearl). Green Star included six levels; the minimum level that is considered within the comparisons is level three as it represents good practice. Only SEAM has six levels of certification and the highest one was plotted but no average line was calculated. CASBEE, GSAS and SABA were excluded from the comparisons as they rely on assigning performance measures for each indicator before calculating the final score which is plotted on the performance graph.

It is clear from Figure 6.7 that the minimum average credits required for certification is 37, while the minimum points required to achieve the highest level of certification is 93. Therefore, to compare the performance of residential buildings within the Iraqi sustainability assessment framework with other international frameworks, the calculated averages shown in Figure 6.7 was used. They were then further used as the basis for the development of new certified levels for the Iraqi sustainability assessment framework as shown in Figure 6.7.

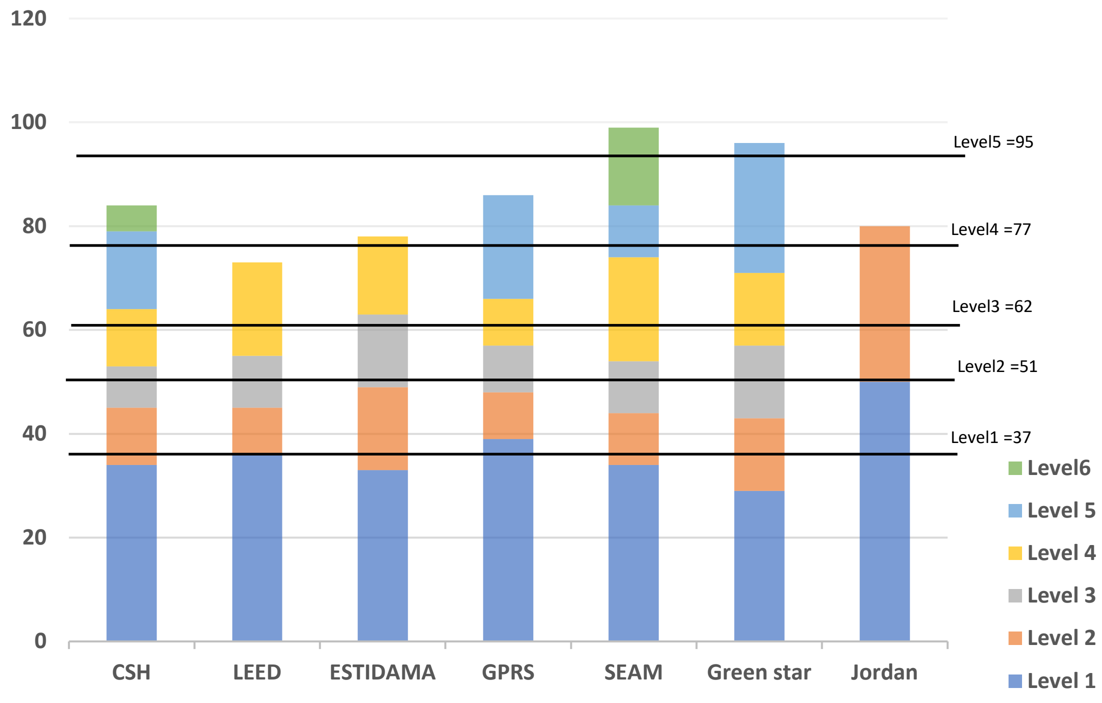


Figure 6.7 Comparisons of certification levels among various assessments

Table 6.1 Represents the level of certifications available for the developed assessment in Iraq.

Credits required	Level of rating
37 to 50	Level 1 or certified level (★)
51 to 61	Level 2 (★★)
62 to 77	Level 3 (★★★)
77 to 95	Level 4 (★★★★)
95 to 100	Level 5 (★★★★★)

Four levels of certifications were identified as demonstrated in Table 6.1 and these were: (1) Certified or Level 1: 37 to 50 points; (2) Good practise or Level 2: 51 to 61 points; (3) Very good practise or Level 3: 62 to 76 points; (4) Excellent practise or Level 4: 77 to 95 points and (5) Extraordinary performance or Level 5: 95 to 100.

6.7 The impact of microclimate on the sustainability assessment framework for Iraq

Owing to the global growth of sustainability assessment frameworks for residential buildings, it is important that as new assessments are developed for different climatic conditions are considered, particularly when they are applied to assess the sustainability of buildings. The climate for a particular region or city influence the effectiveness of sustainability assessments for buildings is influenced by the prevailing climate (Ding 2008; Moussa and Farag 2017). Therefore, it is imperative to design these frameworks to consider the impact of current and future climate scenarios to fully optimise the sustainability performance of residential buildings.

The discussion in this section has focussed on providing further assistance to the framework users and the assessors on how to optimise the usability of the framework. Therefore, the main aim of this section is not to discredit the current developed indicators within the assessment by rather it does provide further guidance for assessor on potential indicators that must be considered in the future when the climate changes. The analysis was done through entering the weather files for current and future scenarios in 2080 from Meteonorm database and then these files were then exported to climate consultant software and IESVE to generate two types of chart: (1) psychometric chart that assess the thermal comfort; (2) full year weather chart that highlights the cold, stress and hot time period with colour coded on every month of the year.

6.7.1 Iraq climate zones

Climate conditions have a direct impact upon energy consumption in buildings. As such, it is important to examine the climatic conditions in Iraq to identify early design solutions for buildings to maximise thermal comfort while simultaneously reducing energy consumption as discussed in Chapter three section 3.2.

Further examination of the best strategies to be used is now discussed, considering the three main cities in Iraq:

A. **Mosul:** Assessors should focus on giving credits/points for the use of both an efficient HVAC system and the use of evaporative cooling as both measures constitute 53.3% of comfort hours in a typical year, as shown in Figure 6.8. It is also recommended to encourage the maximisation of passive cooling strategies by the incorporation of wind catchers as the temperature in the summer drops at night to thermal comfort levels as shown in Figure 6.9. However, in 2080 wind catchers will only be effective for two months, May and October, due to climate change, as also shown in Figure 6.9.

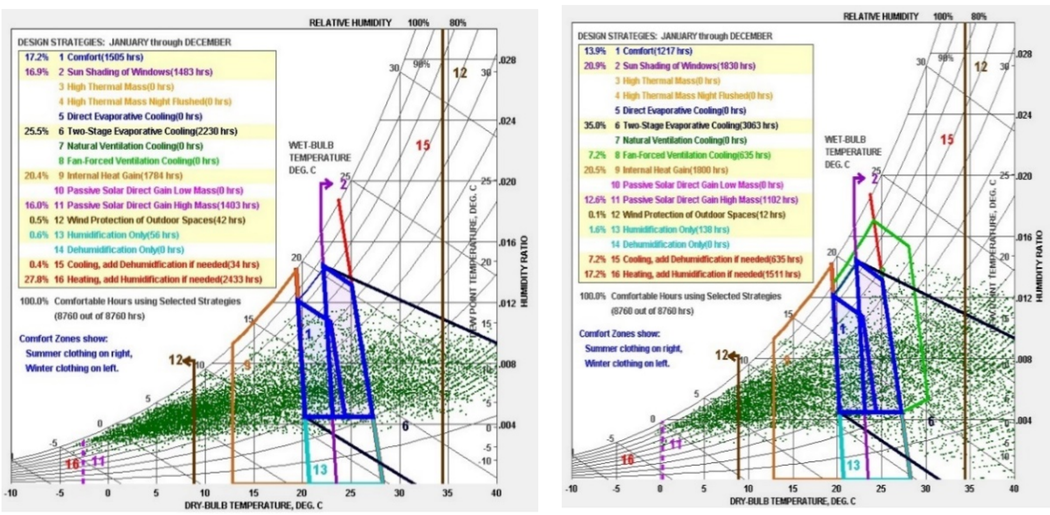


Figure 6.8 Psychometric chart for Mosul’s current weather on the left side, and for 2080 on the right side

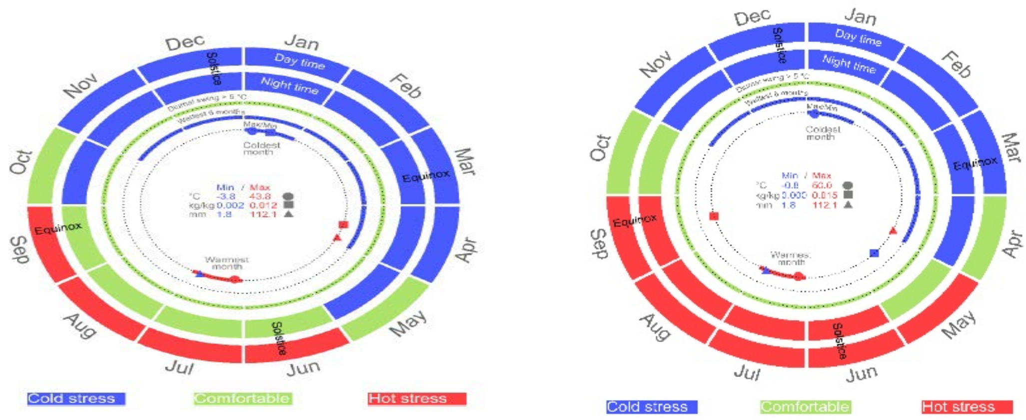


Figure 6. 9 Weather variables for Mosul's current weather on the left side, and for 2080 on the right side

B. Baghdad: Assessors should focus on targeting the evaporative cooling indicator as it contributes to 47.7 % of comfort hours during a typical year and also maximising sun shadings on the south façade of buildings as it covers 23.8 % of comfort hours, as shown in Figure 6.10. Moreover, less heating is needed in Baghdad as there are only 991 hours in winter, compared to Mosul with 2433 hours in winter. Wind catchers are less effective in Baghdad compared to Mosul during the warmest months, as shown in Figure 6.11. On the other hand, active cooling is predicted to increase in 2080 and therefore there will be a need to incorporate fan cooling that contributes to 7% of comfort hours in future, as demonstrated in Figure 6.10.

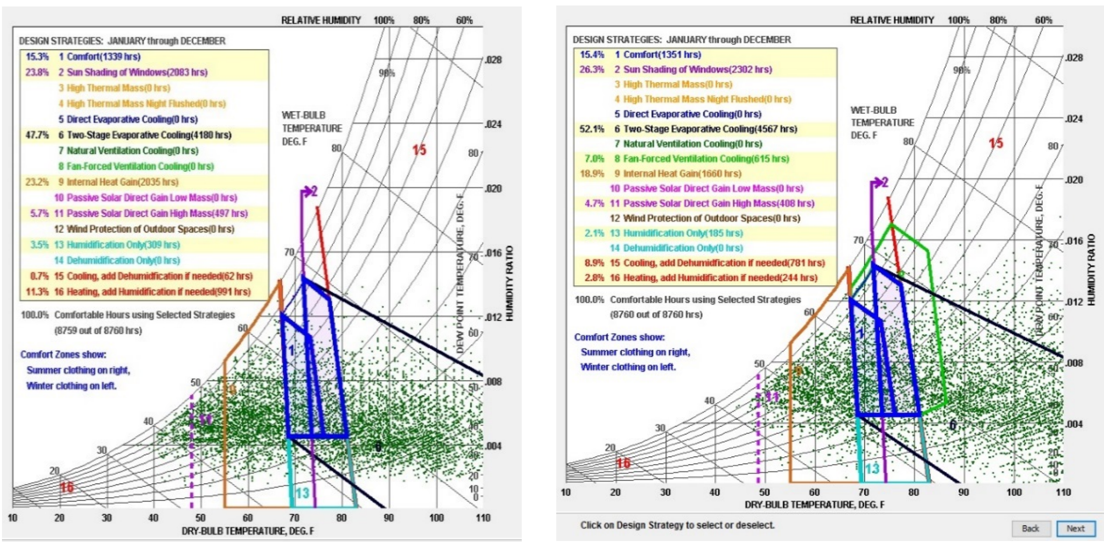


Figure 6.10 Psychometric chart for Baghdad's current weather on the left side, and for 2080 on the right side

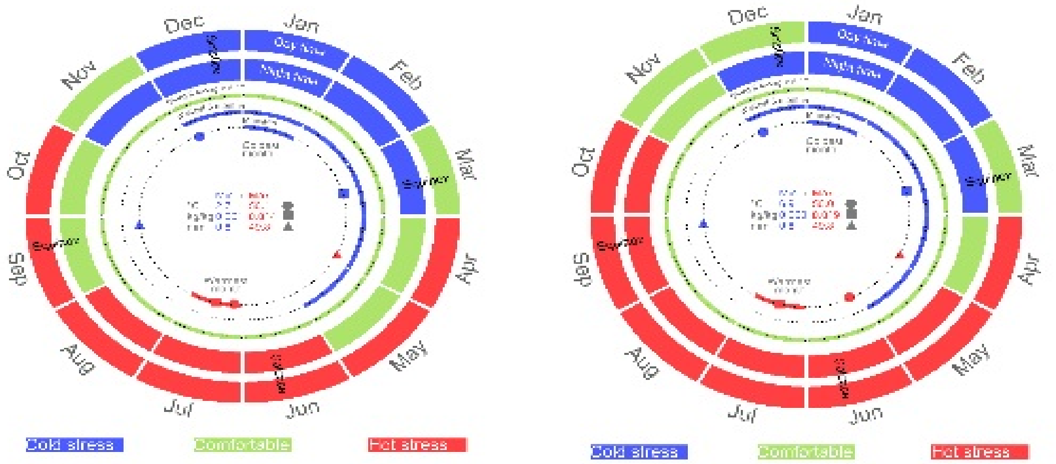


Figure 6.11 Weather variables for Baghdad's current weather on the left side, and for 2080 on the right side

C. Basra: The city's climate is very similar to that of Baghdad with the hottest weather being in August. To maximise thermal comfort, evaporative cooling and an active HVAC system could be used concurrently as both contributed to 54.8% of comfort hours, as shown in Figure 6.12. Importantly, as with Baghdad and Mosul, wind catchers are not very effective during the hot weather in July, also fan cooling will become more effective in 2080 in Basra, as shown in Figure 6.13.

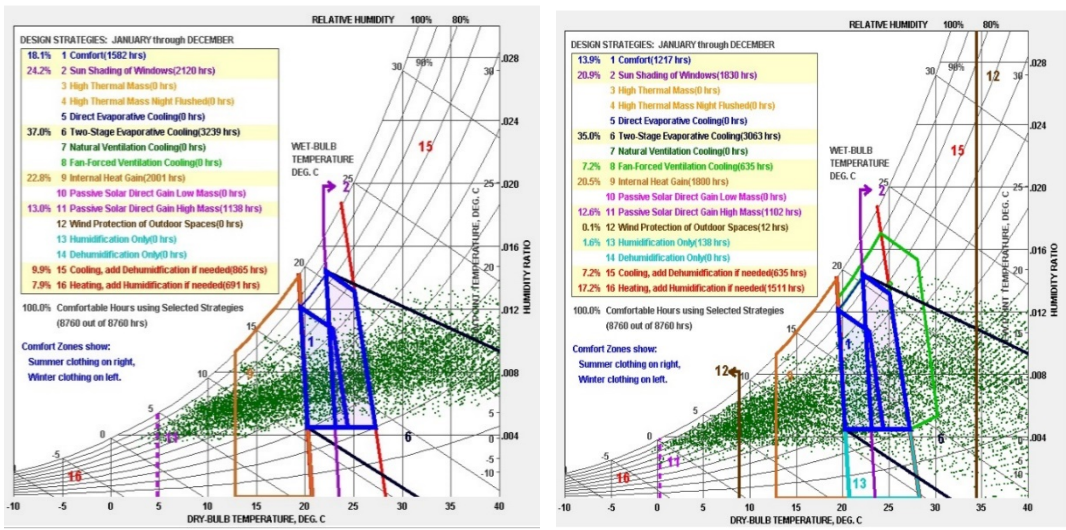


Figure 6.12 Psychometric chart for Basra's current weather on the left side and for 2080 on the right side

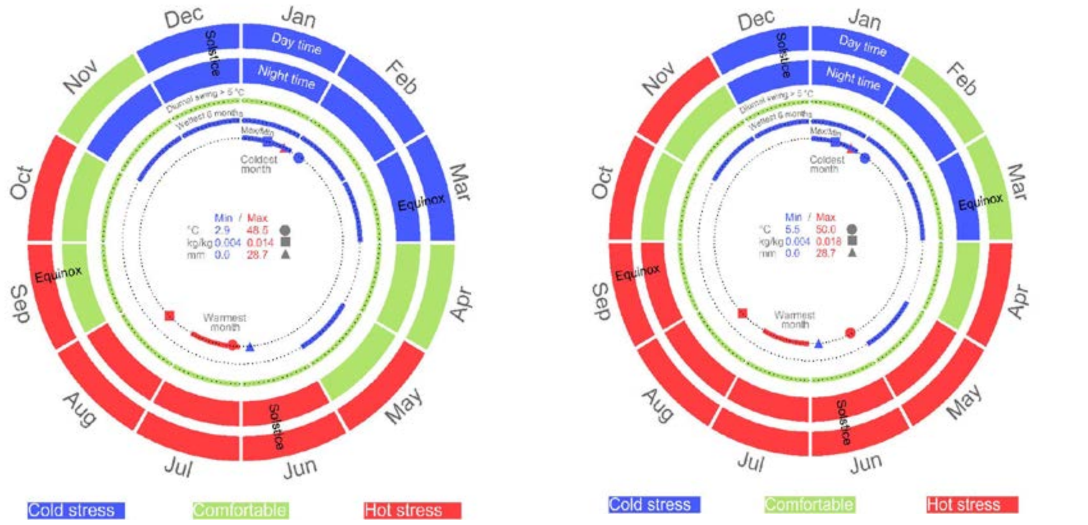


Figure 6.13 Weather variables for Basra's current weather on the left side and for 2080 on the right side

Overall, there are similarities and differences evident among the various microclimates in Iraq. All microclimates in Iraq showed good potential in terms of harvesting solar energy with the highest solar resources available being recorded in Basra, as well as swinging diurnal temperatures in some months which encouraged use of passive cooling strategies. These findings were concurrent with the final indicators included for the Iraqi sustainability assessment framework.

6.8 Implications of the study

During the development of the sustainability assessment framework for Iraq through this study there were many indicators identified which were not discussed in previous frameworks. These indicators were:

Indoor environmental quality: These measures include the following indicators: (1) roof shading devices; (2) lighting glare; (3) airtight ducts; (4) accessibility to the internet; (4) cross ventilation and (5) meeting needs of occupants.

Roof shading devices aim to reduce heat gains which can be high in Iraq since the temperature reaches 50°C, as explained in Chapter three section 3.2. Accessibility to the Internet is a very important aspect highly emphasised within the Iraqi framework as Iraq has the lowest internet access compared to all the other countries discussed in this thesis (i.e. USA, UK, Australia, Japan, Egypt, UAE, Qatar, Jordan) as only 21.2% of population have access (CIA 2017). Furthermore, cross ventilation was listed as a strategy to optimise natural ventilation in buildings for Iraq. However, this strategy was also applicable to other assessments, particularly in the Middle East where the cross section of the building is stretched horizontally rather than vertically, allowing for natural air to pass through the building, as discussed in Chapter three section 3.7.

Energy optimisation: The novel strategies listed within these indicators were focused on improving the building envelope performance and these include: (1) reducing or eliminating windows on the west and east façade; (2) installing large windows on the north façade of buildings; (3) installing large windows on south façade of buildings; (4) dividing window openings into vertical strips; (5) installing wind catchers; (6) installing roof ponds; (7) installing evaporative coolers; (8) installing a ceiling fan; and (9) installing heat pumps. These indicators optimise the passive design and passive cooling in buildings and are not listed within other sustainability assessment frameworks. Aas discussed in Chapter three section 5.3, wind catchers were used in traditional houses in Iraq and the Middle East to cool the temperature and optimise ventilation. Ceiling fans can improve ventilation, reduce temperature by 5°C in hot climate (Yang et al. 2010) and reduce energy consumption by 30% (Haase and Amato 2008). Similarly, evaporative coolers and heat pumps both have a great impact on reducing energy consumption with the former achieving an energy reduction of 75% of cooling loads in summer (Delfani et al. 2010) and the latter reducing energy consumption by 50% (Chua et al. 2010).

Other types of indicators that aim to improve the behaviour of occupants were also listed within this category: (1) use of courtyard; (2) linking living rooms with recreational outdoor facilities; (3) use of outdoor cooking facilities and (4) use of subterranean spaces. As demonstrated in Chapter three section 3.5, the use of a courtyard acts as a moderator to enhance ventilation and cooling when the ambient temperature is within comfort levels during summer evenings. All the listed indicators encourage occupants to use less energy by using outdoor spaces rather than using ordinary spaces (i.e. living room, kitchen, and bedroom). It is estimated that 20 % of energy can be saved if strategies to control the behaviour of occupants' strategies were applied for buildings (Sun and Hong 2017). These strategies are also applicable to the Iraqi sustainability assessment framework, since most of the listed measures are part of vernacular architecture in the Middle East.

Site and microclimate: The indicators within this group focused on improving the microclimate as well as reducing the Heat Wave Island effect and the phenomena of high temperatures in urban cities. These indicators were: (1) reflective pale walls; (2) green roofs and (3) availability of water bodies. It is estimated that applying these outdoor climate strategies can reduce microclimate temperature by 4 degrees Celsius. The second group of indicators focus on improving the quality of service and infrastructure of sites for residential buildings in Iraq. These indicators were not listed in previous sustainability assessment frameworks where the infrastructure for other countries was in better condition and did not lack provision for service and maintenance of buildings, as explained in Chapter three section 3.10. These indicators include the following: (1) site with accessibility to water supply and electricity grid and (2) measures to enhance food productions.

Water efficiency: The indicators within this group focus on two issues that were not discussed in previous sustainability assessment frameworks. The first problem, targeted through new indicators in the Iraqi sustainability assessment framework, was reducing energy consumption through the efficient use of hot water. This was achieved by automatically switching the boiler off on extremely hot summer days. These findings were in line with the recent findings in the literature; for example, Giusti and Almoosawi (2017) conducted a study in Abu Dhabi and found switching off boilers temporarily during weekdays, coupled with using double glazing and high thermal insulation can save up to 52% of energy consumption in residential buildings. Hence, this indicator is equally important to other indicators related to energy consumption and should be included in other frameworks as well. The second issue targeted in the Iraqi framework was reducing water consumption using the following indicators: (1) regulating the water consumption of occupants; (2) use of native plants and (3) reducing the use of embodied water. The last indicator is extremely important as Iraq is predicted to suffer from water scarcity as explained in Chapter three section 3.10. Therefore, this indicator which was not incorporated previously, should be incorporated in other assessments especially in the Middle East which also suffers from water scarcity.

Material efficiency: Two main novel indicators were included in the Iraqi sustainability assessment framework for this category: (1) simplification and standardisation and (2) design for deconstruction. For the former, simplification of design can reduce waste and the extra cost associated with assembling complicated components in construction. For the latter, designing for deconstruction can also reduce waste and the costs associated with disassembling buildings. There is also the benefit from reusing or selling salvaged materials.

Cultural: The new indicators developed within this category were: (1) compliance with local building codes; (2) accessibility for the handicapped; (3) Access to exterior natural views; (4) respecting privacy design and (5) designing an aesthetic exterior. The first indicator was highly important as it focused on following local codes. Most buildings are self-constructed in Iraq and therefore tend to ignore any building codes, as explained in Chapter three section 3.10. Incorporating disability access was also an important indicator. According to the World health organisation 15% of the world's population are disabled and the percentage is expected to increase in future due to the aging populations and increase in chronic diseases (WHO 2016). Hence, this indicator is not only applicable to Iraq, but applicable to all sustainability assessment frameworks.

Economy: the indicators developed within this sustainability assessment framework focus on implementing a systematic method for construction to facilitate all activities, as well as providing savings in construction. These were: (1) use of BIM in design and construction and (2) following green initiatives. Furthermore, other types of indicators which focus on improving the local economy and encouraging the use of local labour are also highlighted, including: low capital cost; finishing construction project on time; local labouring.

6.9 Summary

Transforming conventional building strategies and promoting sustainable practise requires large scale interventions. This can be achieved by the application of a sustainability assessment framework to enhance the environmental and sustainability performance of buildings. Whilst some countries are already engaged in this practise, Iraq does not have either standards or guidelines that promote such development for buildings. Thereby, it is essential to develop and establish a sustainable scheme that assesses the performance of buildings against sustainability benchmarks. As a result, the use of sustainability assessment frameworks promotes the use of green buildings which have less impact on the environment. The main aim of this research was to develop a sustainability assessment framework for residential buildings Iraq to encourage the adoption of sustainable practise for new residential buildings. The aim was delivered through the implementation of the Delphi technique and the use of the Analytical Hierarchy Process (AHP) to identify categories and indicators and evaluate their relative weights. The results obtained highlighted water as the main category, with a weight 19.6 %. This reflects the fact that the country is experiencing water scarcity due to reduction of its water resources.

This chapter justified the weights used in the Iraqi assessment by comparing each category with the categories of other assessments in use worldwide. Following the development of the weighting system, the certification levels were then established based on the average certification points awarded by well-established sustainability assessment frameworks. The reasoning behind following such an approach was to enable comparisons of the sustainability performance of buildings in Iraq with its counterparts in the world. It was important to discuss the potential for enhancing the performance of the Iraqi framework by investigating its suitability for the current and future microclimates in Iraq. The investigation revealed strategies that guided the assessor in the use of the framework by drawing attention to the appropriate indicators within each category.

Chapter 7: Conclusion

7.1 Introduction

This chapter summaries the main conclusions of this study emphasising how the research questions and objectives have been addressed.

The aim of this research is to develop a sustainability assessment framework that suits the environmental, social and cultural context of residential buildings in Iraq. To answer the four research questions, the aim and objectives of the research was developed to provide guidance for the researcher to follow. This chapter summarises the findings of the research and provides a response to the research questions. The chapter also presents the contribution to knowledge and final conclusions reached during various stages of the research. The limitations of the research study will also be given together with recommendations for future work to be considered by other researchers and academics interested in the same subject area.

7.2 Research Summary

The study set out to develop a sustainability assessment framework for residential buildings in Iraq. As discussed in **Chapter one**, they should be developed to fit the specific local context due to the variation in socio-economic and environmental factors across countries and regions. These variations are: (1) the local climatic conditions; (2) local architecture; (3) the cultural conditions of the building occupants and their requirements. Therefore, this research has given support to this argument by developing a framework for residential buildings in Iraq, based on the environmental and other sustainability performance indicators. Furthermore, the research investigated the utilisation of renewable energy applications as well as the use of passive architecture as a method to reduce the energy demands. A number of requirements were considered while delivering the main aim of this study, these were: (1) the need to determine the main categories, subcategories and indicators that are relevant to residential buildings in Iraq; (2) the selection and engagement of panels of experts specialising in the requirements for sustainable buildings and who are familiar with the Iraqi building context; (3) the achievement of consensus by the panel on the most applicable categories and indicators that must be included within the sustainability assessment framework; (4) the establishing of a weighting system for the categories, subcategories and indicators that are applicable to residential buildings in Iraq.

The main findings of the research were demonstrated and discussed through the followings:

1. Well known-sustainability assessment frameworks for buildings cannot be applied to multiple countries unless they are modified and adjusted to suit the issues and local criteria that reflects the country's needs and conditions for buildings;
2. The housing in Iraq suffers from the old infrastructure and inadequate services provided for buildings. These issues caused problem of water supply and electricity along with increasing the level of pollution through use of private electricity generators that further harmed the environment and the residents;
3. Renewable energy potentials are high in Iraq especially solar energy due to the geographical location of the country;
4. Delphi technique can be used as main method to develop a sustainable assessment framework as it allows for providing double loop feedback process of extracting, consolidating and confirming the main components of the assessment framework particularly the indicators. In addition, it allows for providing an ideal platform for each member of the panel to engage in research without being influenced by dominant opinion of other members of the panel;
5. Iraq has very limited rainfall percentage per year and also predicted to suffer from water shortage under some future climate scenario, therefore, the highest percentage of weighting of 19.6% was assigned to the water category.
6. The developed certification levels for the new framework allows for 5 types of awards, with total points for the scoring system of 100. The lowest certification that awarded for building must be equal or more than 37 points, whilst the highest certification level which demonstrated extraordinary performance requires achieving 95 points.
7. Novel indicators were developed for Iraqi local context which was not mentioned in previous international and Middle Eastern assessments, and these indicators

focused on issues such as: controlling occupant's behaviour through use of resources; managing urban microclimate; utilising district renewable resources; enhancing food production and embedding social and economic indicators that are country specific.

7.3 Research Aim and questions

Four research questions were formulated to give direction and structure to the research. Figure 7.1 summarises the relationship between these research questions and the aim, objectives and methodology adapted to answer these key research questions.

The aim of this research was to develop a sustainability assessment framework that constructs, selects and prioritises categories and subcategories of building performance indicators based on their applicability to Iraq and the Middle Eastern region in general.

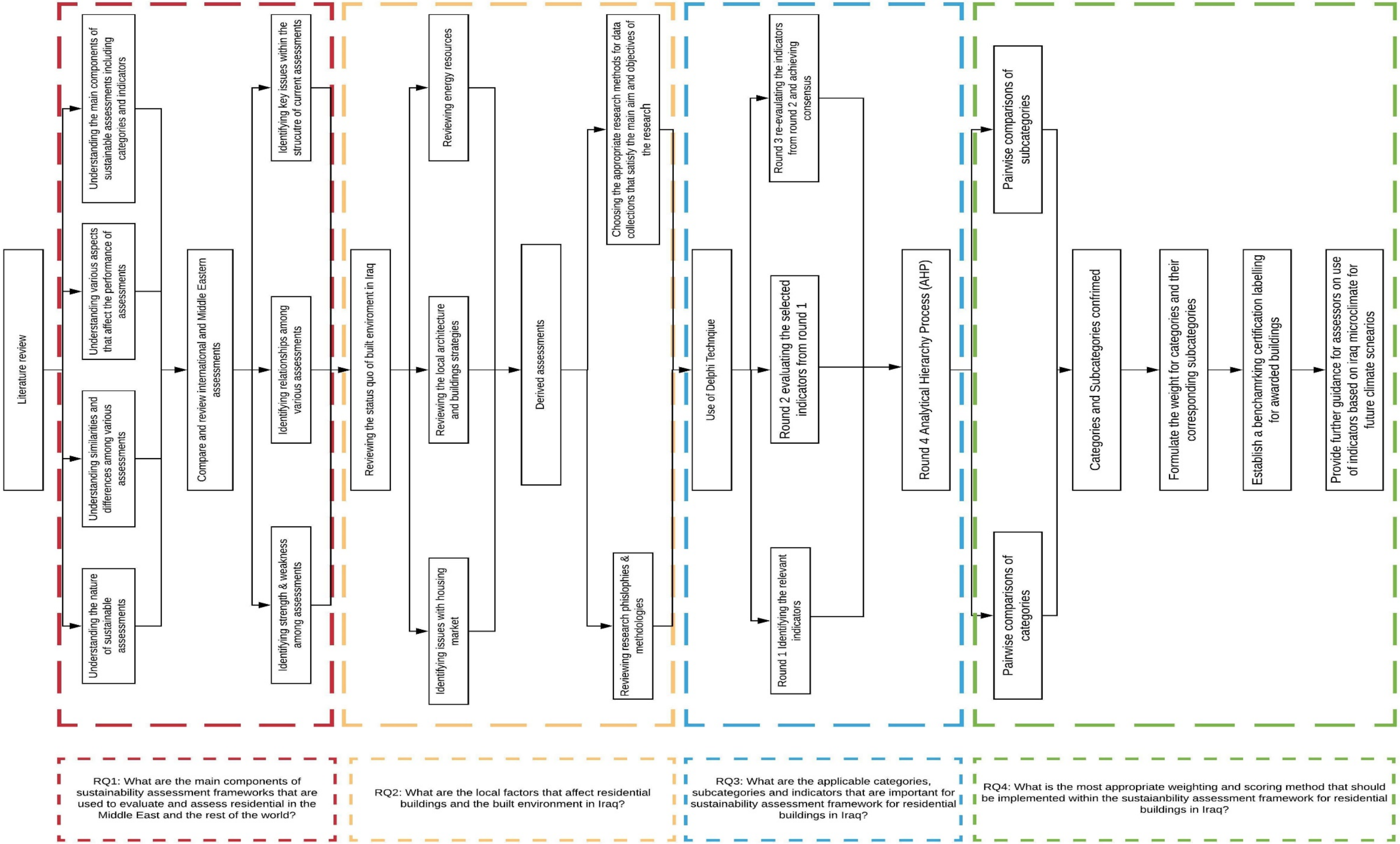


Figure 7.1 Diagram shows research questions and research development stages

RQ1: What are the main components of sustainability assessment frameworks that are used to evaluate and assess residential buildings in the Middle East and the rest of the world?

The research question was answered through objectives one and two in **Chapter two** which included a review of the concept of sustainability, definitions and core pillars within the buildings context. This was followed by the critical review of the application of these sustainability pillars in buildings as reflected in existing sustainability assessment frameworks. A critical analysis was conducted to compare international and Middle Eastern sustainability assessment frameworks with a view to understanding the main differences and overlaps to lay the foundation for the development of a new sustainability assessment framework for Iraq. Overall, the findings from the literature showed there was lack of performance indicators in the sustainability assessment framework that were applicable to the Iraq and Middle Eastern region. Therefore, the findings from the comparisons justified the need to develop a sustainability assessment framework for Iraq.

RQ2: What are the local factors that affect residential buildings and the built environment in Iraq?

This question was answered through objective three, as discussed in **Chapter three** which presented an overview of Iraq's climate and resources as well as identifying the environmental issues for the current and future climate scenarios. Furthermore, a detailed review of Iraq local architecture strategies was performed while considering the current issues that are impacting the buildings sector. The findings from **Chapter three** showed that Iraq's buildings are lacking sufficient infrastructure and services as well as the current standards for designers of sustainable buildings to follow. However, there is a great potential for renewable energy due to the high solar profile of the country and the use of passive architecture to improve the current standards of buildings. Therefore, the findings from this chapter contributed to the development of categories and indicators for the sustainability framework for buildings in Iraq.

RQ3: What are the applicable categories, subcategories and indicators that are important for sustainability assessment framework for residential buildings in Iraq?

Objective four was set to answer this question, as discussed in **Chapter four, five** and **six**. This was achieved by establishing an empirical study and use of the Delphi technique. The aim of using this technique was to reach a consensus between a panel of experts to select and evaluate the indicators for sustainability assessment framework by several rounds of questionnaires coupled with controlled feedback. Three rounds were established through the Delphi technique: (1) brainstorming to gather opinions for questionnaire questions; (2) structuring the questions; (3) achieving consensus between the panel members on the answers to questions. Upon the completion of last round a final list of categories, subcategories and indicators were established and confirmed together with importance rating and priorities. 41 unique indicators were found and discussed in **Chapter five** and **six** that focused on improving the current infrastructure of buildings, social behaviour of occupants, as well as social, economic and local passive architecture features that all contributed to enhance the sustainability for residential buildings in Iraq.

RQ4: What is the most appropriate weighting and scoring method that should be implemented within the sustainability assessment framework for residential buildings in Iraq?

This question was answered through objectives four and five in **Chapter four, five** and **six**. This was delivered by the implementation of AHP to prioritise and compare the extracted categories and their corresponding subcategories and indicators that were developed from the third round of Delphi technique. Within the realm of this research AHP provided a solution to convert the qualitative prioritising of issues into a quantitative scale to assess the labelling for sustainability certification of the buildings. The sustainability assessment frameworks allocated the highest weight for water with 19.6% followed by energy optimisation with 18.4% due to the importance and the impact of improving the sustainability level for buildings in Iraq. The weighting system was used for categories and their subcategories as well as the rating of indicators to formulate a scoring system from 1-100 percent with 5 labels for certification that reflects the level of sustainability awarded for buildings.

7.4 Research Contributions

The original contribution achieved within this study is the development of a sustainability assessment framework that provides a roadmap for academics and industry experts to follow and evaluate residential buildings in Iraq. During the process of development of such system many contributions were achieved which were:

1. The study contributed to the development of the Delphi technique by demonstrating its functions and clarifying its use within the field of sustainability assessment frameworks. The thesis contributed to the establishment of local performance indicators together with a weighting and scoring system that assesses their importance for the Iraqi residential building context. The developed indicators are tailored based on the Iraqi building context and reflect the issue are considered important to the stakeholders in Iraq. The significance of the framework of indicators coupled with the weighting system is that it can be used as a generic system by industry and academic experts to assess different types of buildings in Iraq. For example, each category developed within the assessment can be used by itself as a separate tool to assess the building. Tools can be developed to just evaluate the energy performance or assess the consumption and use of water for buildings;

2. The study developed a certification system which highlights labels of certification achievable under different scenarios. This will allow practitioners to award building labels based on their sustainability scores which will allow for comparison of the performance of buildings in Iraq with their counterparts in the Middle East and across the world.

3. The thesis contributed by testing the applicability of indicators that contributed to improve thermal comfort as well as energy for the current and future climatic conditions for the three main cities in Iraq (i.e. Baghdad, Mosul and Basra). This will allow buildings to be more resilient and adaptable as some of these indicators will improve the performance of the building in the future.

Therefore, the mapping of these indicators was imperative to inform the practitioners on what indicators they should focus on in the future.

7.5 Research limitations

There were some challenges that limited this research such as the financial and organisational limitations. However, issues related to the recruitment of the panel of experts was the main one. It was hard to identify a representative group of experts from Iraq with suitable experience of sustainability in buildings due to the limited resources and time for this study. However, the use of the Delphi technique provided a solution to overcome this issue by the selection of a limited number of experts through use of purposive sampling.

Another limitation identified within this research was at the early stages of the study through use of focus groups was identified as one of the main methods for data collection. Nevertheless, after consideration, it was decided not to include this approach as the Delphi technique overcomes this issue by consulting with experts through an online platform. This allowed for each expert to express their opinion freely without being affected by the opinions of the rest of the group. Other limitation was achieving consensus through indicators formulation process, there was no unified process of selecting a consensus, and number of rounds that should be determined based on the consensus achieved was not clear from previous studies. Therefore, this study overcome this issue by reviewing various statistical measurements that were applicable to the research and used it as defined method that can be followed by researchers in the future.

Finally, the sustainability assessment framework was not tested for actual buildings as this was not part of the study and the purpose of the research was descriptive and exploratory and did not include explanatory aspects. Therefore, to overcome this issue an external method for validity was constructed by using correlation to compare the weights and issues of the new sustainability assessment framework with the weights and issues from other existing frameworks to ensure the validity of the findings.

7.6 Recommendations for future work

- Assessments update annually or every two years and some like LEED add the options of using pilot credits for one year only. Therefore, it is recommended to update the Iraq sustainability assessment framework as new data or regulations emerge that are concerned with the buildings context in Iraq.

- Assessors must be trained and must have a comprehensive background in how to score each individual indicator. Furthermore, they must be very knowledgeable on aspects of building including management, ecology, civil engineering, building services and architecture and design.

- The sustainability assessment framework is designed for residential buildings, therefore, it is recommended that an extended version of the current framework designed for other type of buildings such as hospitals, health facilities, as well as neighbourhood and commercial buildings is developed.

- The assessments did not propose a mandatory requirement to encourage the use and adaptation of such schemes for residential buildings. Hence, it is important to consider which indicators should be mandatory and which are optional, and this should be decided by a panel of experts or assessment committee members.

- Further research should investigate the possibilities of analysing the energy consumptions and footprints of buildings within Iraq microclimates. This will help to establish a national benchmark for various type of buildings and embed these benchmarks within indicators in future updated versions of the developed framework.
- Further legislations and regulations should be introduced to the construction market in Iraq by governmental bodies and planning authorities to maintain the implementation of the developed framework. Establishing a green building council or research establishment bodies that update the framework regularly based on latest research findings, like other countries such as USA, UK, Egypt and UAE.

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Appendix A

Please note that I: included within the assessment

N/A= Not applicable

Categories	CASBEE	LEED-H	CSH	ESTIDAM	Green star	GSAS	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Reducing CO_2	I within the (construction, operation/ occupancy and demolition)	I within the energy and atmosphere (envelope Insulation)	I within the energy and CO_2 emissions (energy display devices)	I within resourceful energy; particularly under the energy and monitoring criteria	I within management through (metering and monitoring system)	I within the energy category (E.4 CO_2 emissions)	I within indoor environmental quality category (5.1 optimised ventilation	I within B energy and resource consumption: (B2.1 electrical peak demand for building operations)	I within energy category: 1 building envelope performance	I within energy efficiency category: CO_2 mitigation strategy
Electrical Peak Demand	I within LRH1 well informed maintenance and operation schemes	I within energy and atmosphere: (advanced utility tracking)	I within the energy and CO_2 emissions	I within resourceful energy; particularly under the energy and monitoring criteria	N/A	I within energy as (E.1 energy demand performance Kwh/m^2.year)	I within energy efficiency category (2.5 peak load reduction)	I within B energy and atmosphere (B2 electrical peak demand):	N/A	I within energy efficiency (energy management system)
Eliminate Sunlight Radiation During Summer	I within QH1 heating and cooling: 1.1 basic performance, 1.1.2 sunlight adjustment capability	I within the energy and atmosphere (windows)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Home Size	N/A	I within the energy and atmosphere prescriptive pathway	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Drying Space	N/A	N/A	I within energy and CO_2 emissions (drying space)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I: included within the assessment N/A= Not applicable										

Appendix B

Categories	CASBEE	LEED-H	CSH	ESTIDAM	Green star	GSAS	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Interior Water Use Reduction	I within LRh1 (3.1 water saving system)	I within water efficiency category (indoor water use)	I within water (indoor water use)	I within precious water category (PW-R1 minimum interior water use reduction)	I within water (sanitary fixture efficiency)	I within water category: W.1 water reduction	I within water efficiency category (3.1 indoor water efficiency improvement)	I within the energy and atmosphere category (B4.2 use of water for occupants needs during operations)	I within water category: Innovative reduction of water technologies	I within water efficiency category (water consumption)
Exterior Water Reduction	N/A	I within outdoor water efficiently (reduce water use)	I within precious water category (exterior water use)	I water category (PW-R2 exterior water reduction)	I within water (landscape irrigation)	I within water category: W.1 water reduction	I water efficiency (3.2 outdoor water efficiency improvement recommends to be replaced by water efficient landscaping)	I within energy and atmosphere (use of portable water)	I within water category: water efficient landscape	I within water efficiency category (irrigation system)
Runoff Water Management	I within LRh1 conserving energy and	Iwithin sustainable sites (rainwater	I within surface water run-off (	Iwithin the precious water (PW-3 storm water	I within water (rainwater reuse)	I within water category: W.1 water reduction	I within water efficiency (3.6 storm water harvesting)	I within B4 water category; particularly under (B4.4 use of water	N/A	Included within water efficiency category: (rain

	water (3.2 rainwater use)	management }	management of surface water run-off from developments)	management)				for building system)		water harvesting)
Boilers and Heaters	I within LRh1 (2.2 Hot-water equipment	I within energy & atmosphere (hot water distribution system)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Embodied Water Use	N/A	N/A	N/A	N/A	N/A	N/A	I within water efficiency category: 3.6 efficiency water during construction (to demonstrate efficiency use of water only for mixing concrete purposes)	I within the energy and atmosphere category (embodied water in original construction materials)	N/A	N/A

I: included within the assessment

N/A= Not applicable

Appendix C

Categories	CASBEE	LEED-H	CSH	ESTIDAM	Green star	GSAS	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Commissioning Plan	N/A	N/A	N/A	N/A	I within management (commissioning and tuning)	N/A	I within management category: 6.m.1 presentation of a suitable integrated plan and method statement for site operations	I within B energy and resource consumption (B1 total life cycle non-renewable energy)	N/A	N/A
Integrated Process	N/A	I integrative process: this credit is pre-request for the assessment evaluation; IDP-3: sustainable construction practices	N/A	I within integrated development process (IDP-R: integrated development strategy).	N/A	N/A	N/A	N/A	N/A	Included within management and innovation: (integration of services)
Construction Best Practise	N/A	N/A	I within management category (man 2 considerate constructor schemes)	I within integrated development process (IDP-3 sustainable construction practices)	I within management (environmental management plan)	N/A	N/A	N/A	N/A	Included within management and innovation: (construction site impacts)
Health and safety (healthy to occupants from the use of the building's facility)	I within Qh2 ensuring a long service life, this include the following indicators: 1.5 fire preparedness; 1.5.1 fire resistance structure; 1.5.2 early	N/A	N/A	N/A	N/A	N/A	I within management category: 6.m.2 compliance with all relevant national health & safety and Welfare regulations	I within E1 safety and security	N/A	N/A

	detection of fire									
Function (layout function)	Qh2 ensuring a long service life: 3. functionality (3.1 size and layout of rooms, barrier free design)	N/A	N/A	SM-2 design for durability	N/A	N/A	N/A	I within E2. functionality and efficiency	N/A	N/A
I: included within the assessment N/A= Not applicable										

Appendix D

Categories	CASBEE	LEED-H	CSH	ESTIDAM	Green star	GSAS	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Materials CO_2 Emissions	Included within (LRH3: 1 consideration of global warming	Included within materials and resources categories (environmental preferable products)	Included within energy and CO_2 emissions (Ene1 dwelling emission rate)	Included within resourceful energy (RE-1 improved energy performance)	I within materials (product transparency and sustainability)	I within materials category: m.2 responsible sourcing of materials	I within materials and resources (4.7 use of higher durability materials with minimum maintenance need during its lifecycle)	I within B energy and resource consumption (B1 total life cycle non-renewable energy)	Included within materials category: environmental of materials	Included within material: (materials with low environmental impact)
Re-Use of Materials	Included within LRh2 (using resources sparingly and reducing waste)	Included within materials and resources (construction waste management)	I within energy and CO_2 (Mat 2 responsible sourcing of materials)	I within stewarding materials: SM-5 recycled materials	I within materials (building reuse)	I within materials category: m.3 recycled materials	I within materials and resources (4.5 use of recycled materials)	I within the B energy and resource consumption (B3.1 degree of re-use of suitable existing structure(s) where available)	Included within materials category: resource reuse	Included within material: (re-use of structural frame materials)

Protection of Endangered Materials/ Use of Regional Materials	N/A	I within the materials and resources category (certified tropical wood)	N/A	N/A	N/A	I within materials category: m.1 regional materials	I within materials and resources (4.1 regionally procured materials)	I within B energy and resource consumption: (protection of materials during construction phase)	N/A	N/A
Envelope Materials Efficiency	Included within energy and atmosphere (2.1 production stage members for building frames; 2.2 production stage members other than those for building frames	Included within energy and atmosphere (envelope insulation)	I within the energy and CO_2 emissions; (fabric energy efficiency, also known as (FEE))	I within stewarding materials (SM-R3 building reuse)	N/A	N/A	N/A	I within B energy and resource consumption: (material efficiency of structural and building envelope components.)	N/A	Included within materials: (building fabric component)
Ease of Disassembly	I within LHR2 (1.3 exterior materials and 1.4 interior materials)	I within materials and resources (construction waste management)	N/A	I within stewarding materials: SM-5 recycled materials	N/A	N/A	N/A	I within the B energy and resource consumption: B4.4 ease of disassembly, re-use or recycling.	Included within materials category: recycle material	N/A
Material Life Cycle	N/A	N/A	N/A	I within materials (environmental impacts of materials)	I within materials (life cycle impacts)	N/A	N/A	N/A	N/A	Included within materials: (material LCA)
I: included within the assessment N/A= Not applicable										

Appendix E

Categories	CASBEE	LEED-H	CSH	ESTIDAM	GSAS	Green star	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Site Contamination and Disturbance Control	N/A	I within the sustainable site category (SS Prerequisite construction activity pollution prevention)	Included within the ecology category (Eco 1 ecological value of Site)	Included within integrated development process (IDP-3: sustainable construction practices)	N/A	I within land use & ecology (contamination and hazardous materials)	Included within ecological plan (3.2.2.1.1 path A: erosion and sedimentation control plan))	Included within the location, services and site characters (S3 site characteristic).	N/A	Included within site quality category: (contamination land)
NO_x Emission	N/A	N/A	I within category 6 pollution (pol2. NO_x Emissions)	N/A	I within (E.5 SOx and NOx particle matters)	N/A	N/A	N/A	N/A	N/A
Ozone Depletion (GWP-global warming potential) Emissions	Included within (LRH3 1. consideration of global warming)	N/A	Included within pollution (Pol 1 global warming potential (GWP) of insulants)	Included within resourceful energy (RE-R3: ozone impacts of refrigerants)	I within Energy efficiency (2.m.3 ozone depletion avoidance)	I within emissions (refrigerants impacts)	N/A	I within B energy and resource consumption: (protection of materials during construction phase)	N/A	Included within site quality category: (refrigerant gwp)
Pest Control	N/A	I within sustainable site category (SS Non-toxic pest control)	I within ecological category (low use of residential pesticides)	I within natural system (NS-1: landscape design & management plan)	N/A	N/A	I within ecological plan (3.2.4 landscaping)	I within environmental loadings (C5.1 impact of construction process on local residents and commercial facility users)	N/A	N/A

Exterior Light Pollution	I within (3 safety and security of the region) the efforts include installing exterior lights with sensors	I within energy and atmosphere category (EA CREDIT: LIGHTING)	I within the energy category (external lighting)	I within integrated development process (IDP-3: sustainable construction practices)	N/A	N/A	N/A	I within environmental loadings (C5.8 degree of atmospheric light pollution caused by project exterior lighting systems.	N/A	N/A
Adverse Wind Direction	I within LRH1 (1.2 natural energy use)	N/A	N/A	NS-R1: natural systems assessment & protection	N/A	N/A	N/A	I within environmental loadings C4.5 adverse wind conditions at grade around tall buildings	N/A	N/A
Impacts on solar Energy Potential of the Adjacent Property	N/A	N/A	N/A	N/A	I within site (shading of adjacent properties)	N/A	N/A	I within environmental loadings (C5.1 impact on access of daylight or solar energy potential of adjacent property)	N/A	N/A
Compartmentalisation	N/A	I within the indoor environment quality category; particularly under the EQ prerequisite compartmentalization	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Enhancing the Combusting Ventilation	I within 2 health, safety and security: 2.1 counter-measures against chemical contaminants	I within environmental quality; particularly under combusting venting	N/A	N/A	N/A	N/A	N/A	I within D indoor environmental quality; particularly D1.7 effectiveness of ventilation in naturally ventilated occupancies during cooling seasons; D1.8 effectiveness of ventilation in naturally ventilated occupancies during heating seasons	N/A	N/A
Composting	N/A	N/A	I within waste	I within stewarding materials SM-8: composting	N/A	N/A	N/A	N/A	N/A	N/A
I: included within the assessment N/A= Not applicable										

Appendix F

Categories	CASBEE	LEED-H	CSH	ESTIDAM	GSAS	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Landscape Design and Management	I within the LRH3 consideration of the global, local and surrounding environment (2.2 preservation of the existing natural environment)	I within sustainable site: heat island reduction	I within the ecology category (eco 2 ecological enhancement)	I within the natural system category (NS-1: landscape design & management plan)	I within site category: s.4 vegetation	I within sustainable site, accessibility and ecology (1.1.4 compatibility with the national development plan)	I within the location, services and site characters (S3 site characteristic)	I within Site (8 landscape design)	I within site quality (vegetation and shading)
Heat Island Effect	I within LRH3 consideration of the global, local and surrounding environment (3.2 improvement of the thermal environment of the surrounding area	N/A	N/A	I within liveable villas (LV-R2: outdoor thermal comfort) the inclusion of shading devices (screens, trees canopies, projections)	N/A	N/A	I within environmental loadings (C5.7 contributions to heat island effect from roofing, landscaping and paved areas).	N/A	N/A
Animal/Birds Protection	N/A	N/A	I within ecological category (ecological enhancement),	I within stewarding materials (SM-R3 building reuse)	N/A	I within sustainable site, accessibility and ecology (1.3.1 protection of habitat)	I within site regeneration and development, urban design and infrastructure (A1.3 reforestations for carbon sequestration, soil stability and biodiversity).	N/A	N/A
Neighbourhood Harmony, Architectural elements that are similar to its context	N/A	I within the location and transportation category (LT credit: compact development)	N/A	LV-R1: urban systems assessment	I within cultural & economic value category: CE.1	N/A	I within environmental loadings (impact of site and building orientation on	N/A	I within social category: habits and custom effects on the built environment

					heritage & cultural identity		natural ventilation of buildings during warm season		
Light Coloured External Wall	N/A	N/A	N/A	N/A	N/A	N/A	Use light coloured external walls	N/A	N/A
Building Orientation & Morphology	LRH1-energy savings through building innovation (1.2 natural energy use)	I within the energy category (active Solar-ready design)	N/A	LV-R1: urban systems assessment	N/A	N/A	Included under A site regeneration and development category (A2.4 building morphology, aggregate measure)	N/A	N/A
access to transport/community service and compact development	N/A	I within location and transportation (community resources)	N/A	I within Liveable villas (lv-4 public transport)	I within urban connectivity (Public transport)	I within Sustainable site, accessibility and ecology (transport infrastructure connection)	I within site regeneration and development, urban design and infrastructure (provision of on-site communal transportation system)	I within site category (Transportation)	I within site quality (transport links)
Cycle Storage And/or Daily Walking	N/A	I within location and transportation (site selection)	I within energy (Ene 8: cycle storage)	I within Liveable villas (lv-5 bicycle facilities)	N/A	I within Sustainable site, accessibility and ecology (alternative methods of transport)	N/A	N/A	N/A
I: included within the assessment N/A= Not applicable									

Appendix G

Categories	CASBEE	LEED-H	CSH	ESTIDAM	GSAS	Green star	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Quietness and Noise Level	I in LRH3-3.1 reduction of noise vibration, exhaust, and exhaust heat	N/A	I within health and wellbeing (sound insulation)	I in liveable villas category (LIV-9 indoor noise)	I within indoor environment category: IE.8 acoustic comfort	I within indoor environmental quality (acoustic separation)	I within: indoor environmental quality (5.5 acoustic comfort)	I within the indoor environment quality category as well as the site S 3 as ambient noise condition	N/A	N/A
Daylighting	I within QH1 within the 3. brightness category and specifically explained through 3.1 daylight	I in energy and atmosphere category and embedded within the windows	I within health and wellbeing (daylighting)	I within the liveable villa category; particularly under (LV-8 daylight)	I within indoor environment category: IE.5 daylighting	I within indoor environmental quality (minimum lighting comfort)	Included within indoor environmental quality (5.4 visual comfort)	I within the environment category; particularly under (D3 daylighting and illumination)	I within indoor environment quality (daylight)	N/A
Inclusion of Private Space (i.e. garden, terrace, balconies, patio, roof terrace).	I within QH2 (2.1 greening of the premises)	Iwithin sustainable sites SS (heat island effect)	I within health and wellbeing (private space)	I within natural system category, particularly under (NS-1: landscape design & management plan)	N/A	N/A	N/A	N/A	N/A	N/A
Durability	I within QH2 functionality: (3.1 size and layout rooms)	N/A	N/A	I within stewarding materials (design or durability)	N/A	N/A	I within materials and resources (4.7 use of higher durability materials)	I within E service quality as: 1- (E1 functionality and efficiency); 2- flexibility and adaptability	N/A	N/A
Ventilation	I within QH1 2 2.2 proper planning for ventilation	I within the indoor environme nt quality category, particularly through (ventilation)	I within: the energy (ene9 home office),	I within the liveable villas category; particularly under the LV-R3 minimum ventilation and its pre-request	I within indoor environment category (IE 2 natural ventilation)	I within indoor environmental quality (provision of outdoor air)	I within indoor environmental quality, specifically under (5.m.1 minimum ventilation and indoor air quality	I within indoor environment as (D1 indoor air quality and ventilation)	I within indoor environment al quality (ventilation)	I within indoor environmental quality (natural ventilation)

				mandatory credits						
Fire Protection	I within: QH2 1.5.1 fire preparedness	I within the environmental air quality categories Under (the environmental tobacco smoke as pre-request credit.)	N/A	I within integrated development process (IDP-3: sustainable construction practices)	N/A	I within management (monitoring systems)	I within indoor environmental quality (5.m.2 control of smoking in and around the building)	N/A	N/A	N/A
Enhancing the Combusting Ventilation	I within 2 health, safety and security: 2.1 countermeasures against chemical contaminants	I within environmental quality; particularly under combusting venting	N/A	N/A	N/A	N/A	N/A	I within service quality as (E1 safety and security)	N/A	N/A
Safety Control and Precautions	QH1 2.3 precautions against crime; and QH3- 3 safety and security of the region	N/A	I within management category (Man 4 security with 2 allocated points)	N/A	N/A	N/A	I within management (6.M.2 compliance with health & safety and welfare regulations)	I within service quality as (E1 safety and security)	N/A	N/A
Indoor Thermal Comfort	I within the heating and cooling: particularly (1.1.1 ensuring thermal insulation and airtightness performance)	I within the energy category: particularly under (EQ credit: balancing of heating and cooling distribution systems)	N/A	I within the liveable villas category; particularly within (LV-7: thermal comfort & controls)	N/A	I within indoor environmental quality (thermal comfort)	I within indoor environmental quality (5.3 thermal comfort)	I within indoor environment quality as (D2 Air temperature and relative humidity)	Included within indoor environment quality: indoor air quality	I within indoor environmental quality (thermal comfort and control)
Glare Control	N/A	N/A	N/A	N/A	N/A	I within indoor environmental quality (Glare reductions)	I within the Included within indoor environmental quality (5.4 visual comfort)	I within daylighting and illumination category: D3.2 control of glare from daylighting	N/A	I within indoor environmental quality (glare measure)

Roof Shading Device	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A
I: included within the assessment N/A= Not applicable										

Appendix H

Categories	CASBEE	LEED-H	CSH	ESTIDAM	GSAS	Green star	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Visual accessibility from the interior to the exterior spaces	N/A	N/A	N/A	N/A	N/A	I within indoor environmental quality (Views)	N/A	I within Social, Cultural and Perceptual Aspect (Access to exterior views from interior)	N/A	I within economic (life cycle cost)
Designing an aesthetic exterior	N/A	N/A	N/A	N/A	N/A	N/A	N/A	I within Social, Cultural and Perceptual Aspect (Perceptual)	N/A	N/A
Neighbourhood harmony, architectural elements are similar to the district existed one	N/A	N/A	N/A	I within liveable villas (urban systems assessment)	I within Cultural & Economic Value (CE.1 Heritage & cultural identity)	N/A	I within innovation and added value (cultural heritage)	I within Social, Cultural and Perceptual (Culture and Heritage)	N/A	I within social (heritage & cultural identity)
I: included within the assessment N/A= Not applicable										

Appendix I

Categories	CASBEE	LEED-H	CSH	ESTIDAM	GSAS	Green star	GPRS	SBTool	SABA in Jordan	SEAM in Saudi Arabia
Construction Cost/Life cycle cost	N/A	I within Materials & resources as: MR-Environmentally preferable products	N/A	I within integrated development process IDP-1: Life Cycle Costing	N/A	N/A	I within materials and resources (LCC analysis of materials in the project)	I within Cost and Economic Aspects as: G1.3 Life cycle cost	I within cost and economics (materials and construction)	I within indoor environmental quality (view out)
Affordability of operation and maintenance cost	I within (QH2 maintenance)	N/A	N/A	N/A	N/A	N/A	N/A	I within optimisation and maintenance of operation system (E5.8 Provision of performance incentives in leases or sales agreements.	N/A	I within economic (operation and maintenance cost)
Affordable residential rent or cost	N/A	N/A	N/A	N/A	N/A	N/A	N/A	I within Cost and Economic Aspects (G1.5 affordability of residential rental or cost levels)	N/A	I within social (heritage & cultural identity)

I: included within the assessment

N/A= Not applicable

Appendix K

Round 1: Questionnaires

Developing a residential buildings sustainable assessment for Iraq

Dear Sir/ Madam,

A research study is established to investigate the factors that affect the energy and environmental performance residential buildings in Iraq with a view to developing sustainability assessment framework/system. The main purpose of this study is: to reach a consensus from different stakeholders' perspectives on developing a residential sustainable assessment for buildings in Iraq.

This research is adopting the approach of consolidating the most important factors from a well-known sustainable assessment indicator from across the world in order to test their applicability/ usability in Iraq. The research will also utilise the implementation of Delphi technique: a research method used to gather experts' opinions on the subject matter and compare the results of the poll in order to reach consensus among stakeholders.

The process requires the participation of a range of stakeholders who are expert in the field of design and construction of buildings as well as familiar with socio-economic, environmental and cultural dynamics of the country under investigation. I am inviting you all as experts in your fields to take part in this study, your participation is very critical to the success of this important process of developing the first sustainability assessment framework for Iraq.

The process involves 4 important stages and you will be expected to a questionnaire in all of the 4 stages. Each questionnaire will take approximately 25-30 minutes to complete. All data collected will be treated as confidential and the names of participants will not divulge in any external facing publication without the explicit permission of the participant and the data will only be used for the purpose of this academic research work.

Your participation in this study is highly appreciated and you will be making a significant contribution to the field of Architecture and Construction in Iraq.

Sincerely Yours,

Yahya Al-Saeed

PhD Candidate
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1- Management Plan— This category promotes the integration between stakeholders during the design and construction stage, and ensures the long-life performance in the operation and maintenance of the building. From your own experience, could you please list the main management plan factor or strategies that must be taken into consideration during the design and construction of the building?

2- Indoor Environmental Quality— This category is concerned with the factors that affect the health and wellbeing and satisfaction of the occupants which might include for example, the level of noise or illumination. From your own personal experience, could you please list the main issues that affect the indoor environmental quality?

3- Energy Optimisation— This category is focused on the factors and strategies that could improve energy consumption in buildings which might include for example, passive design strategies, and the use of renewable energies. From your own personal experience, could you please list the main strategies that affect the energy consumption in residential buildings?

4- Water Efficiency—This category includes factors and strategies that associated with efficient consumption of water in buildings. This may include the following criteria: water recycling for instance. From your own opinion experience, could you please list the main factors and strategies that affect the water-efficiency in residential buildings?

5- Waste Management— This category is concerned with factors that are related to pollution from waste generation. This might include: recycling facilities and the re-use of structure or materials. From your own experience, could you please list the main factors or strategies that affect the waste management in residential buildings?

6- Materials and Resource Use—This category is concerned with issues that are related to the efficient utilisation of materials during various construction stages in the building, this might include: the use of environmentally friendly or recycled materials. From your own opinion, could you please list the main factors or strategies that concerned with the utilisation of materials and natural resources in residential buildings?

7- Site and Microclimate—This category is concerned with issues that relate to the selection of the site and the influence of the microclimate influence on the buildings. This might include, for example, outdoor thermal comfort and biodiversity. From your own experience, could you please list the main site and the microclimate factors or strategies that influence the design and the construction of residential buildings?

8- Transportation— This category is concerned with the implementation of measures that encourage sustainable transportation during the design and construction of the building. Question, from your own opinion, could you please list the main factors or strategies that affect the utilisation of transportation measures in buildings?

9- Social and cultural—This category is concerned with issues that are related to the selection of traditional cultural or social aspects, such as local architectural features or specific local codes, that enforce a certain type of design or use of materials. From your own opinion, could you please list the main the social and cultural indicators/factors that must be considered in the design or construction of the building?

10- Economic Efficiency—this category is concerned with issues that related to cost of building. This might include: certain procedure for construction, incentive scheme promoted by the government, or any codes/ design legislation that contribute to reduce the cost of the building. from your own opinion, could you please list the main factors or strategies that affect the economic-efficiency in residential buildings?

Appendix L

Round 2: Questionnaires

Please fill in the following background information:

Name:

Institution/Company:

Background/Work Sector:

Country:

Email:

1- Management Plan—this category promotes the integration between stakeholders during the design and construction stage, and to ensure the long-life performance of operation and maintenance service. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Building Management):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Following construction best practice (e.g. equivalent sustainable construction code (ISO))					
Project team integration					
Durability: maintenance and operation					
Flexible operation of building systems					
Resource availability					
Flexible and adaptable design (easy to construct and change)					
Commissioning plan					
Evacuation plan for emergency purposes					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Occupants Management):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Post occupancy evaluation					
User manual: that informs occupants on the way of using the buildings efficiently					

Please add and evaluate any further relevant strategies that are not listed above?

2- Indoor Environmental Quality—this category is concerned with the factors that affect occupants' health and wellbeing and satisfaction. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Controllability):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Natural ventilation					
Efficient mechanical heating and cooling system					
Lighting glare controllability					
Daylighting glare controllability (internal shade like louver and curtains)					
Roof shading devices					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Indoor Services):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Natural daylighting accessibility to functional spaces					
Acoustic comfort					
Thermal comfort					
Materials with low VOC					
Smoke detector					
Airtight air-conditioning ducts and opening; to provide protection from dust					
Security and protection measures					
Fan exhaust for bathroom and kitchen					
Damp protection					
Accessibility to internet services					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY C (Interior Qualities and Functions):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Functionality of the spaces through interior space orientation					
Provision of recreation spaces like balconies and gardens (mean 2.97)					
Flexibility and durability in the design of spaces (mean 3.34)					
Open space layout to enhance cross ventilation					
Meetings occupants needs (room size)					
Interior design quality					

Interior colours that have a positive impact on occupant's visual comfort					

Please add and evaluate any further relevant strategies that are not listed above?

3- Energy Optimisation—this category is focusing on the factors and strategies that could improve energy consumption in buildings as well as reduce its associated running costs. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Building Envelope):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Use of external thick walls with low heat thermal conductivity (i.e. concrete wall panels)					
Use materials with thermal insulation for walls and roofs					
Minimise home size					
Great air tightness fabric, (less air infiltration)					
Efficient glazing (i.e. double or triple)					
Use roof ponds or Skytherm: roof filled with water bags for cooling and heating					
Use of roofs with dome's shapes covering whole or part of the roof					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Efficient indoor Appliances, Heating and Cooling):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Use of efficient lighting appliances					
Use of ceiling fans					

Use of efficient lighting appliances	
Use of evaporative coolers	
heat pumps	
Cooling the bed area only during night instead of cooling the whole bedroom (bed's cooling compartmentalization)	

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY C (Efficient Design and strategies):

Indicators	**Not applicable**	**Not Important**	**Important**	**Very Important**	**Extremely Important**
Wind catchers					
large windows on the north facade					
Building orientation					
Dividing window openings into vertical strips within the same area designated for conventional shape					
Occupants migrations through summer and winter (i.e. use of subterranean spaces during for summer use; to reduce demand on cooling)					
Reduce/Eliminate windows on west and east façade					
large shaded windows on the south facade					
Use of courtyards and intermediate open spaces; for ventilation and natural lighting					
linking living rooms with recreational outdoor spaces like gardens (that could be used in summer)					
Drying space					
Inclusion of private space (i.e. office)					
Provision of outdoor cooking area					

Provision of safe outdoor sleeping facilities to be used by occupants in summer (e.g. roof, courtyard)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY D (Renewables):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
In-situ renewable PV					
In-situ renewable solar panels					
District heating and cooling (mean 2.80)					
Use of biomass appliances (i.e. stove, boiler, fireplace					
Waste-based power generation					

Please add and evaluate any further relevant strategies that are not listed above?

4- Waste and Pollution Management— this category is concerned with factors and strategies related to pollution from waste generation. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Indoor Waste):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Measures to eliminate the hazards generated by the materials used indoor					
Carbon Mono-oxide monitoring devices in kitchens and around fireplaces					
Compartmentalisation					
Measures to enhance the ventilations of (stoves, ovens,					

fireplaces, boilers) through an exhaust fan	
Limits NOx emission	

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Outdoor Waste):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Provision of separate waste containers					
Use of refrigerants system with zero or low impact on ozone depletion					
Composting					
Minimise site contamination (i.e. topsoil erosion)					
Keeping waste facilities far from living spaces					
Reduce exterior light pollution					
Pest control					
Dust storm protection					
Reduce the Impacts on solar energy potential of the adjacent property					
Mitigate the un-wanted wind influence on building					

5- Water Efficiency—this category includes factors and strategies that associated with efficient consumption of water in buildings. Please evaluate the following indicators based on their level of Importance:

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Rainwater harvesting					
Efficient fixtures					
Grey water recycling					
Regulating occupants water consumption Liter/per day					
Irrigation controllers					
Availability of fresh water					

Automatically boiler control switch for summer	
Reduce the use of embodied water	
Use of native plants	

Please add and evaluate any further relevant strategies that are not listed above?

6- Site and Microclimate— this category is concerned with issues that relate to the selection of the site and the microclimate influence on the buildings. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Heat Wave Island):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely important
Availability of water bodies to enhance the micro climate					
Reflective pale walls					
Landscape beautification					
Green roofs					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Biodiversity and Infrastructure):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Select brownfield site or pre-developed land					
Mitigate site's pollution (e.g. noise, particles and emissions from factories)					
Site with accessibility to water supply and electricity grid					
Reduce development of the site on greenfield sites					

Enhancing the biodiversity by protecting the endangered species					
Protection of any heritage and historical monument located within the site					
Measures to enhance food production					

Please add and evaluate any further relevant strategies that are not listed above?

7- Materials and Resource Use—this category is concerned with issues that related to the efficient utilizations of materials during various construction stages in the building. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (sourcing of resources):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Use of local materials (i.e. local cement, clay blocks)					
Use of renewable materials					
Protection of endangered materials					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Materials' environmental Impacts):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Re-use of broken/faults materials during construction					
Design for deconstruction					
Use of materials with low maintenance and replacement cost					
Simplification and standardization of materials					

Please add and evaluate any further relevant strategies that are not listed above?

8- Transportation—this category is concerned with the implementation of measures that encourage sustainable transportation during the design and construction of the building. Please evaluate the following indicators based on their level of Importance:

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Provision of bicycle parking					
Proximity to public buses transport					
Accessibility to green park or recreational space					
Connection to public main road					
Limit/regulate the use of private cars per residential unit					
Proximity to services (i.e. shops, hospital, schools)					
Accessibility to green park or recreational space					
Provision of bicycle lane or network linked with the street					

Please add and evaluate any further relevant strategies that are not listed above?

9- Cultural and social —this category is concerned with the implementation of measures that enrich and enhance the local cultural and social values. Please evaluate the following indicators based on their level of Importance:

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Maintaining and keeping the cultural architectural value features of the building through the exterior design					

Harmony with the neighing buildings or context					
Respecting privacy in design					
Compliance with local buildings codes					
Handicapped accessibility into the building					
Innovation measures					
Designing an aesthetic exterior					
Access to exterior natural views from the interior					

Please add and evaluate any further relevant strategies that are not listed above?

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10- Economic Efficiency—this category is concerned with issues that related to reduce the cost of the buildings. Please evaluate the following indicators based on their level of Importance:

Indicators	**Not applicable**	**Not Important**	**Important**	**Very Important**	**Extremely Important**
Low rental cost					
Low cost of maintenance and operation					
Finishing construction within time					
Local laboring					
Materials with low LCC					
Materials manufactured off-site					
Local resources materials					
Low capital cost					
Use of BIM in design and construction					
Following green incentive					
Residual cost					

Please add and evaluate any further relevant strategies that are not listed above?

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Appendix M

Round 3: Questionnaires

Please fill in the following background information:

Name:

Institution/Company:

Background/Work Sector:

Country:

Email:

1- Management Plan—this category promotes the integration between stakeholders during the design and construction stage, and to ensure the long-life performance of operation and maintenance service. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Building Management):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Following construction best practice (e.g. equivalent sustainable construction code (ISO)) (mean 4.58)					
Project team integration (mean 4.17)					
Durability: maintenance and operation (mean 3.41)					
Flexible operation of building systems (mean 3.17)					
Resource availability (mean 3.68)					
Flexible and adaptable design (easy to construct and change) (mean 3.34)					
Commissioning plan (mean 2.92)					
Evacuation plan for emergency purposes (mean 2.73)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Occupants Management):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Post occupancy evaluation (mean 4.36)					
User manual: that informs occupants on the way of using the buildings efficiently (mean 3.58)					

Please add and evaluate any further relevant strategies that are not listed above?

2- Indoor Environmental Quality—this category is concerned with the factors that affect occupants' health and wellbeing and satisfaction. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Controllability):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Natural ventilation (mean 3.53)					
Efficient mechanical heating and cooling system (mean 4.09)					
Lighting glare controllability (mean 3.24)					
Daylighting glare controllability (internal shade like louver and curtains) (mean 3.39)					
Roof shading devices (mean 3.12)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Indoor Services):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Natural daylighting accessibility to functional spaces (mean 4.17)					
Acoustic comfort (mean 3.90)					
Thermal comfort (mean 4.36)					
Materials with low VOC (mean 2.92)					
Smoke detector (Mean 3.19)					
Airtight air-conditioning ducts and opening; to provide protection from dust (mean 3.41)					
Security and protection measures (mean 3.65)					
Fan exhaust for bathroom and kitchen (mean 3.70)					
Damp protection (mean 2.90)					
Accessibility to internet services (mean 3.24)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY C (Interior Qualities and Functions):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Functionality of the spaces through interior space orientation					
Provision of recreation spaces like balconies and gardens (mean 2.97)					
Flexibility and durability in the design of spaces (mean 3.34)					

Open space layout to enhance cross ventilation (mean 3.56)					
Meetings occupants needs (room size) (mean 3.14)					
Interior design quality (mean 3.21)					
Interior colours that have a positive impact on occupant's visual comfort (mean 3.53)					

Please add and evaluate any further relevant strategies that are not listed above?

3- Energy Optimisation—this category is focusing on the factors and strategies that could improve energy consumption in buildings as well as reduce its associated running costs. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Building Envelope):

Indicators	**Not applicable**	**Not Important**	**Important**	**Very Important**	**Extremely Important**
Use of external thick walls with low heat thermal conductivity (i.e. concrete wall panels) (mean 4.48)					
Use materials with thermal insulation for walls and roofs (mean 3.80)					
Minimise home size (mean 2.68)					
Great Air tightness fabric, (less air infiltration) (mean 4.00)					
Efficient glazing (i.e. double or triple) (mean 3.73)					
Use roof ponds or Skytherm: roof filled with water bags for cooling and heating (mean 2.78)					
Use of roofs with dome's shapes covering whole or part of the roof (mean 3.36)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Efficient indoor Appliances, Heating and Cooling):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Use of efficient lighting appliances (mean 3.36)					
Use of ceiling fans (mean 3.87)					
Use of efficient lighting appliances (mean 3.73)					
Use of evaporative coolers (mean 3.92)					
Heat pumps (mean 2.80)					
Cooling the bed area only during night instead of cooling the whole bedroom (bed's cooling compartmentalization) (mean 2.60)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY C (Efficient Design and strategies):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Wind catchers (mean 3.87)					
large windows on the north facade (mean 3.51)					
Building orientation (mean 4.07)					
Dividing window openings into vertical strips within the same area designated for conventional shape (mean 2.82)					
Occupants migrations through summer and winter (i.e. use of subterranean spaces during for summer use; to reduce demand on cooling) (mean 3.09)					
Reduce/Eliminate windows on west and east façade (mean 2.95)					

large shaded windows on the south facade (mean 4.04)					
Use of courtyards and intermediate open spaces; for ventilation and natural lighting (mean 3.53)					
linking living rooms with recreational outdoor spaces like gardens (that could be used in summer) (mean 3.09)					
Drying space (mean 3.41)					
Inclusion of private space (i.e. office) (mean 2.78)					
Provision of outdoor cooking area (mean 2.68)					
Provision of safe outdoor sleeping facilities to be used by occupants in summer (e.g. roof, courtyard) (mean 2.80)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY D (Renewables):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
In-situ renewable PV (mean 4.36)					
In-situ renewable solar panels (mean 4.3)					
District heating and cooling (mean 2.80)					
Use of biomass Appliances (i.e. stove, boiler, fireplace (mean 2.73)					
Waste-based power generation (mean 2.46)					

Please add and evaluate any further relevant strategies that are not listed above?

4- Waste and Pollution Management— this category is concerned with factors and strategies related to pollution from waste generation. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Indoor Waste):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Measures to eliminate the hazards generated by the materials used indoor (mean 4.00)					
Carbon mono-oxide monitoring devices in kitchens and around fireplaces (mean 3.68)					
Compartmentalisation (mean 3.21)					
Measures to enhance the ventilations of (stoves, ovens, fireplaces, boilers) through an exhaust fan (mean 3.19)					
Limits NO_x emission (mean 2.70)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Outdoor Waste):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Provision of separate waste containers (mean 3.92)					
Use of refrigerants system with zero or low impact on ozone depletion (mean 3.24)					
Composting (mean 3.17)					
Minimise site contamination (i.e. Topsoil Erosion) (mean 3.65)					
Keeping waste facilities far from living spaces (mean 3.26)					
Reduce exterior light pollution (mean 3.09)					
Pest control (mean 2.65)					
Dust storm protection (mean 3.48)					

Reduce the impacts on solar energy potential of the adjacent property (mean 2.92)	
Mitigate the un-wanted wind influence on building (mean 3.21)	

5- Water Efficiency—this category includes factors and strategies that associated with efficient consumption of water in buildings. Please evaluate the following indicators based on their level of Importance:

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Rainwater harvesting (mean 3.19)					
Efficient fixtures (mean 3.87)					
Grey water recycling (mean 3.31)					
Regulating occupants water consumption Liter/per day (mean 3.70)					
Irrigation controllers (mean 3.34)					
Availability of fresh water (mean 3.43)					
Automatically boiler control switch for summer (mean 3.00)					
Reduce the use of embodied water (mean 3.26)					
Use of native plants (mean 2.97)					

Please add and evaluate any further relevant strategies that are not listed above?

6- Site and Microclimate— this category is concerned with issues that relate to the selection of the site and the microclimate influence on the buildings. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (Heat Wave Island):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Availability of water bodies to enhance the micro climate (mean 3.31)					
Reflective pale walls (mean 3.43)					
Landscape beautification (mean 2.73)					
Green roofs (mean 2.97)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Biodiversity and Infrastructure):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Select brownfield site or pre-developed land (mean 4.02)					
Mitigate Site's pollution (e.g. noise, particles and emissions from factories) (mean 3.82)					
Site with accessibility to water supply and electricity grid (mean 3.31)					
Reduce development of the site on greenfield sites (mean 3.29)					
Enhancing the biodiversity by protecting the endangered species (mean 2.92)					
Protection of any heritage and historical monument located within the site (mean 3.14)					
Measures to enhance food production (mean 3.12)					

Please add and evaluate any further relevant strategies that are not listed above?

7- Materials and Resource Use—this category is concerned with issues that related to the efficient utilizations of materials during various construction stages in the building. Please evaluate the following indicators based on their level of Importance:

SUBCATEGORY A (sourcing of resources):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Use of local materials (i.e. local cement, clay blocks) (mean 4.29)					
Use of renewable materials (mean 3.70)					
Protection of endangered materials (mean 3.12)					

Please add and evaluate any further relevant strategies that are not listed above?

SUBCATEGORY B (Materials' environmental Impacts):

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Re-use of broken/faults materials during construction (mean 3.90)					
Design for deconstruction (mean 3.26)					
Use of materials with low maintenance and replacement cost (mean 3.58)					
Simplification and standardization of materials (mean 3.14)					

Please add and evaluate any further relevant strategies that are not listed above?

8- Transportation—this category is concerned with the implementation of measures that encourage sustainable transportation during the design and construction of the building. Please evaluate the following indicators based on their level of Importance:

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Provision of bicycle parking (mean 3.92)					
Proximity to public buses transport (mean 4.00)					
Accessibility to green park or recreational space (mean 3.61)					
Connection to public main road (mean 3.68)					
Limit/regulate the use of private cars per residential unit (mean 3.26)					
Proximity to services (i.e. shops, hospital, schools) (mean 4.19)					
Accessibility to green park or recreational space (mean 3.51)					
Provision of bicycle lane or network linked with the street (mean 2.73)					

Please add and evaluate any further relevant strategies that are not listed above?

9- Cultural and social —this category is concerned with the implementation of measures that enrich and enhance the local cultural and social values. Please evaluate the following indicators based on their level of Importance:

Indicators	Not applicable	Not Important	Important	Very Important	Extremely Important
Maintaining and keeping the cultural architectural value features of the building through the exterior design (mean 4.12)					
Harmony with the neighing buildings or context (mean 3.56)					
Respecting privacy in design (mean 3.31)					
Compliance with local buildings codes (mean 4.07)					

Handicapped accessibility into the building (mean 3.80)					
Innovation measures (mean 3.24)					
Designing an aesthetic exterior (mean 3.07)					
Access to exterior natural views from the interior (mean 3.48)					

Please add and evaluate any further relevant strategies that are not listed above?

10- Economic Efficiency—this category is concerned with issues that related to reduce the cost of the buildings. Please evaluate the following indicators based on their level of Importance:

Indicators	**Not applicable**	**Not Important**	**Important**	**Very Important**	**Extremely Important**
Low rental cost (mean 3.53)					
Low cost of maintenance and operation (mean 3.53)					
Finishing construction within time (mean 3.87)					
Local laboring (mean 3.53)					
Materials with low LCC (mean 3.85)					
Materials manufactured off-site (mean 3.14)					
Local resources materials (mean 3.39)					
Low capital cost (mean 3.21)					
Use of BIM in design and construction (mean 2.82)					
Following green incentive (mean 2.80)					
Residual cost (mean 2.29)					

Please add and evaluate any further relevant strategies that are not listed above?

Appendix N

Responses from round three of questionnaires

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
4.00	5.00	3.00	4.00	4.00	3.00	3.00	3.00	5.00	5.00	4.00	5.00	3.00	5.00
4.00	4.00	5.00	3.00	3.00	4.00	3.00	3.00	5.00	3.00	4.00	5.00	4.00	3.00
5.00	4.00	2.00	3.00	4.00	3.00	4.00	2.00	5.00	3.00	4.00	4.00	3.00	4.00
5.00	5.00	3.00	2.00	4.00	4.00	4.00	3.00	5.00	3.00	4.00	3.00	3.00	4.00
5.00	4.00	5.00	4.00	4.00	3.00	4.00	3.00	5.00	5.00	4.00	5.00	4.00	5.00
5.00	4.00	2.00	3.00	4.00	3.00	4.00	2.00	3.00	4.00	5.00	5.00	3.00	3.00
4.00	3.00	4.00	4.00	3.00	5.00	3.00	3.00	5.00	3.00	4.00	4.00	4.00	3.00
4.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00
5.00	3.00	4.00	5.00	4.00	5.00	4.00	3.00	5.00	3.00	3.00	4.00	5.00	5.00
5.00	5.00	4.00	3.00	4.00	3.00	3.00	4.00	5.00	2.00	4.00	3.00	2.00	2.00
4.00	3.00	4.00	5.00	4.00	4.00	3.00	3.00	3.00	4.00	3.00	4.00	3.00	4.00
4.00	3.00	4.00	2.00	3.00	2.00	3.00	2.00	5.00	3.00	4.00	4.00	3.00	3.00
3.00	5.00	2.00	3.00	3.00	4.00	2.00	2.00	4.00	4.00	5.00	3.00	4.00	2.00
3.00	4.00	2.00	3.00	4.00	2.00	4.00	2.00	5.00	3.00	4.00	3.00	4.00	3.00
4.00	5.00	5.00	3.00	5.00	4.00	3.00	3.00	3.00	3.00	5.00	4.00	3.00	3.00
4.00	4.00	3.00	4.00	4.00	3.00	3.00	2.00	3.00	5.00	4.00	3.00	4.00	3.00
5.00	4.00	4.00	4.00	4.00	3.00	3.00	4.00	4.00	3.00	4.00	4.00	4.00	4.00
5.00	4.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	3.00	4.00	4.00
5.00	4.00	3.00	3.00	4.00	3.00	3.00	2.00	4.00	3.00	4.00	3.00	3.00	4.00
4.00	5.00	3.00	3.00	4.00	4.00	3.00	2.00	4.00	3.00	4.00	3.00	4.00	4.00
4.00	3.00	4.00	4.00	3.00	5.00	3.00	3.00	4.00	3.00	4.00	3.00	3.00	4.00
5.00	4.00	3.00	3.00	4.00	3.00	3.00	2.00	4.00	4.00	5.00	4.00	3.00	3.00
5.00	5.00	3.00	3.00	3.00	4.00	3.00	2.00	4.00	4.00	4.00	5.00	3.00	4.00
5.00	4.00	5.00	4.00	5.00	4.00	4.00	3.00	5.00	5.00	4.00	5.00	3.00	3.00
5.00	4.00	3.00	4.00	4.00	3.00	3.00	3.00	5.00	3.00	4.00	4.00	3.00	4.00
5.00	4.00	3.00	3.00	5.00	4.00	3.00	2.00	5.00	5.00	4.00	5.00	3.00	3.00
5.00	4.00	4.00	4.00	3.00	3.00	2.00	2.00	5.00	4.00	4.00	5.00	3.00	4.00
5.00	5.00	3.00	3.00	3.00	3.00	2.00	2.00	5.00	3.00	4.00	4.00	5.00	3.00
5.00	5.00	5.00	5.00	5.00	5.00	3.00	2.00	5.00	5.00	3.00	5.00	3.00	3.00
5.00	5.00	4.00	3.00	4.00	3.00	2.00	4.00	5.00	2.00	5.00	4.00	5.00	3.00
5.00	5.00	3.00	2.00	4.00	2.00	3.00	3.00	5.00	3.00	2.00	5.00	3.00	3.00
5.00	4.00	3.00	2.00	5.00	3.00	1.00	1.00	5.00	5.00	2.00	5.00	2.00	3.00
5.00	5.00	2.00	2.00	3.00	2.00	2.00	3.00	5.00	3.00	2.00	5.00	2.00	3.00
5.00	4.00	2.00	3.00	3.00	3.00	2.00	3.00	5.00	3.00	2.00	5.00	2.00	3.00
5.00	4.00	3.00	2.00	2.00	2.00	2.00	3.00	5.00	3.00	4.00	4.00	5.00	2.00
5.00	4.00	2.00	2.00	2.00	2.00	2.00	2.00	5.00	3.00	2.00	5.00	2.00	3.00
5.00	4.00	3.00	3.00	3.00	3.00	1.00	4.00	5.00	5.00	2.00	5.00	2.00	3.00
5.00	5.00	3.00	3.00	3.00	3.00	2.00	3.00	5.00	5.00	2.00	5.00	2.00	3.00
5.00	5.00	3.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00
5.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00	5.00	5.00	4.00
5.00	5.00	4.00	3.00	4.00	2.00	2.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00

Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28
3.00	4.00	3.00	5.00	4.00	2.00	3.00	4.00	3.00	2.00	3.00	4.00	4.00	3.00
3.00	4.00	5.00	5.00	3.00	4.00	4.00	3.00	5.00	2.00	4.00	5.00	4.00	5.00
3.00	5.00	5.00	5.00	2.00	3.00	4.00	3.00	5.00	3.00	5.00	5.00	2.00	4.00
4.00	4.00	5.00	3.00	3.00	4.00	3.00	4.00	3.00	3.00	4.00	4.00	2.00	3.00
5.00	5.00	3.00	4.00	4.00	2.00	3.00	4.00	5.00	4.00	4.00	4.00	4.00	4.00
4.00	5.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	3.00	4.00	4.00	3.00	4.00
4.00	4.00	5.00	3.00	4.00	2.00	4.00	3.00	4.00	3.00	2.00	4.00	3.00	4.00
2.00	4.00	3.00	5.00	3.00	3.00	2.00	2.00	3.00	4.00	3.00	4.00	3.00	4.00
3.00	5.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00	3.00	3.00	3.00	4.00	3.00
3.00	4.00	5.00	5.00	2.00	3.00	4.00	4.00	4.00	2.00	3.00	4.00	3.00	5.00
3.00	3.00	4.00	5.00	3.00	4.00	3.00	4.00	2.00	3.00	4.00	4.00	2.00	3.00
4.00	4.00	3.00	4.00	2.00	3.00	2.00	3.00	4.00	2.00	4.00	2.00	3.00	3.00
4.00	4.00	4.00	5.00	3.00	2.00	4.00	3.00	2.00	2.00	4.00	4.00	3.00	2.00
3.00	4.00	5.00	5.00	2.00	3.00	4.00	5.00	2.00	2.00	4.00	4.00	2.00	3.00
3.00	5.00	4.00	5.00	4.00	4.00	3.00	3.00	5.00	3.00	3.00	5.00	3.00	3.00
2.00	4.00	3.00	5.00	2.00	3.00	4.00	2.00	4.00	2.00	4.00	4.00	3.00	2.00
3.00	4.00	4.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00
3.00	4.00	4.00	4.00	3.00	4.00	4.00	5.00	4.00	4.00	5.00	4.00	3.00	4.00
4.00	4.00	4.00	5.00	3.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00	4.00	3.00
3.00	4.00	3.00	3.00	2.00	3.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00	4.00
4.00	4.00	5.00	4.00	3.00	3.00	4.00	2.00	3.00	3.00	4.00	4.00	3.00	3.00
3.00	4.00	5.00	4.00	3.00	4.00	5.00	4.00	3.00	4.00	4.00	4.00	3.00	4.00
3.00	4.00	4.00	5.00	3.00	4.00	4.00	3.00	3.00	2.00	4.00	4.00	3.00	4.00
5.00	5.00	3.00	5.00	4.00	4.00	5.00	2.00	5.00	4.00	2.00	4.00	3.00	3.00
3.00	4.00	5.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00
5.00	5.00	3.00	5.00	4.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00
4.00	3.00	2.00	4.00	3.00	3.00	4.00	2.00	4.00	2.00	2.00	3.00	3.00	2.00
3.00	3.00	4.00	4.00	4.00	5.00	5.00	4.00	4.00	4.00	5.00	5.00	3.00	4.00
3.00	4.00	4.00	5.00	3.00	5.00	4.00	4.00	4.00	3.00	3.00	4.00	2.00	5.00
3.00	3.00	3.00	3.00	2.00	3.00	4.00	4.00	5.00	2.00	2.00	3.00	2.00	2.00
2.00	3.00	3.00	4.00	2.00	3.00	3.00	3.00	3.00	2.00	3.00	3.00	3.00	3.00
2.00	5.00	4.00	5.00	2.00	2.00	3.00	4.00	5.00	2.00	2.00	3.00	2.00	2.00
2.00	5.00	4.00	5.00	3.00	3.00	2.00	5.00	5.00	3.00	2.00	3.00	2.00	3.00
3.00	5.00	4.00	5.00	2.00	3.00	2.00	5.00	4.00	2.00	2.00	3.00	3.00	3.00
3.00	5.00	4.00	5.00	2.00	3.00	3.00	5.00	4.00	3.00	3.00	3.00	3.00	3.00
2.00	3.00	4.00	3.00	2.00	2.00	3.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00
3.00	5.00	4.00	5.00	2.00	3.00	3.00	5.00	4.00	3.00	2.00	3.00	2.00	3.00
3.00	5.00	4.00	5.00	2.00	3.00	3.00	5.00	5.00	3.00	2.00	3.00	2.00	3.00
1.00	3.00	3.00	5.00	3.00	3.00	3.00	5.00	2.00	3.00	3.00	3.00	2.00	3.00
1.00	4.00	4.00	5.00	2.00	4.00	2.00	4.00	2.00	3.00	4.00	2.00	4.00	4.00
1.00	4.00	2.00	5.00	3.00	2.00	2.00	5.00	2.00	2.00	5.00	3.00	4.00	4.00

Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42
2.00	3.00	3.00	2.00	3.00	4.00	2.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00
4.00	3.00	4.00	5.00	5.00	5.00	2.00	4.00	5.00	4.00	3.00	5.00	4.00	3.00
3.00	4.00	3.00	3.00	5.00	4.00	3.00	4.00	3.00	2.00	4.00	5.00	5.00	3.00
4.00	4.00	4.00	3.00	4.00	5.00	4.00	5.00	3.00	3.00	3.00	4.00	3.00	5.00
4.00	5.00	3.00	5.00	5.00	4.00	4.00	5.00	4.00	3.00	3.00	4.00	5.00	4.00
4.00	3.00	4.00	5.00	5.00	5.00	1.00	3.00	4.00	2.00	4.00	3.00	4.00	3.00
3.00	3.00	4.00	4.00	5.00	4.00	2.00	4.00	4.00	2.00	4.00	4.00	3.00	4.00
4.00	2.00	4.00	5.00	3.00	4.00	4.00	3.00	5.00	3.00	3.00	4.00	3.00	3.00
4.00	3.00	4.00	2.00	5.00	3.00	4.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00
5.00	4.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00	2.00	2.00	4.00	3.00	3.00
4.00	2.00	4.00	3.00	4.00	5.00	3.00	4.00	5.00	3.00	3.00	2.00	4.00	5.00
3.00	4.00	5.00	3.00	3.00	5.00	2.00	4.00	3.00	2.00	4.00	3.00	4.00	2.00
4.00	3.00	4.00	3.00	5.00	4.00	2.00	4.00	4.00	3.00	2.00	2.00	3.00	4.00
4.00	2.00	3.00	3.00	4.00	3.00	3.00	4.00	2.00	3.00	1.00	4.00	3.00	2.00
4.00	4.00	3.00	5.00	4.00	3.00	4.00	3.00	4.00	2.00	1.00	4.00	4.00	4.00
4.00	3.00	2.00	3.00	4.00	3.00	2.00	3.00	4.00	4.00	4.00	3.00	3.00	4.00
4.00	3.00	3.00	4.00	4.00	4.00	3.00	3.00	3.00	2.00	2.00	3.00	3.00	3.00
3.00	4.00	3.00	3.00	4.00	5.00	3.00	4.00	5.00	1.00	1.00	3.00	4.00	3.00
4.00	3.00	3.00	4.00	5.00	5.00	3.00	4.00	4.00	3.00	3.00	3.00	4.00	3.00
3.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	4.00	2.00	4.00	3.00	3.00	4.00
4.00	4.00	4.00	3.00	5.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00
4.00	3.00	4.00	4.00	4.00	3.00	4.00	4.00	4.00	3.00	4.00	4.00	3.00	4.00
4.00	3.00	3.00	4.00	4.00	3.00	3.00	4.00	5.00	3.00	2.00	4.00	4.00	3.00
4.00	3.00	4.00	4.00	4.00	4.00	2.00	5.00	4.00	3.00	3.00	4.00	3.00	4.00
4.00	3.00	3.00	4.00	5.00	3.00	3.00	4.00	3.00	3.00	3.00	4.00	5.00	3.00
4.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	2.00	2.00	4.00	3.00	4.00
3.00	4.00	2.00	3.00	5.00	5.00	2.00	4.00	4.00	2.00	3.00	3.00	3.00	3.00
4.00	3.00	4.00	3.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00
3.00	3.00	3.00	4.00	5.00	4.00	2.00	5.00	5.00	2.00	4.00	5.00	2.00	3.00
2.00	2.00	2.00	3.00	5.00	4.00	3.00	3.00	3.00	3.00	1.00	4.00	4.00	4.00
3.00	3.00	3.00	3.00	4.00	3.00	2.00	3.00	3.00	2.00	1.00	3.00	3.00	3.00
3.00	2.00	3.00	3.00	5.00	3.00	1.00	5.00	4.00	3.00	3.00	2.00	4.00	5.00
2.00	3.00	3.00	3.00	5.00	4.00	2.00	5.00	3.00	3.00	2.00	3.00	5.00	5.00
3.00	2.00	3.00	5.00	5.00	3.00	2.00	4.00	3.00	2.00	3.00	2.00	5.00	5.00
3.00	2.00	3.00	3.00	5.00	3.00	2.00	5.00	3.00	3.00	3.00	3.00	5.00	5.00
3.00	2.00	3.00	3.00	5.00	3.00	2.00	4.00	3.00	4.00	2.00	3.00	5.00	5.00
3.00	2.00	3.00	3.00	5.00	4.00	3.00	4.00	3.00	4.00	3.00	3.00	5.00	5.00
3.00	3.00	3.00	3.00	5.00	4.00	2.00	4.00	3.00	3.00	3.00	3.00	5.00	5.00
3.00	3.00	2.00	3.00	5.00	4.00	3.00	3.00	5.00	3.00	3.00	3.00	4.00	3.00
4.00	3.00	2.00	3.00	5.00	3.00	2.00	4.00	4.00	3.00	3.00	4.00	2.00	3.00
5.00	3.00	2.00	3.00	4.00	3.00	1.00	4.00	4.00	3.00	3.00	4.00	4.00	3.00

Q43	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
4.00	2.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00
4.00	2.00	3.00	4.00	3.00	4.00	3.00	4.00	3.00	5.00	3.00	3.00	4.00	2.00
4.00	3.00	3.00	5.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00	3.00	4.00	4.00
3.00	2.00	3.00	4.00	3.00	5.00	3.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00
3.00	4.00	1.00	4.00	3.00	4.00	3.00	3.00	2.00	5.00	4.00	4.00	3.00	4.00
5.00	2.00	3.00	4.00	5.00	3.00	3.00	3.00	2.00	5.00	4.00	4.00	3.00	3.00
5.00	2.00	2.00	4.00	3.00	3.00	3.00	3.00	2.00	3.00	4.00	4.00	5.00	3.00
3.00	3.00	3.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	3.00	4.00	2.00
5.00	3.00	3.00	4.00	5.00	3.00	4.00	3.00	4.00	5.00	4.00	3.00	4.00	3.00
4.00	4.00	2.00	3.00	4.00	4.00	2.00	3.00	4.00	3.00	4.00	3.00	3.00	4.00
5.00	2.00	3.00	4.00	4.00	5.00	3.00	3.00	3.00	5.00	4.00	3.00	4.00	1.00
5.00	2.00	3.00	5.00	4.00	2.00	2.00	3.00	2.00	4.00	3.00	4.00	3.00	3.00
3.00	2.00	1.00	4.00	3.00	4.00	3.00	4.00	2.00	4.00	4.00	3.00	4.00	3.00
3.00	4.00	3.00	4.00	2.00	3.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00
2.00	2.00	1.00	3.00	3.00	5.00	2.00	2.00	2.00	3.00	3.00	2.00	2.00	2.00
4.00	2.00	2.00	4.00	2.00	4.00	3.00	3.00	2.00	4.00	4.00	3.00	3.00	4.00
3.00	3.00	3.00	4.00	4.00	4.00	3.00	3.00	3.00	4.00	4.00	3.00	4.00	3.00
5.00	3.00	1.00	3.00	4.00	4.00	4.00	3.00	4.00	4.00	5.00	3.00	3.00	4.00
5.00	2.00	2.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	5.00	3.00	3.00	3.00
4.00	2.00	3.00	4.00	4.00	5.00	4.00	4.00	3.00	4.00	4.00	4.00	4.00	3.00
4.00	3.00	3.00	4.00	4.00	3.00	4.00	4.00	3.00	4.00	4.00	3.00	4.00	4.00
4.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	4.00
4.00	2.00	2.00	4.00	4.00	3.00	4.00	3.00	2.00	4.00	4.00	3.00	4.00	4.00
3.00	3.00	2.00	3.00	2.00	4.00	3.00	2.00	3.00	4.00	3.00	3.00	4.00	2.00
4.00	2.00	3.00	4.00	4.00	5.00	3.00	3.00	3.00	4.00	3.00	3.00	3.00	3.00
3.00	3.00	3.00	3.00	2.00	4.00	3.00	4.00	2.00	4.00	4.00	3.00	3.00	3.00
4.00	2.00	2.00	3.00	2.00	5.00	3.00	4.00	3.00	4.00	5.00	3.00	2.00	2.00
3.00	2.00	4.00	4.00	4.00	4.00	3.00	4.00	2.00	3.00	4.00	2.00	2.00	2.00
3.00	3.00	3.00	2.00	3.00	5.00	2.00	3.00	2.00	3.00	3.00	2.00	4.00	2.00
3.00	2.00	1.00	5.00	4.00	5.00	2.00	4.00	1.00	4.00	3.00	2.00	2.00	2.00
4.00	2.00	2.00	3.00	3.00	5.00	2.00	2.00	2.00	4.00	3.00	3.00	3.00	2.00
5.00	3.00	3.00	5.00	5.00	5.00	2.00	1.00	2.00	5.00	3.00	2.00	2.00	2.00
4.00	4.00	1.00	5.00	3.00	5.00	2.00	2.00	3.00	5.00	2.00	3.00	2.00	2.00
5.00	4.00	2.00	5.00	5.00	5.00	2.00	2.00	2.00	4.00	3.00	2.00	2.00	2.00
3.00	4.00	4.00	3.00	5.00	1.00	2.00	2.00	4.00	5.00	3.00	2.00	3.00	3.00
4.00	3.00	2.00	5.00	3.00	5.00	2.00	2.00	3.00	5.00	2.00	4.00	4.00	1.00
4.00	3.00	3.00	5.00	3.00	5.00	2.00	2.00	3.00	5.00	3.00	4.00	3.00	2.00
4.00	3.00	3.00	5.00	3.00	5.00	3.00	2.00	3.00	4.00	3.00	4.00	3.00	2.00
4.00	4.00	3.00	2.00	3.00	5.00	3.00	3.00	4.00	4.00	3.00	2.00	3.00	3.00
3.00	2.00	3.00	2.00	3.00	4.00	1.00	3.00	3.00	3.00	3.00	2.00	4.00	3.00
4.00	3.00	3.00	2.00	3.00	5.00	3.00	2.00	3.00	5.00	3.00	4.00	4.00	2.00

Q57	Q58	Q59	Q60	Q61	Q62	Q63	Q64	Q65	Q66	Q67	Q68	Q69	Q70
3.00	3.00	4.00	3.00	3.00	4.00	2.00	4.00	3.00	3.00	2.00	3.00	4.00	3.00
4.00	3.00	5.00	4.00	2.00	2.00	2.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00
2.00	3.00	5.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00	4.00
3.00	3.00	5.00	4.00	3.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00	5.00	4.00
3.00	4.00	4.00	5.00	4.00	4.00	4.00	4.00	5.00	4.00	4.00	4.00	4.00	3.00
2.00	2.00	4.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00
2.00	3.00	5.00	4.00	3.00	4.00	2.00	4.00	5.00	3.00	3.00	2.00	4.00	3.00
3.00	1.00	5.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	5.00	3.00
3.00	1.00	5.00	3.00	4.00	2.00	2.00	4.00	3.00	4.00	2.00	3.00	4.00	3.00
4.00	3.00	4.00	3.00	2.00	3.00	2.00	4.00	3.00	3.00	4.00	4.00	3.00	4.00
2.00	2.00	3.00	4.00	2.00	1.00	1.00	3.00	3.00	4.00	3.00	4.00	4.00	3.00
4.00	3.00	5.00	4.00	3.00	4.00	2.00	3.00	2.00	2.00	3.00	1.00	4.00	3.00
3.00	4.00	5.00	3.00	4.00	3.00	1.00	3.00	2.00	2.00	4.00	2.00	2.00	3.00
2.00	4.00	4.00	3.00	3.00	2.00	1.00	3.00	3.00	4.00	4.00	2.00	4.00	3.00
2.00	4.00	4.00	4.00	3.00	1.00	1.00	3.00	5.00	3.00	3.00	3.00	4.00	5.00
2.00	4.00	4.00	3.00	2.00	3.00	2.00	4.00	2.00	3.00	2.00	2.00	4.00	2.00
1.00	2.00	4.00	4.00	3.00	4.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00
2.00	2.00	5.00	4.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	3.00
2.00	4.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00	3.00
4.00	3.00	4.00	4.00	3.00	4.00	2.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00
2.00	3.00	4.00	4.00	3.00	2.00	3.00	5.00	3.00	3.00	2.00	3.00	4.00	3.00
3.00	2.00	4.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00	4.00
3.00	2.00	4.00	4.00	4.00	3.00	2.00	4.00	4.00	3.00	3.00	2.00	4.00	4.00
2.00	3.00	4.00	4.00	2.00	2.00	3.00	4.00	4.00	5.00	5.00	4.00	3.00	4.00
2.00	2.00	4.00	3.00	3.00	3.00	2.00	4.00	4.00	3.00	4.00	2.00	4.00	4.00
3.00	3.00	4.00	3.00	3.00	3.00	3.00	5.00	4.00	5.00	4.00	2.00	3.00	4.00
2.00	2.00	3.00	3.00	3.00	2.00	2.00	3.00	3.00	3.00	4.00	3.00	2.00	3.00
3.00	4.00	3.00	4.00	3.00	3.00	3.00	5.00	3.00	4.00	4.00	4.00	5.00	3.00
3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	5.00	3.00
3.00	1.00	5.00	4.00	2.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00	5.00	3.00
2.00	2.00	4.00	3.00	2.00	2.00	2.00	5.00	3.00	3.00	3.00	2.00	3.00	3.00
2.00	3.00	5.00	4.00	2.00	1.00	2.00	4.00	5.00	2.00	2.00	1.00	5.00	4.00
3.00	4.00	5.00	2.00	2.00	1.00	3.00	4.00	5.00	3.00	3.00	1.00	4.00	3.00
2.00	2.00	5.00	3.00	2.00	1.00	3.00	5.00	4.00	4.00	3.00	1.00	4.00	4.00
4.00	2.00	5.00	2.00	2.00	3.00	2.00	4.00	4.00	3.00	2.00	1.00	4.00	3.00
3.00	3.00	5.00	2.00	2.00	3.00	3.00	4.00	5.00	3.00	2.00	1.00	4.00	3.00
3.00	3.00	5.00	3.00	2.00	3.00	3.00	4.00	3.00	2.00	2.00	2.00	5.00	4.00
3.00	3.00	5.00	3.00	2.00	2.00	3.00	2.00	5.00	2.00	2.00	2.00	5.00	3.00
3.00	3.00	4.00	5.00	2.00	4.00	3.00	5.00	4.00	5.00	3.00	3.00	2.00	3.00
3.00	3.00	5.00	4.00	3.00	3.00	3.00	5.00	5.00	2.00	3.00	2.00	3.00	3.00
4.00	3.00	3.00	5.00	3.00	3.00	3.00	5.00	4.00	4.00	3.00	3.00	3.00	2.00

Q71	Q72	Q73	Q74	Q75	Q76	Q77	Q78	Q79	Q80	Q81	Q82	Q83	Q84
3.00	2.00	3.00	3.00	2.00	3.00	2.00	3.00	3.00	2.00	3.00	3.00	2.00	3.00
4.00	4.00	5.00	4.00	2.00	4.00	4.00	3.00	5.00	3.00	3.00	4.00	5.00	4.00
5.00	3.00	4.00	3.00	3.00	5.00	2.00	4.00	5.00	4.00	5.00	3.00	4.00	4.00
4.00	5.00	4.00	4.00	3.00	5.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	3.00
4.00	5.00	3.00	4.00	4.00	3.00	4.00	4.00	4.00	4.00	5.00	4.00	5.00	4.00
4.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	4.00	5.00	4.00
3.00	3.00	4.00	3.00	2.00	4.00	3.00	4.00	4.00	5.00	3.00	4.00	5.00	3.00
4.00	3.00	4.00	3.00	4.00	3.00	2.00	4.00	4.00	2.00	4.00	2.00	4.00	3.00
4.00	2.00	4.00	4.00	2.00	3.00	4.00	2.00	4.00	5.00	2.00	3.00	4.00	3.00
3.00	4.00	3.00	4.00	3.00	2.00	4.00	5.00	2.00	3.00	3.00	4.00	2.00	4.00
2.00	3.00	2.00	4.00	2.00	2.00	3.00	4.00	4.00	3.00	4.00	5.00	3.00	2.00
3.00	4.00	5.00	4.00	2.00	2.00	4.00	5.00	4.00	2.00	3.00	4.00	2.00	4.00
4.00	2.00	4.00	2.00	1.00	2.00	2.00	3.00	3.00	4.00	2.00	4.00	2.00	3.00
3.00	4.00	3.00	3.00	2.00	3.00	2.00	4.00	4.00	3.00	4.00	3.00	4.00	3.00
3.00	5.00	5.00	3.00	3.00	3.00	3.00	3.00	5.00	5.00	5.00	2.00	5.00	5.00
3.00	3.00	2.00	3.00	2.00	2.00	3.00	4.00	4.00	4.00	3.00	4.00	3.00	3.00
3.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	4.00	4.00	4.00	3.00	3.00	4.00
4.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00	3.00	4.00	3.00
3.00	4.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00
4.00	4.00	4.00	3.00	3.00	4.00	2.00	3.00	3.00	4.00	4.00	3.00	4.00	5.00
4.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00	4.00	4.00	3.00	4.00	4.00
3.00	4.00	3.00	3.00	3.00	5.00	3.00	3.00	4.00	4.00	4.00	3.00	4.00	4.00
3.00	3.00	4.00	3.00	3.00	4.00	4.00	5.00	4.00	5.00	3.00	4.00	5.00	4.00
2.00	4.00	4.00	3.00	4.00	5.00	3.00	3.00	3.00	4.00	3.00	3.00	3.00	5.00
3.00	4.00	3.00	4.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00	4.00
4.00	4.00	4.00	4.00	3.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00
3.00	3.00	3.00	2.00	3.00	4.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00	5.00
3.00	3.00	3.00	3.00	4.00	5.00	3.00	3.00	4.00	5.00	4.00	4.00	4.00	5.00
3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	5.00	5.00	4.00	4.00
3.00	3.00	3.00	3.00	4.00	4.00	3.00	3.00	2.00	5.00	5.00	5.00	4.00	4.00
3.00	3.00	3.00	3.00	2.00	3.00	2.00	3.00	3.00	4.00	3.00	3.00	3.00	3.00
3.00	5.00	2.00	2.00	1.00	2.00	1.00	3.00	2.00	5.00	3.00	5.00	2.00	2.00
2.00	4.00	4.00	2.00	1.00	2.00	2.00	3.00	2.00	5.00	2.00	4.00	2.00	3.00
2.00	5.00	2.00	2.00	2.00	3.00	3.00	2.00	3.00	5.00	3.00	5.00	2.00	3.00
3.00	5.00	3.00	2.00	1.00	5.00	1.00	2.00	3.00	4.00	2.00	4.00	3.00	3.00
3.00	5.00	3.00	2.00	1.00	5.00	3.00	2.00	2.00	4.00	2.00	4.00	3.00	3.00
3.00	5.00	3.00	2.00	2.00	4.00	3.00	2.00	2.00	4.00	3.00	5.00	2.00	2.00
3.00	5.00	3.00	2.00	2.00	3.00	3.00	2.00	2.00	4.00	3.00	5.00	2.00	2.00
3.00	3.00	2.00	3.00	4.00	3.00	2.00	2.00	3.00	3.00	3.00	4.00	4.00	3.00
2.00	2.00	2.00	3.00	1.00	2.00	3.00	2.00	2.00	2.00	2.00	2.00	3.00	2.00
3.00	3.00	2.00	4.00	4.00	3.00	2.00	3.00	2.00	4.00	2.00	3.00	3.00	2.00

Q85	Q86	Q87	Q88	Q89	Q90	Q91	Q92	Q93	Q94	Q95	Q96	Q97	Q98
3.00	3.00	3.00	3.00	2.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	3.00	4.00
4.00	3.00	2.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00	3.00	3.00	3.00	4.00
3.00	4.00	2.00	4.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	3.00
4.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	3.00	4.00	4.00	3.00	3.00	4.00
4.00	5.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00	3.00	4.00	2.00	3.00	4.00
3.00	4.00	4.00	4.00	3.00	4.00	4.00	3.00	5.00	3.00	4.00	4.00	3.00	4.00
4.00	5.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	3.00	3.00	4.00
3.00	4.00	3.00	4.00	3.00	4.00	2.00	4.00	3.00	4.00	3.00	2.00	4.00	2.00
3.00	2.00	1.00	2.00	3.00	2.00	3.00	4.00	3.00	4.00	5.00	3.00	3.00	2.00
2.00	4.00	2.00	3.00	4.00	4.00	3.00	3.00	4.00	3.00	3.00	2.00	3.00	4.00
3.00	4.00	3.00	2.00	3.00	2.00	2.00	4.00	3.00	3.00	3.00	4.00	2.00	3.00
3.00	4.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00	4.00
3.00	4.00	3.00	4.00	2.00	2.00	3.00	4.00	3.00	4.00	3.00	4.00	3.00	4.00
4.00	3.00	2.00	3.00	2.00	2.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00	4.00
3.00	5.00	4.00	2.00	2.00	4.00	3.00	5.00	5.00	5.00	5.00	3.00	5.00	2.00
4.00	3.00	2.00	4.00	3.00	4.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00	4.00
3.00	3.00	3.00	4.00	3.00	3.00	3.00	4.00	4.00	4.00	3.00	3.00	4.00	4.00
3.00	4.00	4.00	4.00	3.00	3.00	3.00	4.00	4.00	3.00	3.00	3.00	4.00	3.00
4.00	3.00	3.00	5.00	4.00	3.00	4.00	4.00	3.00	3.00	4.00	3.00	4.00	3.00
4.00	3.00	2.00	5.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	3.00
4.00	4.00	2.00	4.00	3.00	3.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	4.00
3.00	4.00	3.00	4.00	3.00	2.00	3.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00
4.00	3.00	3.00	5.00	3.00	2.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	3.00
3.00	3.00	4.00	3.00	4.00	3.00	3.00	3.00	5.00	5.00	3.00	3.00	4.00	3.00
3.00	4.00	4.00	4.00	4.00	2.00	3.00	4.00	4.00	3.00	3.00	4.00	3.00	3.00
3.00	3.00	3.00	3.00	5.00	3.00	3.00	3.00	5.00	5.00	3.00	3.00	4.00	2.00
3.00	3.00	3.00	3.00	4.00	3.00	4.00	4.00	3.00	5.00	3.00	2.00	3.00	2.00
3.00	4.00	4.00	3.00	4.00	2.00	3.00	4.00	4.00	4.00	3.00	3.00	3.00	3.00
4.00	4.00	4.00	3.00	3.00	3.00	4.00	4.00	3.00	3.00	3.00	4.00	4.00	5.00
2.00	4.00	2.00	4.00	2.00	2.00	2.00	5.00	3.00	2.00	3.00	2.00	2.00	3.00
3.00	3.00	2.00	3.00	3.00	2.00	2.00	5.00	3.00	3.00	5.00	2.00	2.00	3.00
2.00	2.00	3.00	4.00	3.00	2.00	3.00	5.00	4.00	4.00	5.00	3.00	2.00	3.00
2.00	2.00	4.00	2.00	5.00	2.00	2.00	5.00	4.00	3.00	2.00	3.00	3.00	3.00
2.00	2.00	3.00	2.00	5.00	2.00	1.00	5.00	4.00	3.00	2.00	2.00	3.00	3.00
2.00	2.00	3.00	2.00	2.00	2.00	2.00	5.00	4.00	3.00	2.00	3.00	3.00	3.00
2.00	2.00	3.00	3.00	5.00	2.00	2.00	5.00	4.00	3.00	2.00	2.00	2.00	3.00
2.00	2.00	3.00	3.00	5.00	2.00	2.00	5.00	4.00	3.00	2.00	2.00	2.00	5.00
2.00	2.00	3.00	2.00	5.00	2.00	2.00	5.00	4.00	3.00	2.00	2.00	2.00	2.00
3.00	3.00	3.00	3.00	5.00	2.00	2.00	4.00	4.00	3.00	3.00	2.00	2.00	2.00
3.00	2.00	3.00	3.00	5.00	3.00	2.00	3.00	4.00	3.00	3.00	2.00	2.00	2.00
3.00	5.00	3.00	3.00	4.00	3.00	1.00	5.00	4.00	3.00	3.00	2.00	3.00	3.00

Q99	Q100	Q101	Q102	Q103	Q104	Q105	Q106	Q107	Q108	Q109	Q110	Q111	Q112
3.00	4.00	3.00	3.00	2.00	3.00	4.00	4.00	3.00	4.00	5.00	5.00	3.00	4.00
5.00	4.00	4.00	2.00	3.00	4.00	4.00	4.00	3.00	4.00	4.00	5.00	4.00	3.00
4.00	4.00	4.00	5.00	4.00	4.00	3.00	5.00	5.00	5.00	3.00	3.00	4.00	4.00
4.00	3.00	4.00	5.00	4.00	4.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	3.00
4.00	5.00	4.00	4.00	2.00	4.00	3.00	4.00	4.00	5.00	3.00	4.00	5.00	3.00
5.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00	5.00	4.00	3.00
5.00	4.00	4.00	4.00	2.00	2.00	3.00	4.00	4.00	4.00	3.00	3.00	4.00	2.00
5.00	3.00	3.00	4.00	3.00	3.00	4.00	4.00	4.00	4.00	5.00	5.00	3.00	2.00
4.00	3.00	4.00	4.00	2.00	3.00	4.00	4.00	3.00	3.00	4.00	5.00	4.00	2.00
3.00	4.00	4.00	3.00	4.00	2.00	3.00	2.00	3.00	4.00	3.00	5.00	5.00	4.00
3.00	2.00	2.00	2.00	3.00	2.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	2.00
4.00	2.00	4.00	2.00	3.00	3.00	3.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00
4.00	3.00	4.00	2.00	3.00	3.00	4.00	4.00	3.00	3.00	4.00	4.00	2.00	2.00
3.00	2.00	3.00	4.00	2.00	3.00	3.00	2.00	4.00	2.00	4.00	3.00	4.00	3.00
3.00	4.00	5.00	3.00	4.00	4.00	3.00	5.00	4.00	4.00	5.00	4.00	4.00	2.00
4.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	5.00	5.00	5.00	4.00	4.00	3.00
4.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00	3.00
4.00	4.00	3.00	4.00	3.00	4.00	3.00	5.00	4.00	4.00	4.00	4.00	3.00	1.00
4.00	3.00	3.00	4.00	3.00	4.00	4.00	4.00	5.00	5.00	4.00	4.00	4.00	3.00
4.00	3.00	4.00	4.00	3.00	4.00	4.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00
4.00	4.00	4.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	3.00	4.00	3.00
4.00	3.00	4.00	4.00	3.00	3.00	4.00	4.00	5.00	4.00	4.00	4.00	4.00	3.00
5.00	3.00	3.00	4.00	3.00	2.00	3.00	4.00	4.00	3.00	3.00	4.00	3.00	4.00
5.00	4.00	3.00	4.00	2.00	5.00	4.00	3.00	5.00	4.00	4.00	4.00	4.00	3.00
5.00	4.00	3.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00	3.00	3.00	4.00	3.00
5.00	4.00	3.00	4.00	2.00	5.00	3.00	3.00	5.00	4.00	4.00	3.00	4.00	3.00
4.00	4.00	4.00	4.00	3.00	3.00	4.00	3.00	5.00	5.00	5.00	4.00	4.00	3.00
5.00	5.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00	4.00
3.00	5.00	4.00	4.00	4.00	4.00	4.00	3.00	4.00	4.00	4.00	4.00	3.00	3.00
5.00	4.00	2.00	5.00	5.00	4.00	4.00	2.00	4.00	5.00	2.00	5.00	2.00	3.00
4.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	2.00
5.00	4.00	3.00	5.00	5.00	5.00	2.00	5.00	5.00	2.00	2.00	5.00	3.00	3.00
5.00	5.00	2.00	5.00	3.00	5.00	2.00	3.00	5.00	2.00	2.00	5.00	3.00	3.00
5.00	4.00	2.00	5.00	3.00	4.00	2.00	5.00	4.00	5.00	2.00	5.00	3.00	2.00
5.00	5.00	2.00	5.00	5.00	4.00	2.00	5.00	5.00	3.00	2.00	5.00	3.00	2.00
5.00	5.00	2.00	5.00	5.00	4.00	2.00	4.00	5.00	3.00	2.00	5.00	3.00	2.00
3.00	2.00	4.00	4.00	3.00	3.00	3.00	4.00	5.00	2.00	3.00	4.00	2.00	2.00
5.00	3.00	2.00	4.00	5.00	3.00	2.00	4.00	5.00	2.00	2.00	4.00	5.00	1.00
5.00	5.00	3.00	3.00	3.00	3.00	2.00	3.00	3.00	4.00	2.00	4.00	3.00	3.00
4.00	4.00	2.00	2.00	3.00	3.00	2.00	4.00	4.00	3.00	2.00	5.00	3.00	2.00
5.00	4.00	2.00	3.00	3.00	3.00	2.00	4.00	4.00	5.00	3.00	5.00	2.00	1.00

Q113	Q114	Q115	Q116	Q117	Q118	Q119	Q120	Q121	Q122	Q123	Q124	Q125	Q126
4.00	3.00	4.00	5.00	4.00	5.00	5.00	4.00	4.00	3.00	5.00	3.00	4.00	3.00
5.00	3.00	4.00	4.00	3.00	3.00	4.00	4.00	5.00	4.00	4.00	3.00	4.00	2.00
4.00	3.00	4.00	3.00	5.00	3.00	4.00	4.00	5.00	3.00	4.00	3.00	4.00	5.00
4.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	4.00	4.00	3.00
3.00	4.00	4.00	5.00	4.00	5.00	3.00	4.00	3.00	4.00	3.00	4.00	4.00	4.00
4.00	3.00	5.00	4.00	5.00	4.00	4.00	5.00	4.00	3.00	4.00	3.00	5.00	4.00
4.00	2.00	4.00	3.00	4.00	5.00	4.00	4.00	3.00	3.00	4.00	3.00	2.00	3.00
4.00	5.00	3.00	4.00	5.00	3.00	4.00	5.00	5.00	3.00	4.00	5.00	3.00	4.00
3.00	4.00	3.00	4.00	4.00	5.00	3.00	4.00	5.00	2.00	3.00	2.00	2.00	3.00
4.00	3.00	4.00	3.00	4.00	3.00	4.00	5.00	5.00	3.00	4.00	3.00	4.00	4.00
4.00	2.00	2.00	4.00	3.00	2.00	4.00	2.00	4.00	3.00	3.00	3.00	4.00	4.00
4.00	2.00	3.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	2.00
4.00	2.00	3.00	4.00	3.00	4.00	3.00	4.00	4.00	2.00	3.00	4.00	4.00	4.00
4.00	3.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	3.00	2.00	3.00	4.00	3.00
5.00	4.00	3.00	5.00	4.00	3.00	2.00	3.00	4.00	4.00	4.00	5.00	3.00	2.00
4.00	3.00	4.00	4.00	3.00	3.00	3.00	4.00	4.00	3.00	4.00	5.00	3.00	4.00
3.00	3.00	4.00	4.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00	3.00	4.00	3.00
4.00	4.00	3.00	3.00	3.00	3.00	4.00	4.00	3.00	3.00	4.00	3.00	4.00	3.00
4.00	4.00	3.00	3.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00	4.00	3.00	3.00
4.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00
4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	3.00	4.00	4.00	3.00	4.00
4.00	3.00	4.00	4.00	3.00	4.00	3.00	4.00	4.00	4.00	3.00	3.00	3.00	4.00
4.00	3.00	4.00	4.00	3.00	3.00	4.00	3.00	5.00	3.00	4.00	3.00	3.00	4.00
4.00	3.00	3.00	4.00	4.00	3.00	3.00	3.00	3.00	4.00	3.00	5.00	5.00	3.00
4.00	3.00	3.00	4.00	3.00	3.00	4.00	4.00	4.00	3.00	3.00	4.00	3.00	4.00
4.00	3.00	3.00	4.00	4.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00	4.00	3.00
3.00	2.00	4.00	4.00	5.00	4.00	3.00	4.00	4.00	4.00	5.00	5.00	5.00	4.00
5.00	5.00	5.00	4.00	5.00	3.00	4.00	4.00	5.00	5.00	5.00	5.00	3.00	3.00
3.00	5.00	4.00	4.00	5.00	3.00	3.00	3.00	4.00	5.00	3.00	3.00	3.00	3.00
4.00	4.00	3.00	4.00	2.00	4.00	3.00	3.00	5.00	3.00	5.00	3.00	4.00	4.00
4.00	3.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
5.00	2.00	3.00	5.00	3.00	3.00	2.00	2.00	5.00	5.00	5.00	4.00	5.00	2.00
5.00	5.00	2.00	5.00	4.00	2.00	2.00	3.00	4.00	5.00	4.00	3.00	5.00	2.00
5.00	3.00	2.00	5.00	3.00	2.00	2.00	3.00	3.00	3.00	3.00	5.00	5.00	2.00
5.00	5.00	2.00	5.00	5.00	2.00	2.00	5.00	3.00	5.00	3.00	3.00	5.00	2.00
5.00	5.00	2.00	5.00	4.00	2.00	2.00	2.00	3.00	5.00	5.00	3.00	4.00	2.00
5.00	5.00	3.00	5.00	4.00	2.00	2.00	3.00	3.00	4.00	4.00	5.00	4.00	2.00
4.00	5.00	3.00	5.00	4.00	2.00	2.00	5.00	3.00	4.00	5.00	4.00	4.00	3.00
4.00	3.00	3.00	4.00	3.00	5.00	3.00	3.00	3.00	3.00	2.00	3.00	3.00	3.00
5.00	5.00	4.00	3.00	4.00	3.00	2.00	3.00	3.00	3.00	2.00	2.00	2.00	4.00
5.00	4.00	3.00	5.00	4.00	3.00	3.00	3.00	3.00	4.00	4.00	2.00	4.00	4.00

Q127	Q128	Q129	Q130	Q131
5.00	4.00	2.00	2.00	2.00
3.00	4.00	3.00	4.00	3.00
4.00	4.00	4.00	3.00	2.00
4.00	4.00	5.00	2.00	1.00
4.00	5.00	4.00	3.00	3.00
5.00	4.00	5.00	4.00	5.00
3.00	4.00	3.00	4.00	2.00
3.00	4.00	3.00	3.00	2.00
2.00	3.00	4.00	2.00	2.00
5.00	3.00	4.00	2.00	1.00
2.00	2.00	2.00	2.00	3.00
3.00	3.00	4.00	3.00	2.00
3.00	2.00	2.00	3.00	3.00
3.00	2.00	2.00	3.00	2.00
5.00	3.00	3.00	3.00	3.00
3.00	4.00	3.00	4.00	2.00
4.00	4.00	3.00	4.00	3.00
4.00	3.00	3.00	4.00	3.00
4.00	3.00	3.00	4.00	3.00
3.00	4.00	3.00	4.00	3.00
3.00	3.00	3.00	3.00	3.00
3.00	2.00	3.00	4.00	3.00
3.00	3.00	4.00	4.00	2.00
4.00	5.00	3.00	5.00	4.00
3.00	2.00	3.00	3.00	2.00
3.00	5.00	3.00	4.00	3.00
4.00	4.00	3.00	5.00	3.00
5.00	2.00	3.00	3.00	4.00
5.00	3.00	3.00	3.00	3.00
3.00	4.00	3.00	3.00	3.00
3.00	3.00	2.00	2.00	2.00
2.00	3.00	3.00	2.00	1.00
2.00	4.00	2.00	1.00	1.00
4.00	3.00	1.00	1.00	1.00
2.00	3.00	1.00	1.00	1.00
2.00	3.00	1.00	1.00	1.00
2.00	3.00	1.00	1.00	1.00
2.00	1.00	3.00	1.00	1.00
3.00	2.00	3.00	1.00	2.00
4.00	1.00	2.00	2.00	3.00
4.00	3.00	1.00	4.00	2.00

Appendix O

Round 4: Pairwise Comparisons Questionnaires

Dear participant,

I would like to inform you that the consensus for the last three rounds has been achieved and only one round is left. In this round you are expected to evaluate and compare the categories and sub-categories in this assessment, this process is also known as "a pairwise comparisons".

The outcome of this process will determine the overall weighting and scoring system for the indicators that will be calculated and listed as the final result for this assessment.

In this questionnaire you will be asked to evaluate a set of categories to determine their level of importance compared to each other. Each row in this questionnaire will include a scale with the value 1 which means that compared categories have an equal level of importance; where's the value 9 indicates the highest level of importance and it also demonstrates that one of the categories are more important that the categories on the opposite side of the comparisons: any values that distributed within the 1-9 are a reflection of the level of importance as it shown in the table below this note.

Please refer to the table and the example below before you start filling the questions as this will give you an insight on the way to fill the questions in the right manner.

Scale	Meaning of the Values
1	The importance of both categories are equal
3	One of the categories is slightly favored/more important than the other one
5	One of the two categories is strongly favored/important compared to the other one

7	One of the two categories is very strongly favored/important than the other one
9	One of the categories is extremely favored/important compared to the other one
2,4,6,8	Used to reflect the intermediate values that fall between 1-9 in the scale

Comparisons' examples:

In the following examples, a comparison between a hypothetical categories (A) and (B) will be conducted and the meaning of choices or answers will be explained in a short statement to guide you through this process, as it follows;

if you choose the value (1) in the middle of the scale, that means: (A) is equally important to (B), as it shown in the table below:

category or sub-category	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	category or sub-category
A									✓									B

if you choose the value (3) on the right side of the scale, that means: (B) is moderately important than (A), as it shown in the table below:

category or sub-category	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	category or sub-category

A										✓							B

if you choose the value (9), that means: (B) is extremely important than (A), as it shown in the table below:

category or sub-category	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	category or sub-category
A											✓							B

Part 1.0 Please compare the following subcategories with each other in order to determine their overall weighting based on your pairwise comparisons

1.1 Please compare the listed categories with each other assessment:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Management																		Indoor Environmental Quality
Management																		Energy Optimisation
Management																		Water Efficiency
Management																		Waste and Pollution Management
Management																		Site and Micro climate
Management																		Materials and Resources Use
Management																		Transportation

Management																		Economic
Management																		Cultural and Social

1.2 Please compare the listed categories with each other assessment:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Indoor Environmental Quality																		Energy Optimisation
Indoor Environmental Quality																		Water Efficiency
Indoor Environmental Quality																		Waste and Pollution Management
Indoor Environmental Quality																		Site and Micro climate
Indoor Environmental Quality																		Materials and Resources Use
Indoor Environmental Quality																		Cultural and Social
Indoor Environmental Quality																		Economic

1.3 Please compare the following categories with each other in order to determine their overall weighting based on your pair-wise comparisons

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Energy Optimisation																		Water Efficiency
Energy Optimisation																		Waste and Pollution Management
Energy Optimisation																		Site and Micro climate
Energy Optimisation																		Materials and Resources Use
Energy Optimisation																		Transportation

Energy Optimisation																		Cultural and Social
Energy Optimisation																		Economic

1.4 Please compare the listed categories with each other assessment:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Water Efficiency																		Waste and Pollution Management
Water Efficiency																		Site and Micro climate
Water Efficiency																		Materials and Resources Use
Water Efficiency																		Materials and Resources Use
Water Efficiency																		Transportation
Water Efficiency																		Cultural and Social
Water Efficiency																		Economic Efficiency

1.5 Please compare the listed categories with each other assessment:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Waste and Pollution Management																		Site and Micro climate
Waste and Pollution Management																		Materials and Resources Use
Waste and Pollution Management																		Transportation
Waste and Pollution Management																		Cultural and Social
Waste and Pollution Management																		Economic Efficiency

1.6 Please compare the listed categories with each other assessment:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Site and Micro climate																		Materials and Resources Use
Site and Micro climate																		Transportation
Site and Micro climate																		Cultural and Social
Site and Micro climate																		Economic Efficiency

1.7 Please compare the listed categories with each other assessment:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Materials and Resources Use																		Transportation
Materials and Resources Use																		Cultural and Social
Materials and Resources Use																		Economic Efficiency

1.8 Please compare the listed categories with each other assessment:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Transportation																		Cultural and Social
Transportation																		Economic Efficiency

1.9 Please compare the listed categories with each other assessment:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Cultural and Social																		Economic Efficiency

1.10 Part 2. Please compares the following Management's subcategories with each other:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Subcategory A (Building Management):																		Economic Efficiency

1.11 Please compare the following Indoor Environmental Quality's subcategories with each other:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Subcategory A (Controllability):																		Subcategory B (Indoor Services):
Subcategory A (Controllability):																		Subcategory C (Interior Qualities and Functions):
Subcategory B (Indoor Services):																		Subcategory C (Interior Qualities and Functions):

1.12 please compare the following Energy Optimisation's subcategories with each other:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Subcategory A (Building Envelope):																		Subcategory B (Efficient indoor Appliances, Heating and Cooling):
Subcategory A (Building Envelope):																		Subcategory C (Efficient Design and strategies): م
Subcategory A (Building Envelope):																		Subcategory D (Renewables):
Subcategory B (Efficient indoor Appliances, Heating and Cooling):																		Subcategory C (Efficient Design and strategies):
Subcategory B (Efficient indoor Appliances,																		Subcategory D (Renewables):

Heating and Cooling):																		
Subcategory C (Efficient Design and strategies):																		Subcategory D (Renewables):

1.13 Please compare the following Waste's subcategories with each other:

Subcategory A (Indoor Waste)	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	Subcategory B (Outdoor Waste)

1.14 Please compare the following Site and Microclimates' subcategories with each other:

Subcategory A (heat wave island)	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	Subcategory B (outdoor waste)

1.15 Please compare the following Materials and Resources subcategories with each other:

SUBCATEGORY A (Resources Sourcing)	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	SUBCATEGORY B (Materials' Environmental Impacts)

Appendix P

Random sample of responses from round 4

Note: Numbers with black color= preferring the categories on the row
Numbers with red color= preferring the categories on the column

Respondent 1

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		4	4	5	3	3	4	2	2	3
Energy Optimisation			2	3	3	4	3	3	4	5
Water Efficiency				3	3	3	2	4	5	4
Waste and Pollution Management					3	3	4	4	5	4
Site and Microclimate					3	2	1	3	5	4
Materials and Resources							2	3	4	5
Transportation								3	5	4
Cultural and Society									4	3
Economics	Incon: 0.08									2

Respondent 2

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		2	4	4	3	3	3	1	2	2
Energy Optimisation			2	2	2	3	2	3	4	3
Water Efficiency				1	3	4	3	4	5	4
Waste and Pollution Management					2	3	2	3	5	4
Site and Microclimate						2	2	3	4	3
Materials and Resources							1	2	3	2
Transportation								2	3	2
Cultural and Society									2	2
Economics	Incon: 0.04									2

Respondent 3

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		2	3	3	2	3	3	3	3	2
Energy Optimisation			2	1	3	4	2	3	4	3
Water Efficiency				1	2	2	2	2	5	4
Waste and Pollution Management					4	4	3	4	4	3
Site and Microclimate						2	2	3	5	3
Materials and Resources							2	1	2	2
Transportation								1	3	2
Cultural and Society									2	1
Economics	Incon: 0.06									2

Respondent 4

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		2	4	3	2	2	3	2	3	3
Energy Optimisation			3	2	2	3	3	3	4	3
Water Efficiency				3	3	3	3	3	4	4
Waste and Pollution Management					3	3	2	3	3	3
Site and Microclimate						3	2	3	4	3
Materials and Resources							2	2	3	2
Transportation								2	2	2
Cultural and Society									2	1
Economics	Incon: 0.07									2

Respondent 5

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		4	4	5	3	3	4	2	2	3
Energy Optimisation			2	3	3	4	3	3	4	5
Water Efficiency				2	3	3	2	4	5	4
Waste and Pollution Management					3	3	4	4	5	4
Site and Microclimate						2	1	3	5	4
Materials and Resources							2	3	4	5
Transportation								3	5	4
Cultural and Society									4	3
Economics	Incon: 0.08									2

Respondent 6

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		2	4	2	2	2	2	1	2	2
Energy Optimisation			1	2	3	2	3	3	2	1
Water Efficiency				1	2	2	1	2	4	2
Waste and Pollution Management					2	2	2	3	4	3
Site and Microclimate						2	1	2	2	1
Materials and Resources							2	1	1	1
Transportation								1	2	2
Cultural and Society									2	1
Economics	Incon: 0.05									1

Respondent 7

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		3	3	3	2	2	2	1	2	2
Energy Optimisation			2	1	3	3	3	3	2	1
Water Efficiency				1	2	2	1	2	4	2
Waste and Pollution Management					2	2	2	3	4	3
Site and Microclimate						2	1	2	2	1
Materials and Resources							2	1	1	1
Transportation								1	2	2
Cultural and Society									2	1
Economics	Incon: 0.05									2

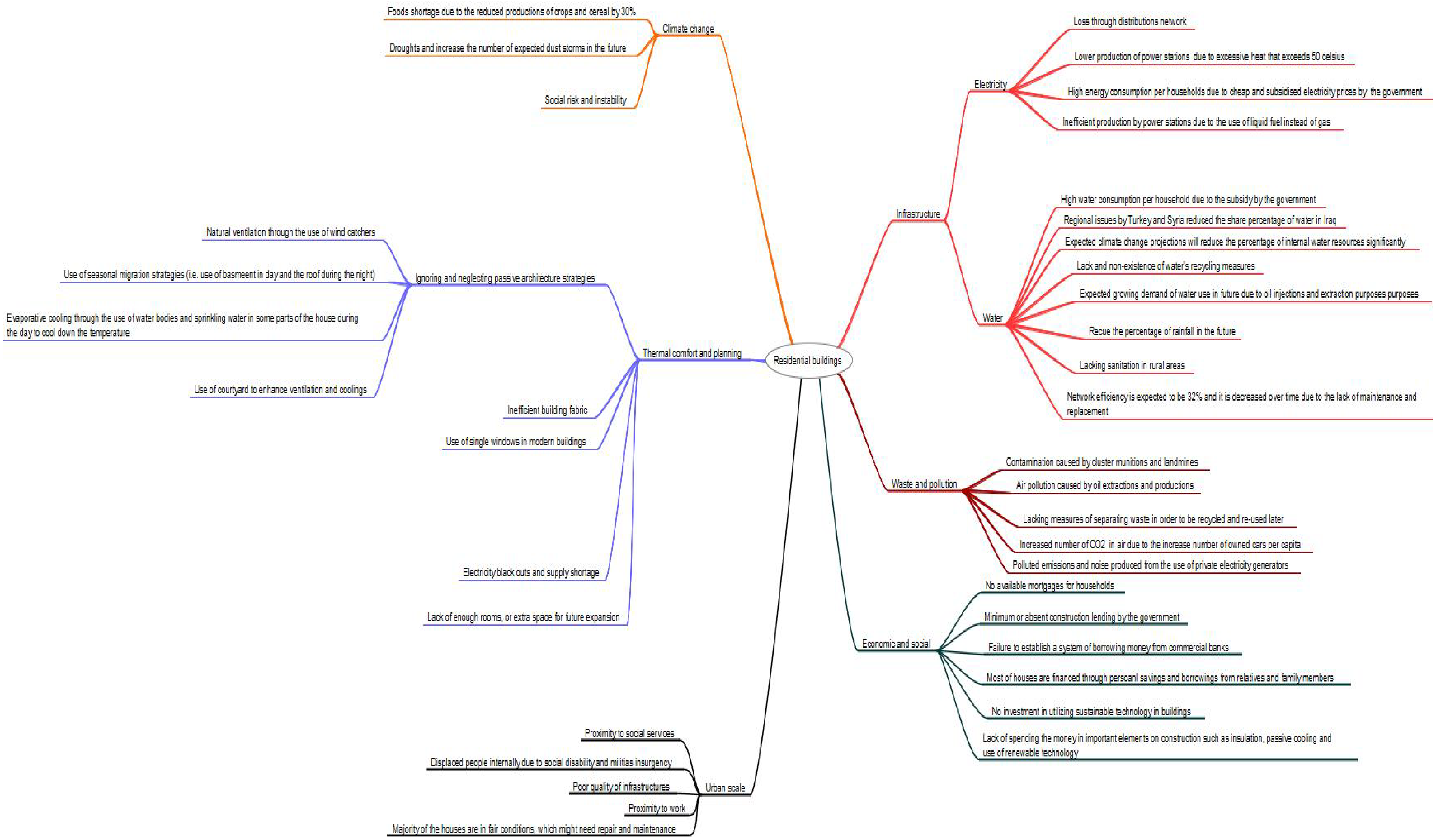
Respondent 8

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		4	4	4	3	3	4	2	2	3
Energy Optimisation			2	3	3	4	3	3	4	5
Water Efficiency				1	3	3	3	4	5	4
Waste and Pollution Management					3	3	4	4	5	4
Site and Microclimate						2	1	3	5	4
Materials and Resources							2	3	4	5
Transportation								3	5	4
Cultural and Society									4	3
Economics	Incon: 0.08									2

Respondent 9

Management	Management	Indoor Environmental Quality	Energy Optimisation	Water Efficiency	Waste and Pollution Management	Site and Microclimate	Materials and Resources	Transportation	Cultural and Society	Economics
Indoor Environmental Quality		3	4	3	3	2	2	2	3	2
Energy Optimisation			3	2	2	1	2	2	3	2
Water Efficiency				2	2	2	3	3	2	4
Waste and Pollution Management					2	3	3	3	3	3
Site and Microclimate						1	2	3	3	2
Materials and Resources							2	2	4	2
Transportation								2	2	4
Cultural and Society									2	2
Economics	Incon: 0.06									2

Appendix Q



Residential buildings
Climate change
Foods shortage due to the reduced productions of crops and cereal by 30%
Droughts and increase the number of expected dust storms in the future
Social risk and instability
Infrastructure
Electricity
Loss through distributions network
Lower production of power stations due to excessive heat that exceeds 50 celsius
High energy consumption per households due to cheap and subsidised electricity prices by the government
Inefficient production by power stations due to the use of liquid fuel instead of gas
Water
High water consumption per household due to the subsidy by the government
Regional issues by Turkey and Syria reduced the share percentage of water in Iraq
Expected climate change projections will reduce the percentage of internal water resources significantly
Lack and non-existence of water's recycling measures
Expected growing demand of water use in future due to oil injections and extraction purposes purposes
Recue the percentage of rainfall in the future
Lacking sanitation in rural areas
Network efficiency is expected to be 32% and it is decreased over time due to the lack of maintenance and replacement
Thermal comfort and planning
Ignoring and neglecting passive architecture strategies
Natural ventilation through the use of wind catchers
Use of seasonal migration strategies (i.e. use of basmeent in day and the roof during the night)
Evaporative cooling through the use of water bodies and sprinkling water in some parts of the house during the day to cool down the temperature
Use of courtyard to enhance ventilation and coolings
Inefficient building fabric
Use of single windows in modern buildings
Electricity black outs and supply shortage
Lack of enough rooms, or extra space for future expansion
Waste and pollution
Contamination caused by cluster munitions and landmines
Air pollution caused by oil extractions and productions
Lacking measures of separating waste in order to be recycled and re-used later
Increased number of CO2 in air due to the increase number of owned cars per capita
Polluted emissions and noise produced from the use of private electricity generators
Economic and social
No available mortgages for households
Minimum or absent construction lending by the government
Failure to establish a system of borrowing money from commercial banks
Most of houses are financed through persoanl savings and borrowings from relatives and family members
No investment in utilizing sustainable technology in buildings
Lack of spending the money in important elements on construction such as insulation, passive cooling and use of renewable technology
Urban scale
Proximity to social services
Displaced people internally due to social disability and militias insurgency
Poor quality of infrastructures
Proximity to work
Majority of the houses are in fair conditions, which might need repair and maintenance

Appendix R

Consent Form

I have read and understand the participant information sheet for this study ☐

By handing this questionnaire back to you, completed, I am giving you my consent for you to use my questionnaire answers in this research study. ☐

I understand that I have the right of withdraw my questionnaire at any point through contacting the researcher using the details on the participant information sheet and quoting the participant reference code written at the top if its included within the questionnaires. ☐

Please fill in the following background information:

Name:

Institution/Company:

Background/Work Sector:

Country:

Email:

Appendix S

List of publications

1- Conference paper “Investigating the inter-relationships between resilience and sustainability of built environment” Published by UCL august 2014

2- Draft paper prepared for submission “Developing a nearly zero carbon residential building case study of Iraq”

3- Draft paper prepared for submission “Developing sustainability assessment frameworks for residential buildings in iraq”

Appendix S

List of publications

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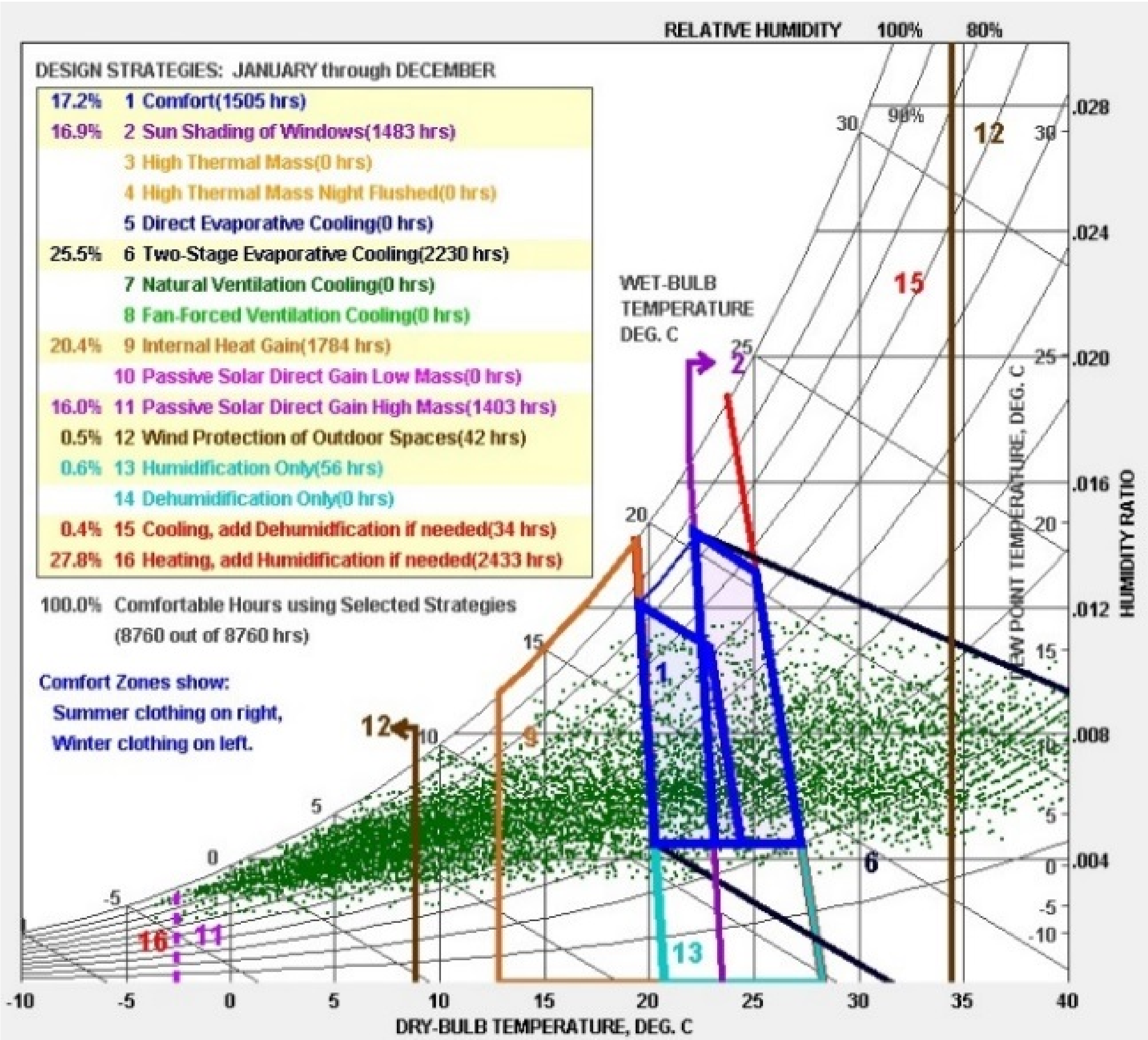
3- Draft paper prepared for submission “Developing sustainability assessment frameworks for residential buildings in iraq”

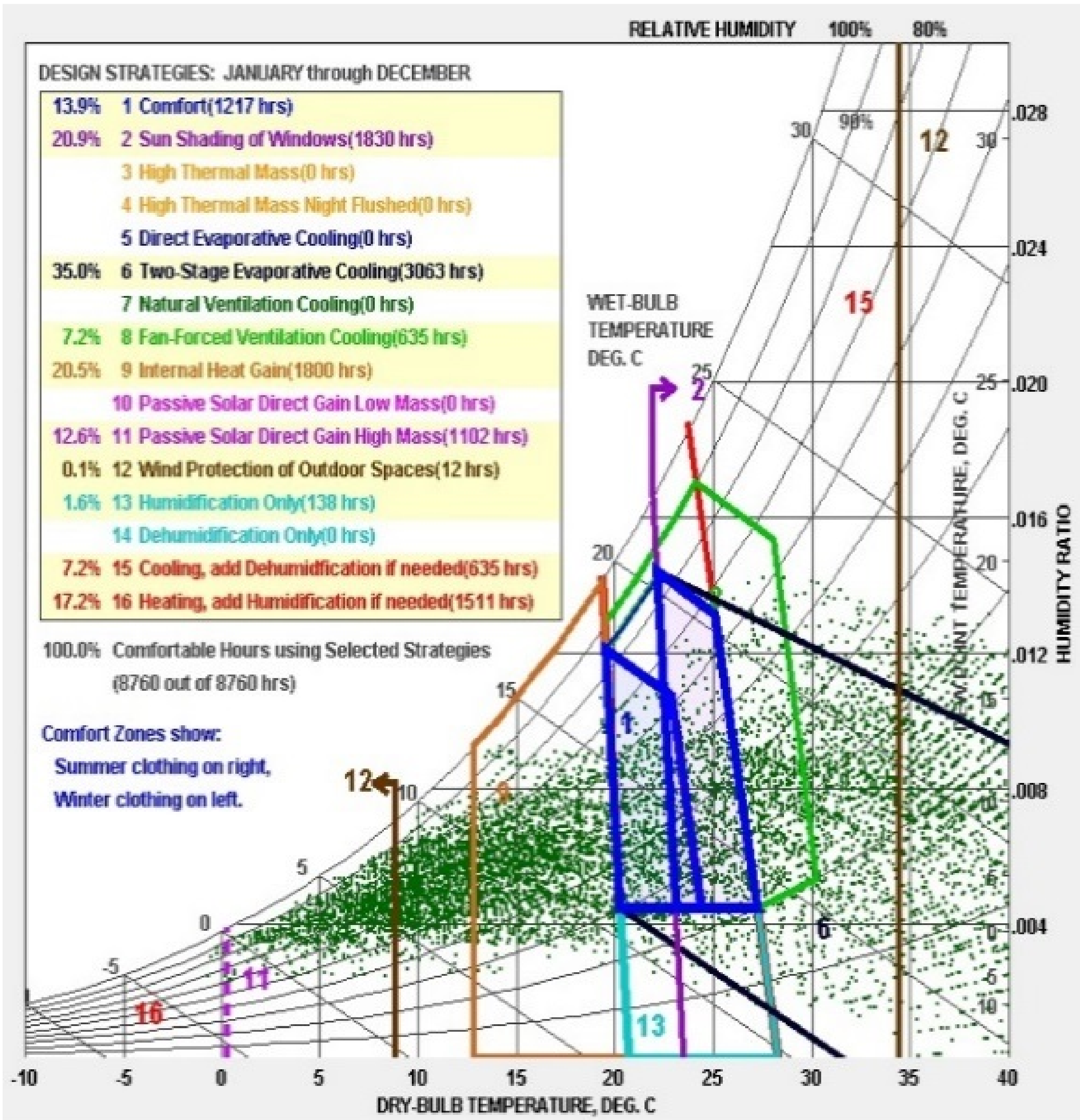
Appendix T

Psychometric chart for Mosul's current weather



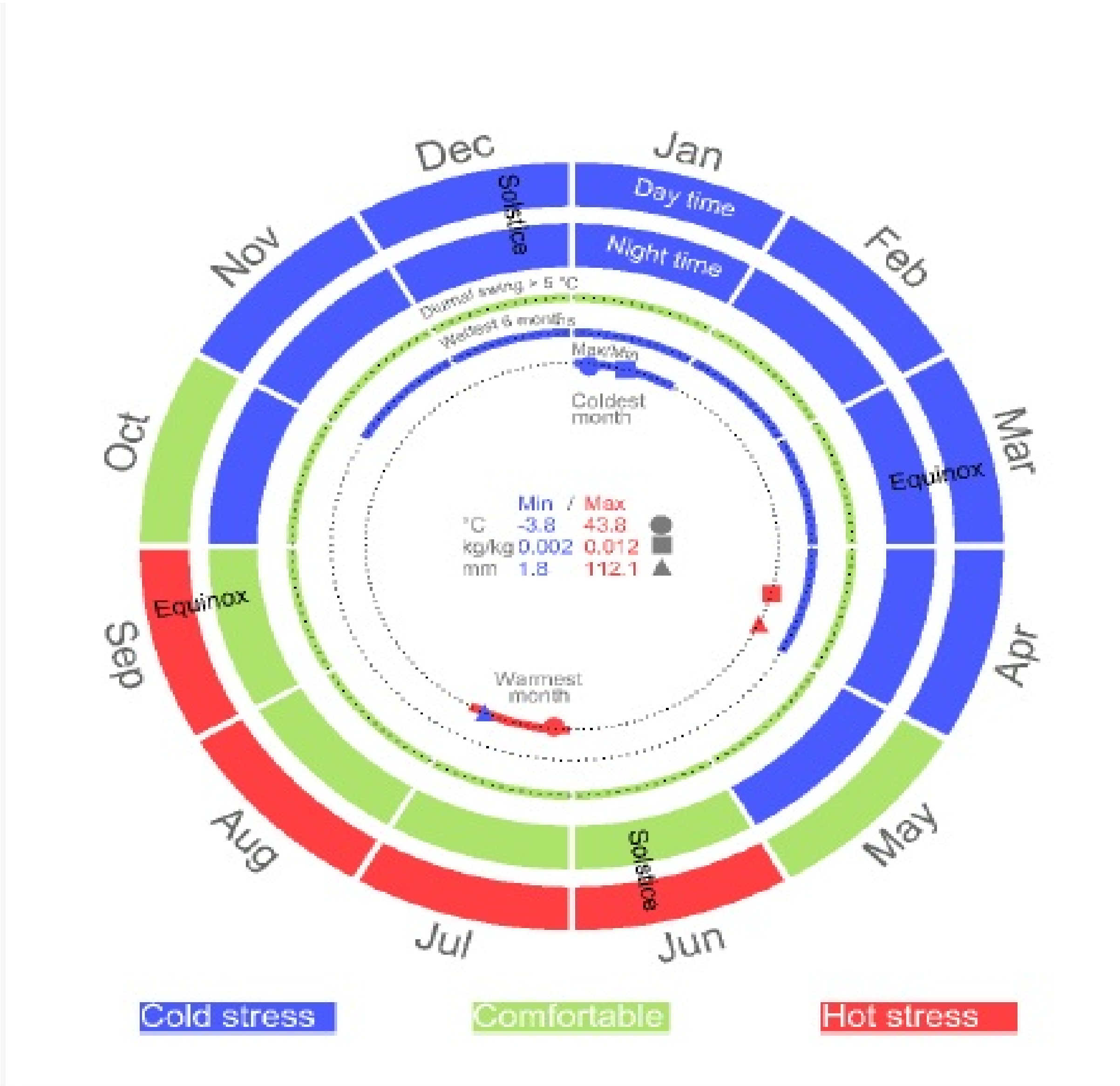
Appendix T continued

Psychometric chart for Mosul's 2080 scenario



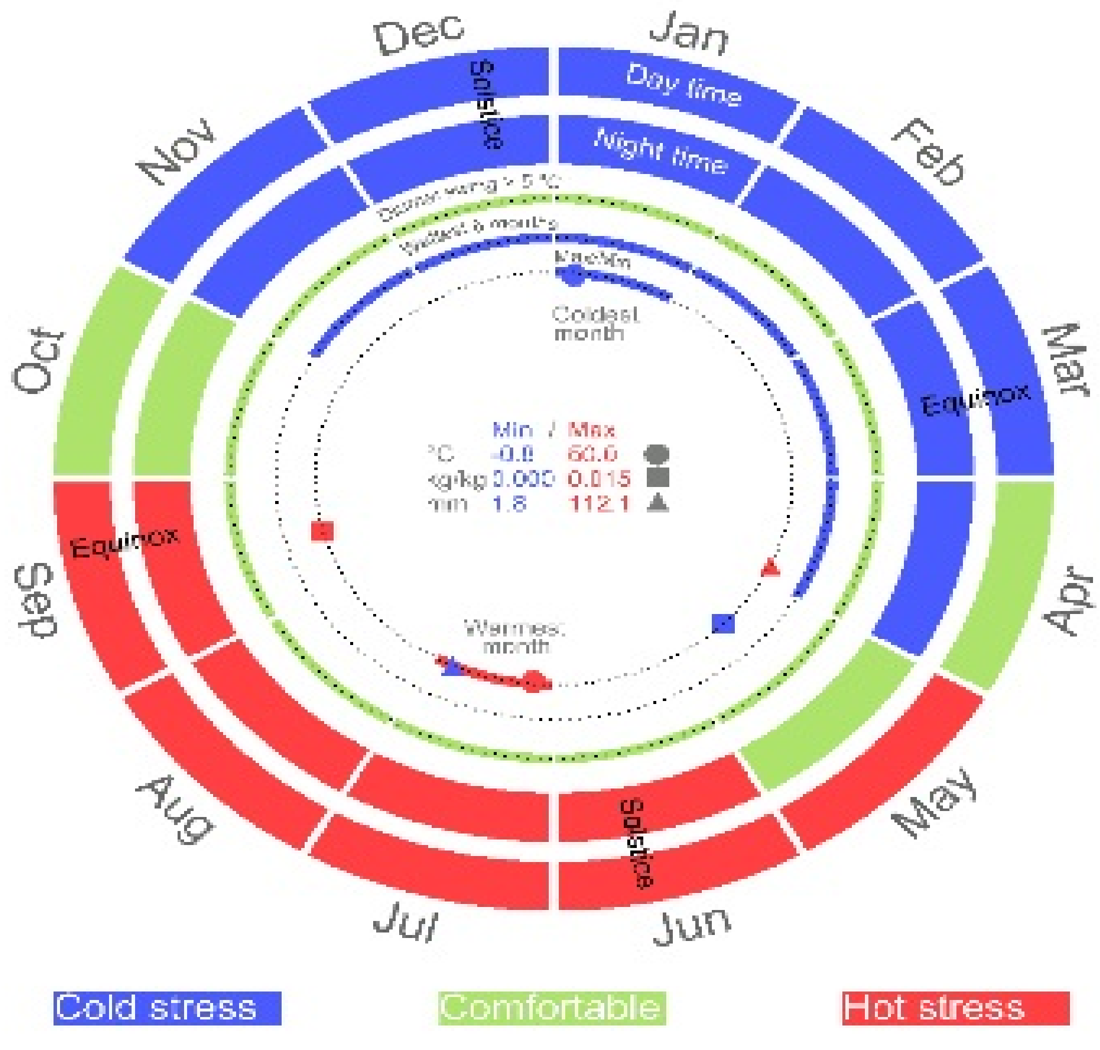
Appendix T continued

Weather variables for Mosul's current weather



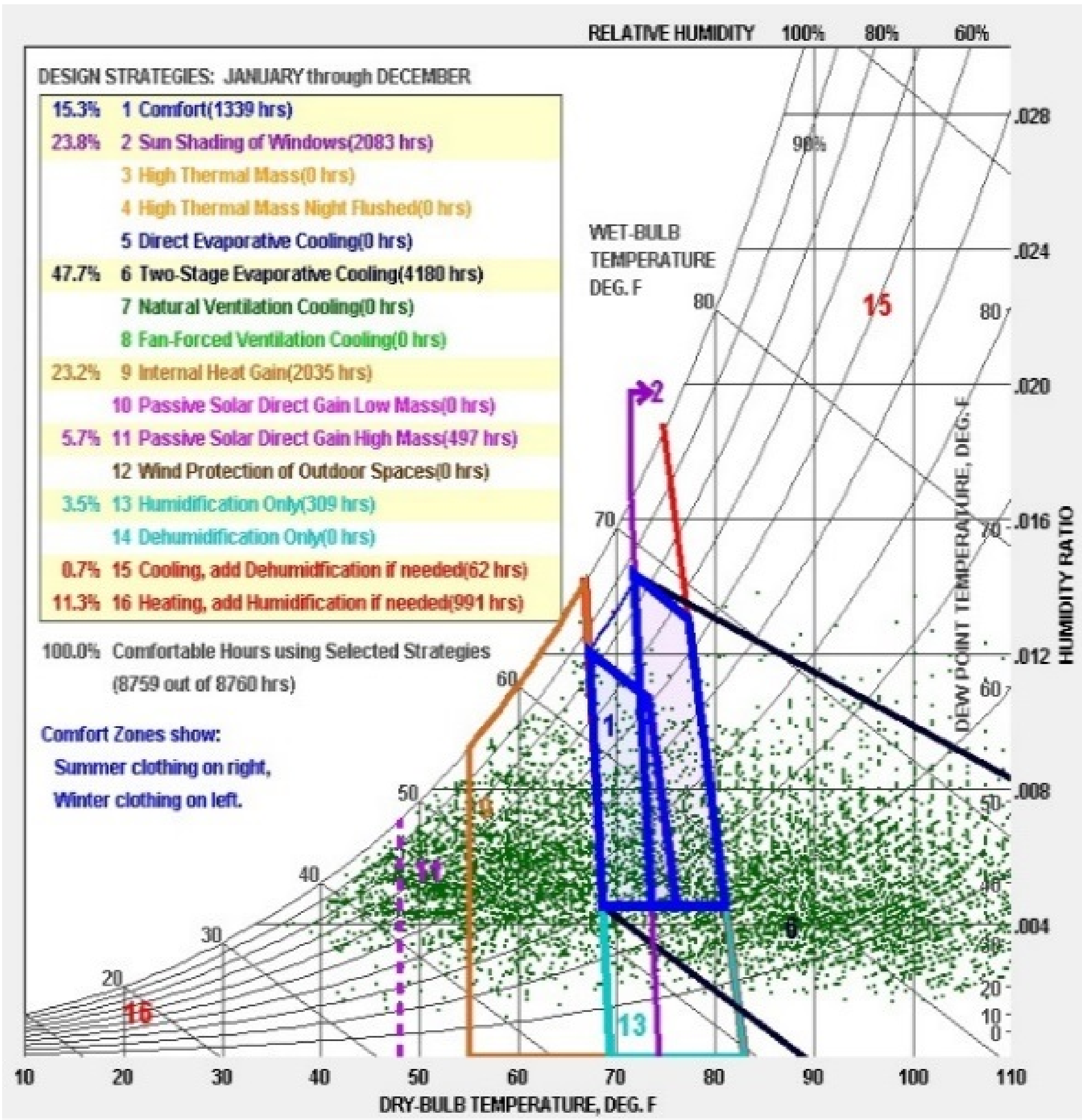
Appendix T continued

Weather variables for Mosul’s 2080 scenario



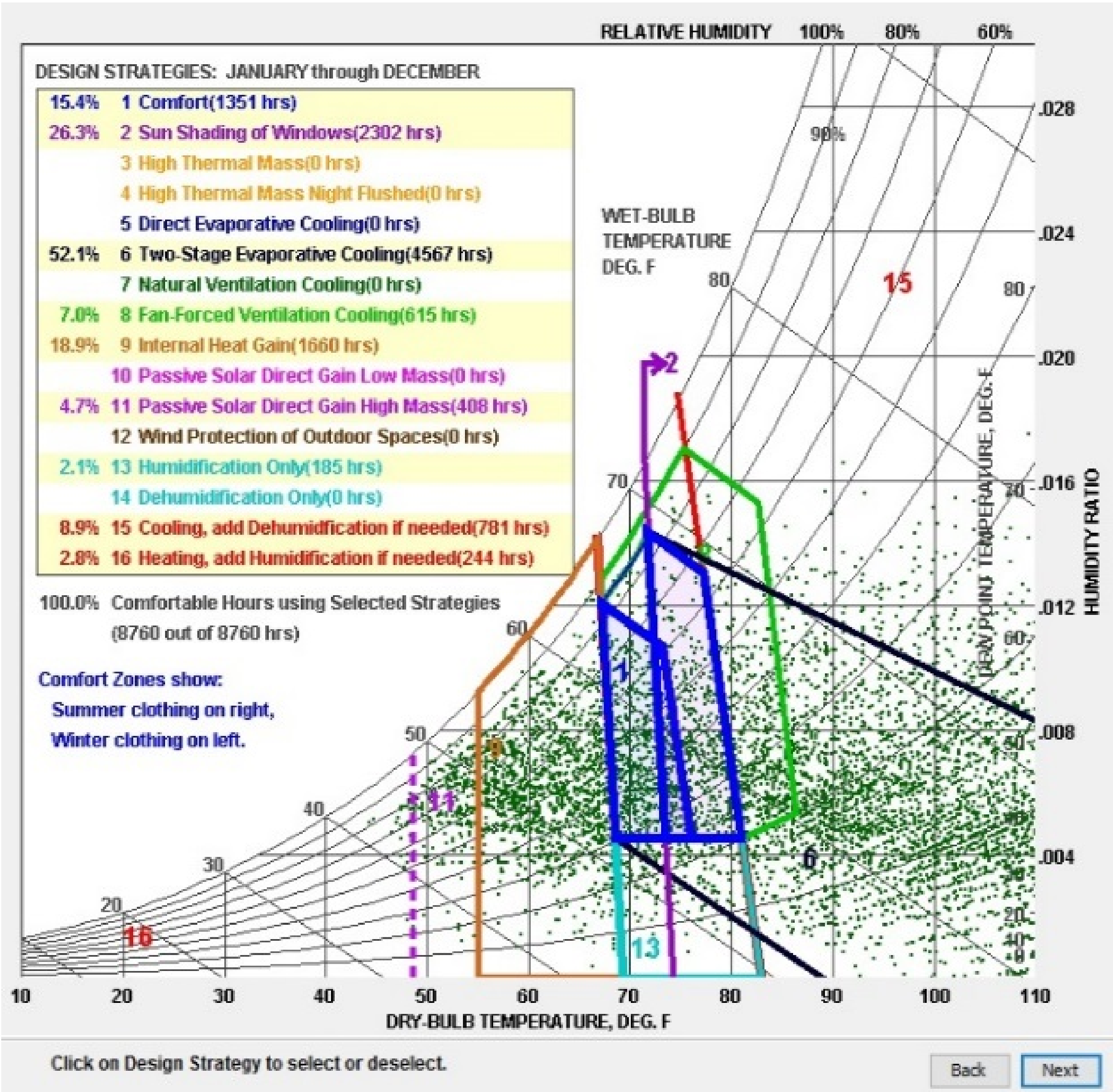
Appendix T continued

Psychometric chart for Baghdad's current weather



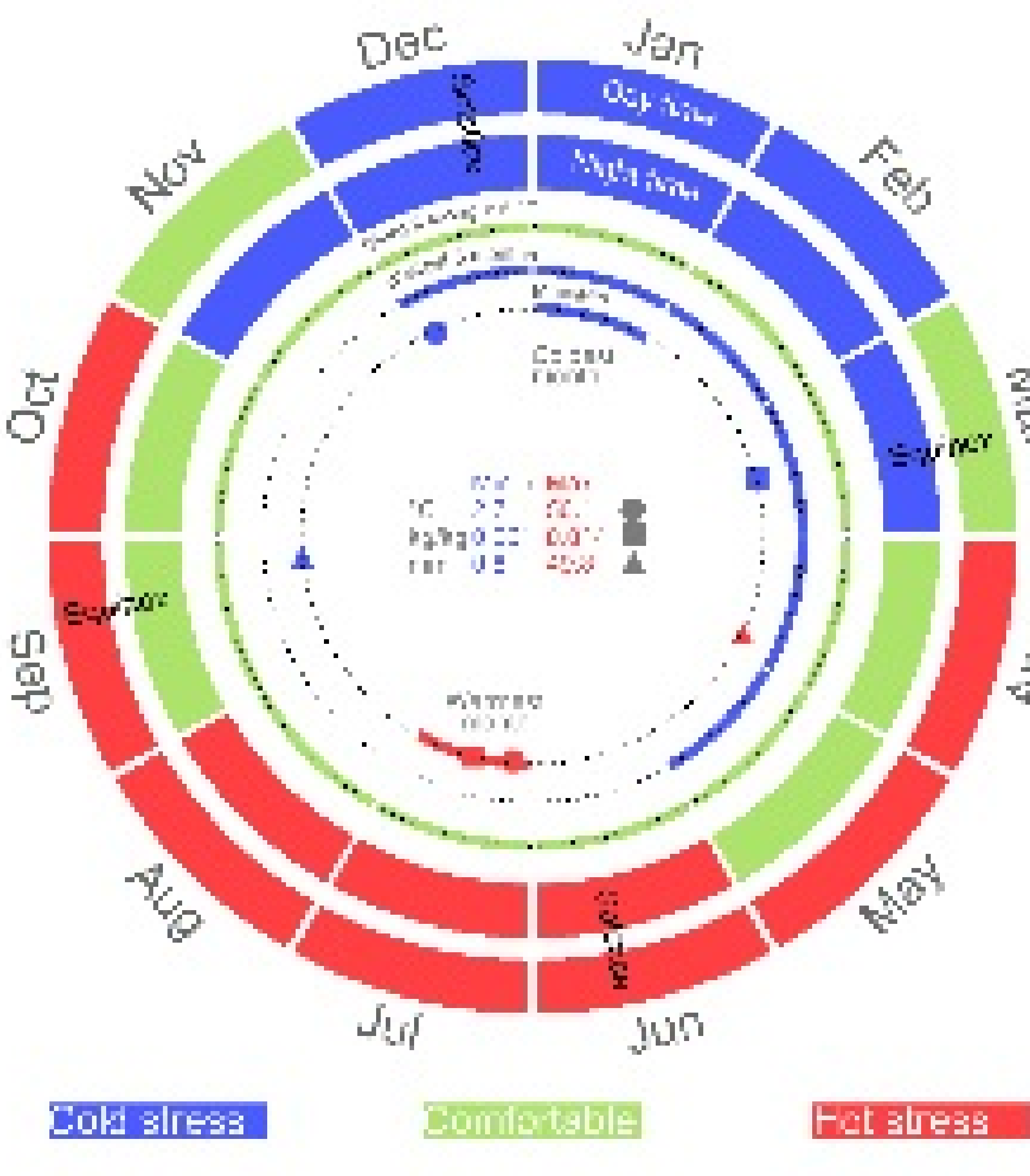
Appendix T continued

Psychometric chart for Baghdad's 2080 scenario



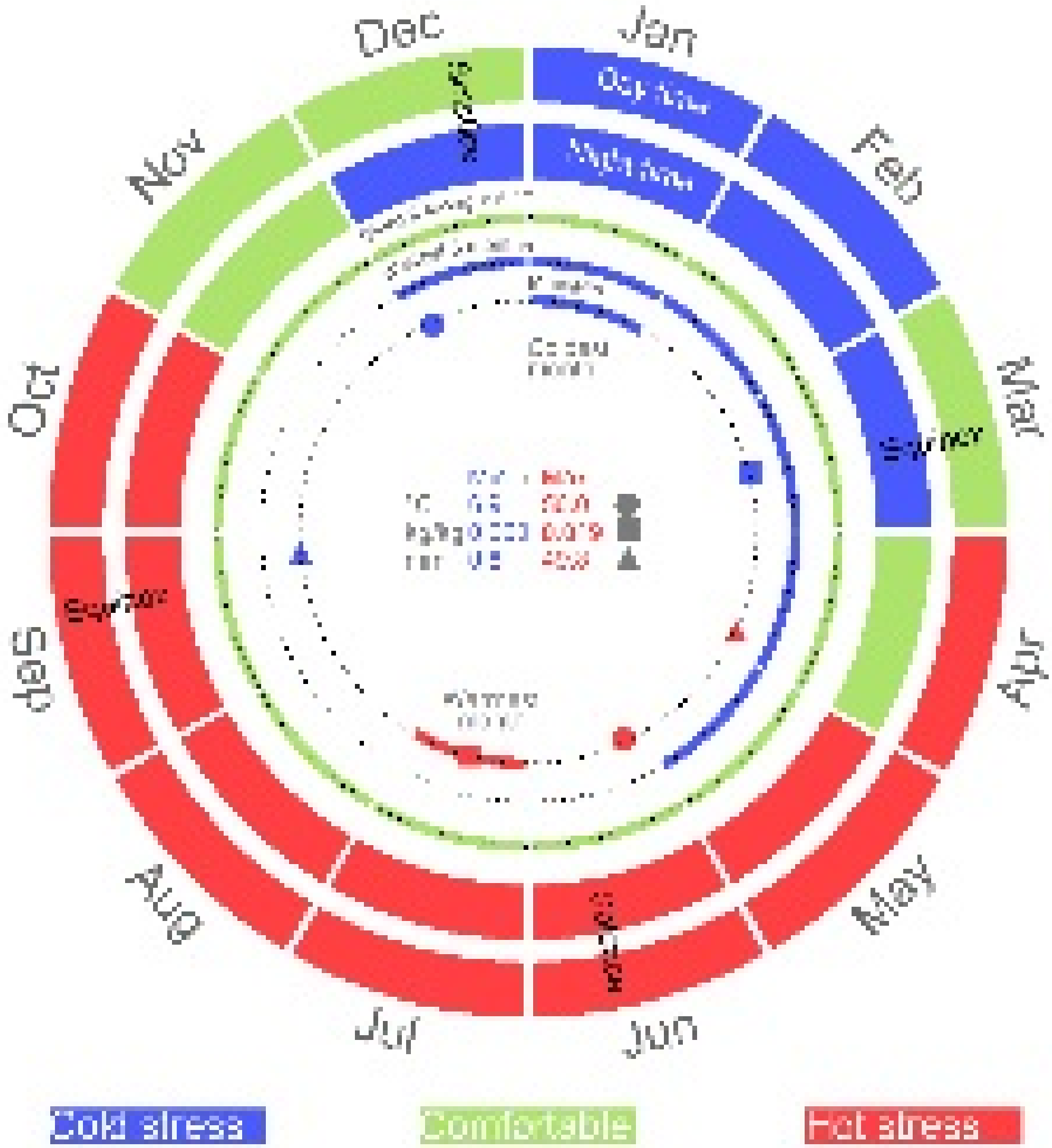
Appendix T continued

Weather variables for Baghdad's current weather



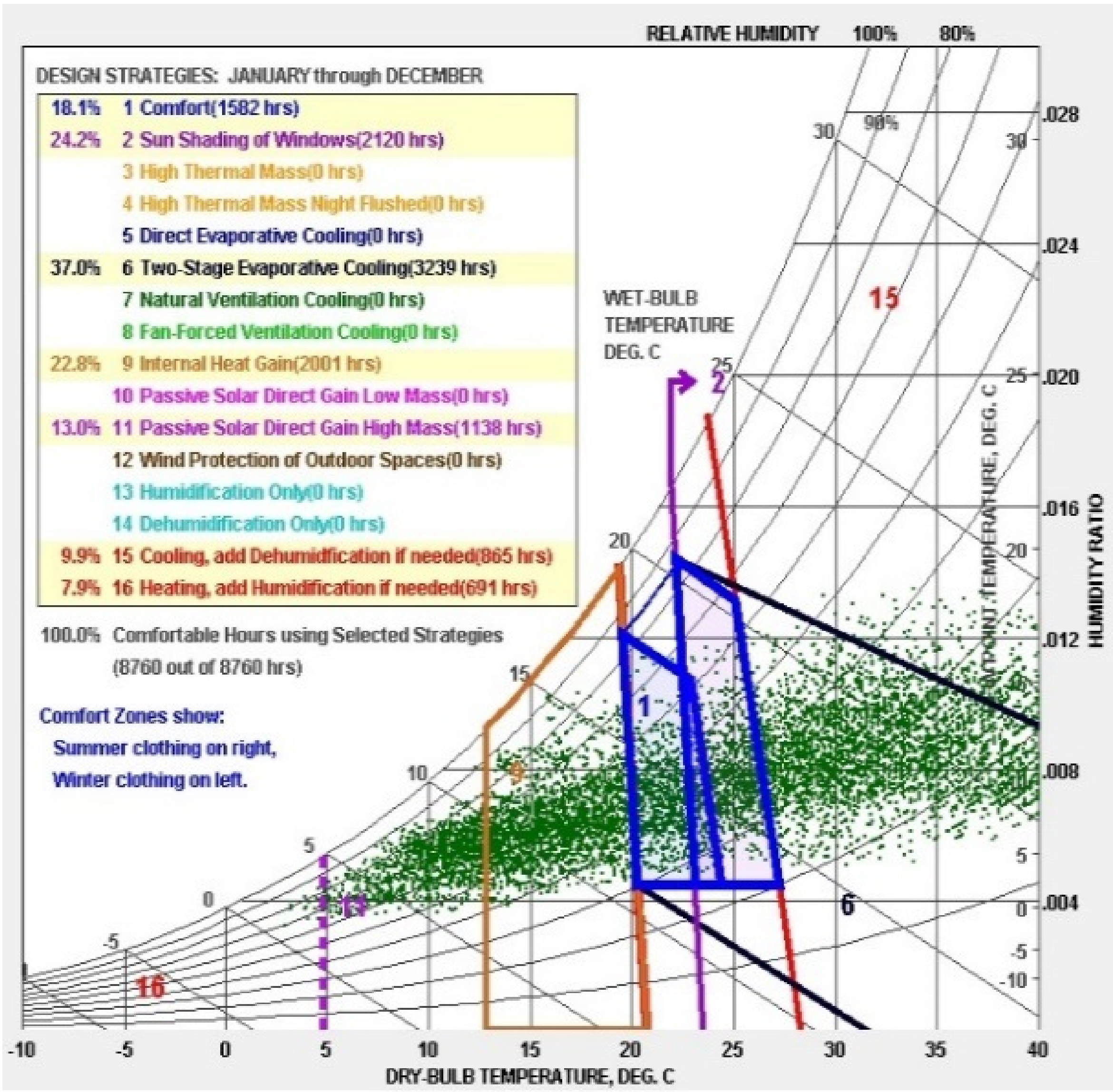
Appendix T continued

Weather variables for Baghdad's 2080



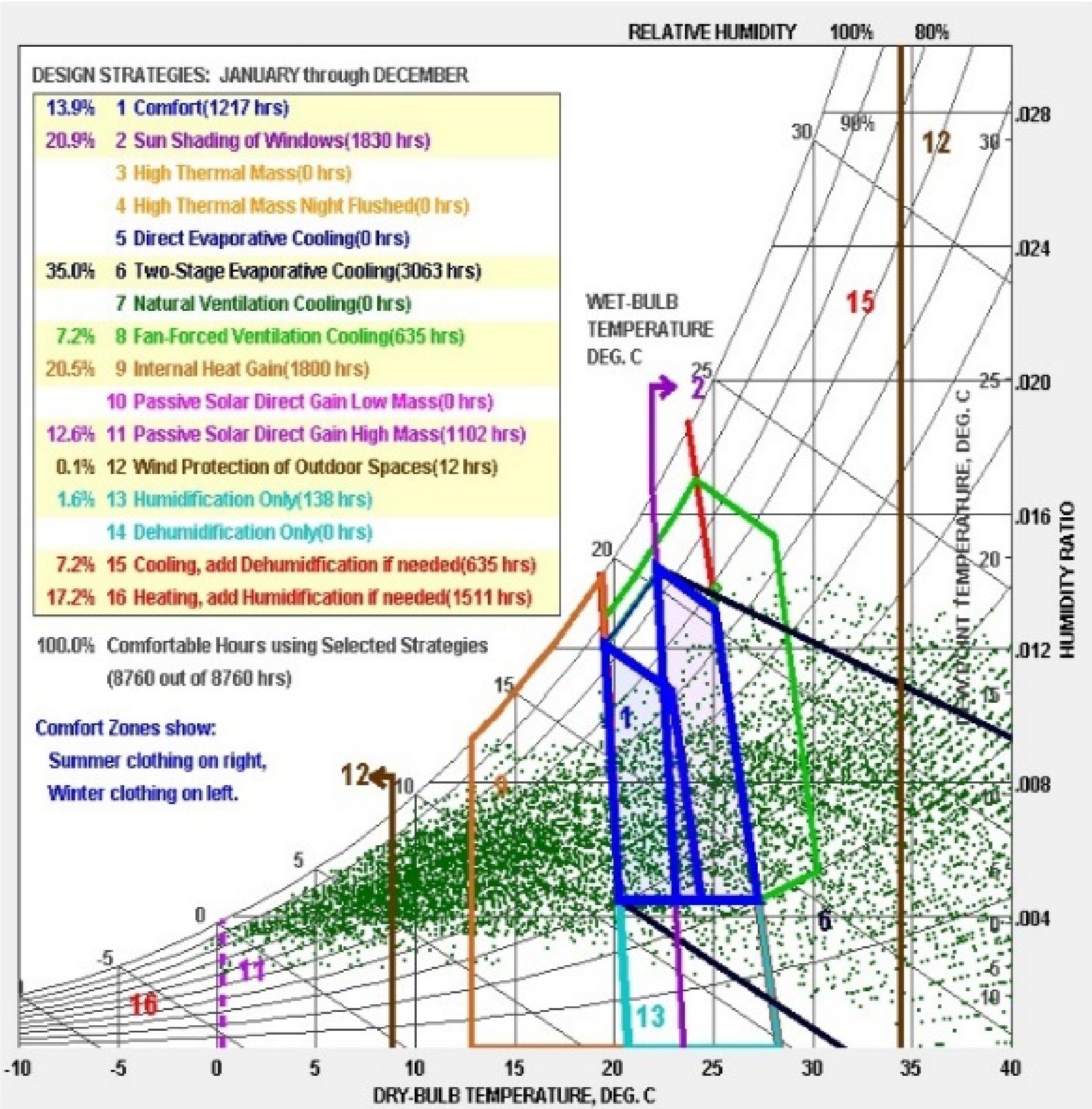
Appendix T continued

Psychometric chart for Basra's current weather



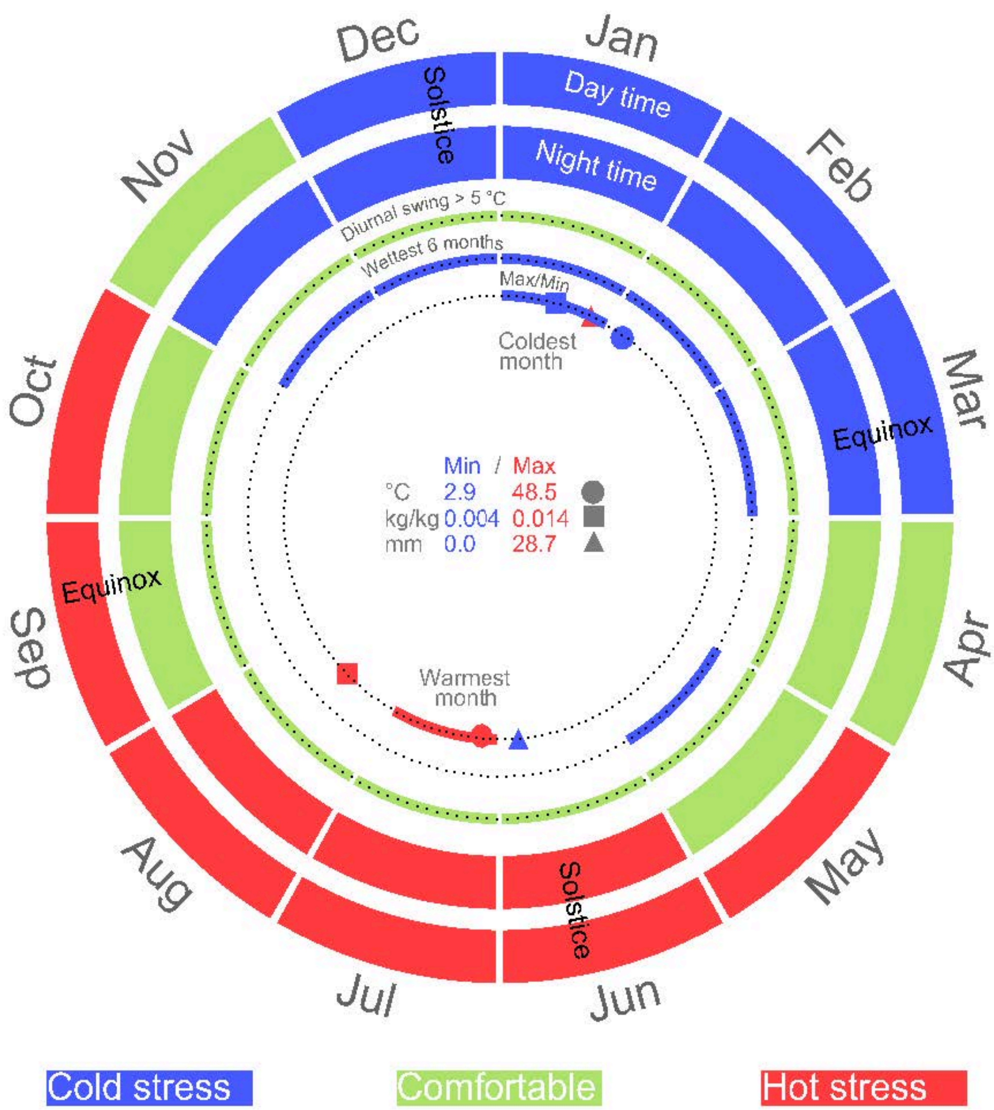
Appendix T continued

Psychometric chart for Basra's 2080 scenario



Appendix T continued

Weather variables for Basra’s current weather



Appendix T continued

Weather variables for Basra’s 2080 scenario