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The evolution of a framework for Building Environmental Assessment (BEA) for green buildings in Saudi Arabia

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ABSTRACT

Sustainable development has become a significant worldwide concern, and Building Environment Assessment (BEA) for green building play an important role to achieve sustainability in buildings. In some countries, rating tools are been used, such as LEED in the US, BREEAM in the UK, and Green Star in Australia. However, Saudi Arabia is yet to develop these tools. A first step recently is the development of the new established council (the Saudi Green Building Council) in Saudi Arabia has the full responsibility to develop such tools.

This research investigates the environmental issues that could underpin such a tool and it discusses the evolution framework for developing a national rating tool for green buildings. The research has investigated the Saudi opinions in developing the new framework, and clarified the most important building applications, environmental scope of studies, and the most important key performance areas (KPA's) in assessing the buildings in Saudi Arabia.

This research concludes that Saudi Arabia has a different priority in considering sustainability in buildings due to the differences in the country environment, location, economy, and community culture. Daily energy saving and water resources were equally the highest priority then any other key performance indicators (KPA's). A more interesting result was preserving the social and cultural character was far more important than carbon dioxide emission reduction. In addition the research has provided an evolution framework including, weighting system for the KPA's. Finally, this research includes recommendations for the development of a new BEA for Saudi Arabia.

INTRODUCTION

According to Hyde (2007), BEA's are rapidly springing up around the world and the challenge is to pick the right one for a particular application in a given country. In the last decade the world has seen a lot of new green building BEA's, which each system has its differences. These systems differ in terms of specialization. Some are intended for the design phase and others for the operation phase while some are intended for both. They also can be developed for a specific region or climate.

According to Hyde (2007) BEA's around the world has a similar framework structure. First finding the environmental criteria, which are usually derived from the negative impacts on the environment. Second developing a scoring system for assessing whether the environmental performance is improved. Third, developing a weightings system for each key performance areas. Which ends up with the rating score.

Since the Government of Saudi Arabia has indicated its intention to achieve a sustainable future, the government has established The Saudi Green Building Council (SGBC) in 2010 (SGBC, 2010). The Saudi Green Building Council is responsible for developing a national standard similar to those in the United States (LEED) and the UK (BREEAM). To achieve that, the SGBC should follow many steps to get to a reasonable BEA for Saudi Arabia. As a main part of developing a BEA, the SGBC has to determine the main KPA in the new BEA. Which lead us to the research questions: What are the KPA's for the Saudi Arabian BEA? and What are the weights for each KPA?

The main objective of this research is providing an evolution framework for developing a national BEA for green buildings in Saudi Arabia. The research will involve steps to achieve this objective reviewing a wide range of relevant literature to understand the issue of sustainable assessment in the building industry which are conducting a questionnaire survey targeting different types of built environment professions, such as Architects, Engineers, Interior Designers, Urban Designers and City Developers; conducting interviews with a number of selected parties to provide a better insight into the issue; and developing a framework for environmental assessment standard for Saudi Arabia.

BACKGROUND

Sustainable design, green architecture, sustainable construction and green building concepts are techniques and methods of design and construction aimed to meet environmental and economic challenges to reduce environmental impact and at the same time lead to lower costs (Al-Swat, 2004). According to Al-Swat (2004)

about 40% of all raw materials are consumed by the global construction industry, estimated to be about 3 billion tons per year. In the United States alone, buildings account for 65% of total consumption and total energy of all types caused 30% of greenhouse emissions (USGBC, 2010). As Rebecca Flora said, the efforts of sustainable green architecture to make buildings more energy efficient will have a significant impact on energy policies in the United States (USGBC, 2010). According to architect James Wines in his book Green Architecture (Mendler & Odell, 2000), buildings consume one-sixth of freshwater supplies in the world, a quarter of the wood, and half of all fuel and manufactured goods. At the same time, they produce half of all harmful greenhouse gases, and this will double within a very short period of 20–40 years' time.

The integration of green design techniques and smart technologies in buildings not only works to reduce environmental impact and the usage of energy, but it also reduces the costs of construction and maintenance, creates a pleasant working environment and improves users' health.

Also as one of the benefits of sustainability in the construction industry is to reduce energy costs over the long term. According to a survey carried out on 99 green buildings in the United States, 30% less energy was used compared with similar traditional buildings. Therefore, any additional costs incurred in their design and construction can be recovered through these energy savings. According to the U.S. Green Building Council, the increase of only 2% in the initial construction cost necessary to meet the requirements of LEED Gold classification will be returned through low running costs in just two years (USGBC, 2010).

It is clear that multiple benefits can be achieved if sustainable buildings are adopted in Saudi Arabia by linking the industry with some of the most current economic problems in the country, which are as follows:

The housing crisis: Many citizens in Saudi Arabia encounter economic difficulties when they start to build their own homes, including high land prices and the rising prices of construction materials and labour (Al-Swat, 2004). Therefore, applying sustainability in the building industry will lead to technical and effective use of land, in addition to the use of space and building surfaces, and will reduce construction-material waste. **Electricity consumption:** The rate of power used in residential buildings in Saudi Arabia is about 70% of total production, which is a very high rate compared to some developed countries. Cooling systems alone use about 70% of the total electrical energy consumed by residential buildings in Saudi Arabia (Al-Swat, 2004). Therefore, applying the concept of sustainable architecture practices will lead to reductions in power use in residential buildings and thus will achieve significant economic savings for the Saudi community. **Shortage of water resources:** Because of the nature of the desert in Saudi Arabia, it is difficult to obtain natural water resources. The building and construction sector is one of the major users of water resources and, at the same time, is a major producer of water waste (Al-Swat, 2004). Therefore, sustainability will lead to a reduction in water losses. **Dependence on oil as the only source of energy:** There are numerous fears about dependence on oil as a source of energy and value to the economy; therefore applying sustainability to reduce the use of conventional electricity in the building sector will reduce the dependence on such non-renewable resources as a power source for buildings, with a gradual move to a greater reliance on alternative energy sources and renewable energy such as solar and wind (Al-Swat, 2004).

According to Al-Swat (2004), there are many ways to encourage architects and engineers in Saudi Arabia to apply the concept of sustainable architecture:

1. Develop a national standard similar to the standard (LEED) in the United States and the standard (BREEAM) in the UK in which it is clear exactly what systems and applications are necessary for sustainable green architecture. This should also provide benchmarks for best practices and integrated design from the standpoint of sustainability, as well as market and promote this approach and reward environmental achievements in this area and enhance the status of public awareness of green building features. Architects and engineers should also be retrained in this area.

2. Establish a professional development system of a delegation of national green building practices similar to the LEED certificate of the U.S. to accredit the professional, and develop incentives to encourage professional Saudi architects and engineers in this area.

3. Set up a professional unit for support and assistance in the Saudi Council of Engineers and a unit under the name "green architecture and sustainable buildings", so as to be a forum for architects, engineers and those interested in this area and provide them with the technical support and information required.

RESEARCH ISSUES

Since the Saudi Government has indicated its intention to achieve a sustainable future, the government has established The Saudi Green Building Council in 2010. The Saudi Green Building Council is responsible for developing a national standard similar to those in the United States (LEED) and the UK (BREEAM).

As Saudi Arabia is different than most other countries in the world (Climatically, Culturally, Environmentally, Economically, etc), It is issued that the KPA’s and its weights for Saudi Arabia BEA will be different.

However, there are fundamental questions that should be answered: What are the KPA's for the Saudi Arabian BEA? and What are the weights for each KPA?

SUSTANABLE DEVELOPMENT AND RATING SYSTEMS

This raises questions about the models and methods designers might use as a basis for designing green buildings. Research work reported by David Yencken and Debra Wilkinson provides a more coherent model of the environmental impacts of humans on the planets. This called the pressure-state-response model (Hyde,2007).

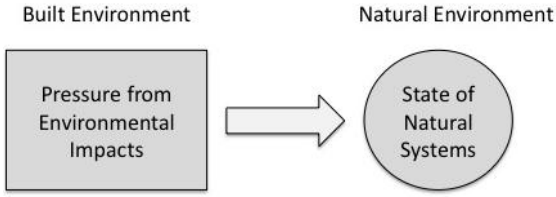

Figure 1: Pressure-State-Response model

The concept of sustainability is seen as the key responding to the pressure of humans is placing on the planet ecosystem.

According to Mawhinney (2002), sustainable development has a debate on its goal, process and/or outcomes. The fundamental aspects of sustainable development are environmental protection; economic growth; and social equity. However, depending on the end goal the indicators may differ. The main difficulty in establishing end-goals that span across social, economic and environmental issues lies in defining a common currency for the study. The use of indicators suggests that this can be avoided by having a sufficiently rounded set of indicators to fully cover the subject (Mawhinney, 2002). According to Hyde (2007), rating systems follows three steps to determine the rating scour. First finding the environmental criteria. Second determine the scoring system. Third weighting the criteria, which ends with finally reduces score to a single number the rating.

RESEARCH METHODS

The main objective of this research is to provide an evolution framework for developing a national environmental assessment standard for green buildings in Saudi Arabia. The research will involve the following steps to achieve this objective 1. Conducting a questionnaire survey targeting different types of built environment professionals, such as Architects, Engineers, Interior Designers, Urban Designers and City Developers; 2.Conducting interviews with a number of selected parties to provide a better insight into the issue; 3.Determining the end-goal for the BEA; 4.Determining the criteria and the KPA for the BEA; 5.Developing a weighting method for KPA; 6.Testing a hypothesis building to determine the rating result.

Table 1: Research methods

Research Questions	Methods	Results
What are the KPA's for the Saudi Arabian BEA?	Conducting a questionnaire survey targeting different types of built environment professions	Finding the KPA's for Saudi Arabia
What are the weights for each KPA?		Ranking the KPA's from most to lease important then weighting by their level of importance

Research was undertaken to provide an evolution framework for environmental assessment standard for Saudi Arabia. In order to achieve the aim of this study in identifying the need and appropriate guidelines, the research method included three main components in the following Sections namely, comparing and discussing the existing BEA, investigating the current status of green building in Saudi Arabia and conducting a survey research. This research begins with an overview of the project brief then investigates the current literature review in the topic of sustainable development. The literature involves three sections, sustainable buildings, sustainable buildings in Saudi Arabia and the concept of the environmental assessment standards. There are three methods concerned in the research design, the discussion of the current BEA, investigating the current status in Saudi Arabia, and conducting questionnaire survey.

At the time the development of this research, was begun there was lack of understanding the concept of the environmental assessment standards for green building in Saudi Arabia. The research was undertaken to provide an evolution framework for environmental assessment standard for Saudi Arabia. In order to achieve the aim of this study in identifying the need and appropriate guidelines, the research method included three main components namely: Comparative study of the existing BEA; Investigating the current status of green building in Saudi Arabia; and Conducting a survey research.

In this research, one of the study approaches is conducting interviews with a numbers of architects and engineers. This step provided the research a better insight into the issue.

The concepts in the interview were about: Critical information on the current status of green building in Saudi Arabia; Investigating what drives Saudi Arabia to adopt green buildings as part of its national strategies; The role of the Saudi Green Building Council, and how will it affect the Saudi market; The education in the building environment schools toward sustainability; The future of the building industry and sustainability in Saudi Arabia; And Acceptance of developing a Saudi BEA.

The survey has three parts: **Part 1:** Demographic Information includes; Years of experience; Types of profession; Types of projects; Level of education. **Part 2:** Experience in the Existed Environmental Assessment Standards, on the assessments method which been used. Some of the questions have been adopted from a previous research by Tam (2007) titled: "The Effectiveness of the Green Building Evaluation and Labeling System". **Part 3:** Opinions on the development of the new BEA for Saudi Arabia, includes, Questions on types of buildings needs to be assessed; Questions the level of importance of, Buildings applications, Environmental study scopes, and Assessments indicators.

TARGET SAMPLING

Sampling involves selecting members (e.g., individuals, pairs, groups, organizations) from a population so that they are representative of that population. If the sample is representative, the results of the study can be generalized to the population from which it was drawn. There are two broad types of sampling approaches, probability and non-probability sampling. In probability sampling approaches, each member of the population has a known, non-zero chance of being selected. Unlike probability sampling approaches, in non-probability sampling, the researcher does not know the probability of any particular member of a population being selected in the sample. Therefore, in the non-probability sampling, there is a greater chance of researcher selecting some members from the population for inclusion in the study than others (Tharenou & Donohue, 2007).

In this research, judgement (purposive) sampling of non-probability sampling techniques was used. The judgement sampling was used because the researcher selected the sample on the basis of his judgement concerning a characteristic required of subjects that were included in the study and his knowledge about the target population. The target sample were the building sector architects, engineers (civil, mechanical, electrical...etc.,), urban planners, facility managers and decision makers in Saudi Arabia to represent the public sector and other actors in the building sector of Saudi Arabia such as consultants, contractors and developers to represent the private sector.

SURVEY PROFILE DATA OF BUILDING DESIGN PROFESSIONAL'S

A questionnaire survey was conducted in Saudi Arabia in April 2010. The questionnaire included a cover letter explaining the purposes and benefits of the survey. Questionnaires were distributed to 105 individuals, mostly architects, engineers and other parties involved in building design. Of the questionnaires distributed, 43 were returned. One was excluded from the analysis due to significant incompletion; thus, 42 valid questionnaires remained, achieving an effective response rate of 40%, which is considered satisfactory for research conducted in this field.

The respondents were carefully collected to avoid bias results. However, most respondent were architects, which may affect the results toward an architectural opinion. Most of the respondents were architects 43%, engineers 21%, urban designers 21%, facility managers 10% and interior designers 5%. Fifty percent of respondents had more than 10 years of work experience, 29% 11-20 years, 12% 21 -30 years and 9% over 31 years; 33% had 4-10 years' experience and 17% less than 4 years. Classification of respondents' educational level showed that the half of the respondents had a Masters degree, 21% a Doctorate degree and 29% a Bachelor's degree, meaning that 71% of respondents have a high level of education, strengthening the research results. Most respondents had worked on several types of projects, mostly in government buildings (29%), commercial buildings 21%, housing 21%, education buildings 14%, urbanism and planning 7% and medical buildings 4%; some respondents added the oil and gas industry. The information given by the respondents provided useful and reliable, since most respondents were highly experienced with various building types and had high levels of education.

EXPERIENCE AND OPINIONS ON THE KPA'S AND WEIGHTS OF A NEW BEA

According to the research results, most respondents (86%) have never considered BEA in their projects, while 14% had. This gap reflects the lack of awareness and understanding of the environmental impact caused by the building industry. According to the head of the SGBC, sustainability in Saudi Arabian education has not been taken into account. However, a small number of respondents have considered BEA based on their education overseas. In the other hand, only 7% of respondents' did not agree that a new BEA for green buildings in Saudi Arabia should be developed, on the grounds that adopting a current BEA would be enough.

Government buildings, education buildings and housing were in the highest demand from the respondents to apply green building assessment standards. Commercial buildings, urbanism and city planning, and medical

buildings were in medium demand. Some respondents also included airports and the oil and gas industry as important projects for application of BEA tools.

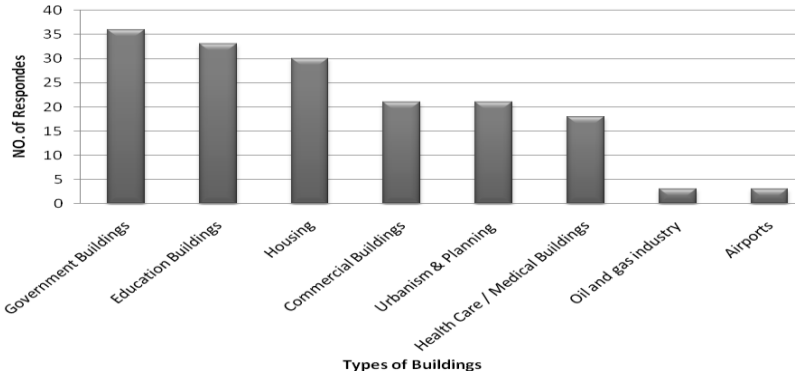

Figure 2: Important Types of Buildings That Should be Using BEA

In the third part of the questionnaire, the respondents were asked about which area should be considered in BEA and how important they are. These applications were environmental management, product marketing, buildings performance targeting, design guidelines, and performance-based codes. According to the results of this question, environmental management and design guidelines were the highest, with more than 90% importance. However, product marketing and buildings performance targeting were less, with 83.3%, and performance-based codes were in between, with 88% importance. In conclusion, all these applications took a high level of importance, over 80 out of 100.

A similar question was conducted on the environmental scope of studies, which included air pollution, noise pollution, water pollution, light pollution, waste management, ecological impacts, energy consumption and resource consumption. The respondents were asked which of these should be included in the new Saudi BEA and how important they were. As a result, air pollution and energy consumption were given the highest importance on the environmental scope of studies. Light pollution was the least important, around 35%, even though more than 78% of respondents think that light pollution is of great importance.

Most of the current BEA for green building use scoring system indicators. The questionnaire asked what KPA's should be included in the BEA for Saudi Arabia and how important each one was. The KPA's were Biodiversity, Greenery, Soil Water Content, Daily Energy Saving, Carbon Dioxide Emission Reduction, Waste Reduction, Indoor Environment, Water Resource, Sewage and Garbage Improvement, Management, Precaution against earthquake, Aesthetic, Economic, Innovative Design, Preserving Social and Cultural Character, and Traffic and Transport.

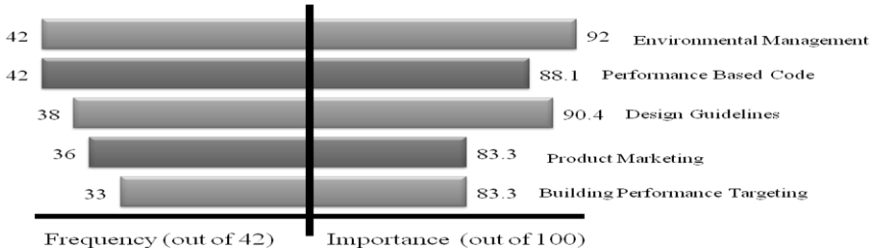

Figure 3: Important Building Applications When Considering BEA

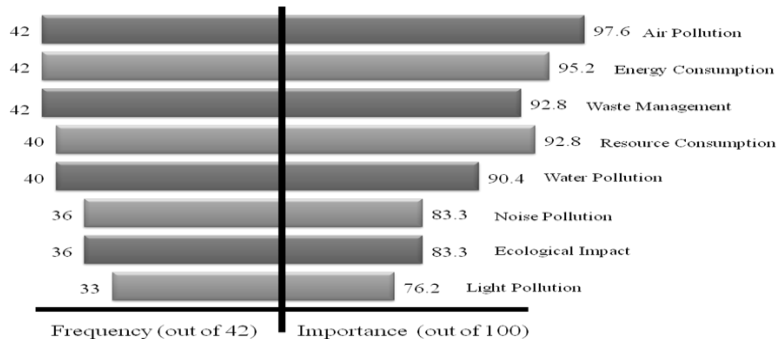

Figure 4: Important Environmental Scope of Studies When Considering BEA

Table 2 shows the results for the KPA's. Daily Energy Saving, Water Resource, Sewage and Garbage Improvement, Traffic and Transport, and Indoor Environment are the most important KPA's in assessing a green building in Saudi Arabia; Precaution Against Earthquake was the least important, because of the low expectation

of earthquakes in Saudi Arabia. An interesting result was that Preserving the Social and Cultural Character was higher in the Saudi opinions compared to other countries such as the European countries, and also the Carbon Dioxide Emission Reduction is very high in the European countries but much lower in the Saudis opinion.

Table 2: KPA for Assessing Green Buildings

KPA	Tick if it should be included	Level of Importance					Average (out of 5)	%
		Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)		
Biodiversity	18	0	0	11	15	15	4	80
Greenery	30	0	0	3	18	21	4.35	87.1
Soil Water Content	21	0	0	9	18	15	4.14	82.8
Daily Energy Saving	39	0	0	0	9	33	4.78	95.7
Carbon Dioxide Emission Reduction	21	0	0	12	13	15	3.88	77.6
Waste Reduction	30	0	0	3	18	21	4.42	88.5
Indoor Environment	30	0	0	3	15	24	4.5	90
Water Resource	33	0	0	0	9	33	4.78	95.7
Sewage and Garbage Improvement	30	0	0	3	12	27	4.57	91.4
Management	18	0	0	6	18	12	3.57	71.4
Precaution Against Earthquake	12	3	3	18	9	9	3.43	68.6
Aesthetic	19	0	0	12	15	15	4.07	81.4
Economic	21	0	3	6	18	15	4.07	81.4
Innovative Design	27	0	0	9	6	27	4.42	88.5
Preserving the Social and Cultural Character	21	0	0	6	21	15	4.21	84.2
Traffic and Transport	33	0	0	6	6	30	4.57	91.4

With these results, developers of the new BEA in Saudi Arabia can get a clear understanding of the importance of each indicator in developing a clear scale similar to those used by the current BEA around the world.
As a positive ending to the questionnaire, respondents were asked if they would consider using the national BEA for green building in their projects after it was developed. Some 93% answered “yes,” while 7% were not sure. None responded negatively.

THE EVOLUTION FRAMEWORK AND MODEL OF SUSTAINABILTY

The aim of this research is to evolve a framework for developing a BEA for green buildings in Saudi Arabia. This section provides the detailed framework as the outcome of this research, in terms of: Pressure-State-Response model; the proposed KPA’s and rating system; and the BEA targets and potential technologies and strategies.

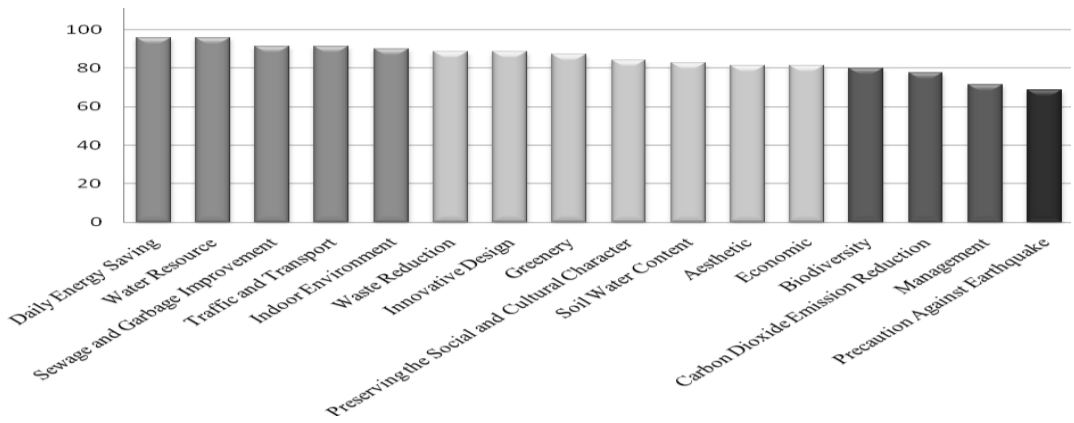

Figure 5: The survey results of the important KPA when assessing BEA

PROPOSED KPA’S AND RATING SYSTEM

From the results of this study, the most important way to assess green buildings is to know the importance of each indicator. According to the survey results, 16 KPA’s are included in the framework. The rating system will

involve assigning a level of importance to each of the identified indicators. Based on the level of importance of each indicator, normalised weight can be calculated; this can in turn be used to calculate the rating score.

To determine the level of importance for each indicator; respondents who participate in the assessment would be asked to provide their rating based on the following Likert scale: 1 (Very Low); 2 (Low); 3 (Moderate); 4 (High); and 5 (Very High).

Average ranking based on all respondents would then be calculated; the rating will then be adjusted to a percentage point, hence representing the level of importance for that particular indicator. This level of importance would then be normalised by dividing the level of importance for the indicator by the total level of importance of all the indicators. Multiplying this normalised weight by the raw score given for the actual condition of the KPA being assessed will yield adjusted score for the indicator. The summation of adjusted scores from all the 16 KPA's will provide the final assessment results for that particular building.

Table 3 provides an assessment data for a hypothetical project. For example, if the average importance rating from the respondents on "Biodiversity" is 4 out of 5, the level of importance for this indicator will be 80%. Then, the normalised weight can be calculated as follow:

Biodiversity normalised weight = 80 ÷ 1356 = 0.059

Therefore, if the assessment result for biodiversity of this building is 65 out 100, the adjusted score for this indicator will be: 65 * 0.059 = 3.835. After calculating all the adjusted scores for each KPA, the total adjusted scores (out of 100) can be calculated. In this case, the total adjusted score is 60.89, which is equivalent to a "Gold" level in LEED.

Table 3: Propose rating system for the new BEA in Saudi Arabia

	KPA's	Level of Importance of 100	Normalized Weight	Hypothetical Example.	
				Rating Out of 100*	Score
1	Daily Energy Saving	95.7	0.07	70	4.9
2	Water Resource	95.7	0.07	85	5.95
3	Sewage and Garbage Improvement	91.4	0.068	55	3.74
4	Traffic and Transport	91.4	0.068	65	4.42
5	Indoor Environment	90	0.067	87	5.829
6	Waste Reduction	88.5	0.065	80	5.2
7	Innovative Design	88.5	0.065	36	2.34
8	Greenery	87.1	0.064	44	2.82
9	Preserving the Social and Cultural Character	84.2	0.062	70	4.34
10	Soil Water Content	82.8	0.061	65	3.965
11	Aesthetic	81.4	0.06	50	3
12	Economic	81.4	0.06	70	4.2
13	Biodiversity	80	0.059	65	3.835
14	Carbon Dioxide Emission Reduction	77.6	0.058	30	1.74
15	Management	71.4	0.053	63	3.34
16	Precaution Against Earthquake	68.6	0.05	25	1.24
	Total		1		60.89 = (GOLD)

* The ratings of the hypothetical example are hypothetical

Table 3 shows the weight for the KPA's and demonstrates a hypothetical example. Each KPA is rated out of 100, and then multiplied by its normalised weight to get the final KPA score. The overall score is out of 100, as in most existing BEA. In the hypothetical example, the overall score is 60.8. In LEED scoring systems for example, this hypothetical building would be reported as Gold.

CONCLUSION

This research has investigated the need of BEA in Saudi Arabia, and it provides the framework for developing a national BEA for green buildings in Saudi Arabia. This research reviewed the current status of the sustainable development in Saudi Arabia. In addition, it provides an extensive comparison and discussion of some of the existing standards. The research has investigated the Saudi opinions in developing the new BEA, and clarified

the most important building applications, environmental scope of studies, and the most important KPA's in assessing the building toward green living.

This research concludes that Saudi Arabia has a different priority in considering sustainability in buildings due to the differences in the country environment, location, economy, and community culture. In addition the research has provided a proposal for developing BEA for Saudi Arabia. Finally, this research includes some recommendation for the development of the new BEA for Saudi Arabia.

The aim of this research was to evolve the BEA framework for developing a national environmental assessment standard for green buildings in Saudi Arabia. From the results of this research, the outcomes are: The concept of sustainable development is one of the main issues worldwide; every country has a large responsibility toward green living. There has been a great response from the Saudi government in considering sustainability part of its national strategy. Adopting an existing BEA from a different country will have some risks; every country has its own environment, economy, resources and culture. Developing a national BEA will benefit Saudi Arabia in three ways: environmental, economic, and cultural. There is great support from the government and private sectors for development of a national BEA. There is a lack of understanding of the aim of the BEA on the part of Saudi architects and engineers. A great deal of research has been carried out on green building design techniques, but they have not been developed in Saudi building standards. Only one building in Saudi Arabia is certified as a green building by LEED-USA. There are several resources to provide energy to buildings in Saudi Arabia besides oil.

STUDY LIMITATIONS AND FUTURE WORK

The aim of this research is to provide an evolution framework for Saudi Arabia only. The study covers the needs of a BEA to assess the Saudi building industry toward sustainable development. The study is also limited to the frame of the standard, and does not involve the rating method for each environmental indicator.

RECOMMENDATION FOR FUTURE RESEARCH

Since a new BEA has been considered lately in Saudi Arabia, below are some recommendations for future research:

- Defining each indicator for each KPA.
- Developing a rating method for each indicator.
- Testing the developed rating system to determine its performance and suitability for Saudi Arabia
- Developing a measurement system for each indicator
- Developing a specific standard for each type of building: new buildings, existing buildings, neighbourhoods, education buildings, residential buildings, and industrial and healthcare.
- Conducting similar studies for other countries.

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