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A STEP FORWARD ENHANCING GREEN BUILDINGS IN DEVELOPING COUNTRIES

NAHLA HAZEM[1] and IRENE SAMY FAHIM[2,3]

[1]*School of Management of Technology, Nile University, Giza, Egypt*
[2]*Dept of Industrial Engineering and Service Management, School of Management of Technology, School of Engineering, Nile University, Giza, Egypt*
[3]*Smart Engineering Systems Research Center, Nile University, Giza, Egypt*

Sustainability is essential for maintaining certain levels of life quality for next generations. Accordingly, Egypt started to establish its own rating system to achieve sustainable development. There are several green building rating systems that are recently used such as: the LEED (Leadership in energy and environmental Design) rating system, Green Pyramid Rating System "GPRS", and TARSHEED rating system. GPRS and LEED are almost the same since GPRS is based on LEED. Due to the significant cultural and environmental changes between Egypt and the United States, LEED rating system cannot be implemented in Egypt. On the other hand, the rating system TARSHEED includes three categories only, namely energy, water, and habitat, to determine sustainable construction performances. For example, waste management category which is one of Egypt's challenges is ignored by TARSHEED. This research introduces a new modified rating system for new construction with new weights to suit Egypt requirements. This work presents a comprehensive study and comparative analysis between the existing green building rating systems for new construction in Egypt. Moreover, some surveys and questionnaires are conducted to take the experts opinion in the green field. A new checklist for new construction is constructed using data obtained from Analytical Hierarchy Process (AHP) decision making tool. This list includes new categories and subcategories with new weights, which suit the environmental challenges in Egypt.

Keywords: GPRS, Sustainability, AHP, New construction, LEED.

1 INTRODUCTION

Green building concept has spread around the world. The rapid population growth in developing countries resulted in poor quality of life and urban resources, which have a negative impact on the economic growth. Construction industry is considered as the most harmful industry to the environment due to the consumed energy during the new buildings' construction (Gobbi *et al.* 2016). Developing countries started to adopt the green building concept through establishing their own green building rating system to maintain and preserve the environment (Andreas *et al.* 2010, Ibrahim 2017).

Green Building Rating Systems (GBRSs) are developed to evaluate the building's performance through pre-defined criteria, guidelines, weights, and scoring system (Gowri 2004). Based on the resulted evaluation, the building is certified and awarded according to the accumulated points.

In Egypt, several steps are initiated towards achieving sustainability through establishing green building rating systems (Ibrahim 2017). Green Pyramid Rating System (GPRS) for new construction was launched in 2011 by the Green building Council in Egypt (Aleem *et al.* 2015, Karmany 2016). The GPRS consists of seven main categories which are: (1) sustainable sites; (2) energy efficiency; (3) water efficiency; (4) materials and resources; (5) indoor environmental quality; (6) management protocols; and (7) innovation and value added (HBRC 2011, HBRC 2017). Each category consists of a list of defined criteria in which the building earns points when achieving them (Daoud *et al.* 2018). Another new rating system named TASHEED was developed by a non-governmental organisation called Egypt Green Building Council (EGGBC) with the goal of encouraging the design and construction of sustainable buildings in Egypt. A project should accomplish a minimum of 20% reduction in water, energy, and habitat (Karmany 2016). The focus of this rating system is to save energy, water and material resources, which will reflect positively on the economy (WGBC 2015).

The GPRS is based on the US LEED rating system for new construction, which is one of the main weaknesses in GPRS system. The LEED rating system is not feasible in Egypt since there are many environmental gaps between Egypt and US. Solid waste management, for example, falls within "materials and resources" category though it should be listed in a separate category as it is one of the crucial problems facing Egypt. This study therefore seeks to create a new rating system for new constructions tailored to suit the Egyptian resources and environment. The proposed rating system is an amendment to the GPRS. New categories and elements with calculated weights will be added to suit the environment in Egypt. A questionnaire will be answered by 15 experts in this field to evaluate the importance of each criterion to the others. A decision-making tool Analytic Hierarchy Process (AHP) is then used to weigh and rank the weights of the elements within the system.

2 LITERATURE REVIEW

Considerable efforts are made in Egypt to develop a national GBRS system (Abdelazim *et al.* 2017). Younan carried out a study to construct a new rating system that fulfils the Egyptian construction sector requirements (Younan 2011). Younan applied a comparative study between four various rating systems: LEED V3 NC, Green Globes, Estidama, and BREEAM Gulf, to create a wide list of categories and subcategories that have an impact on green buildings. A detailed list of weighted categories and subcategories was established based on the above-mentioned comparison, and a questionnaire was then sent to 46 participants (Younan 2011). The weights were computed using AHP based on the questionnaire. This study concentrated on the subcategories of energy and water usage for new constructions.

Another comparative study was applied by Karmany between three rating systems which are: LEED, GPRS and TARSHEED (Karmany 2016). The study highlighted that TARSHEED is a more appropriate rating system than GPRS and LEED for environmental conditions in Egypt. There is a proposal to set up TARSHEED for new commercial buildings that have been built and to upgrade existing residential and commercial buildings. Another study was done by Hazem *et al.* (2020), it introduces a sustainable/green research roadmap and suggests a new green rating system for the existing buildings (Hazem *et al.* 2020). The findings showed that establishing a rating system using AHP is among the least discussed topics, followed by the producing energy rating systems for new and existing buildings; renewable energy is the least discussed (Hazem *et al.* 2020). Most of the research efforts in developing a rating system using AHP were focused on certain categories, but none of them covered all the categories, which are crucial to Egypt.

Accordingly, this study introduces a new rating system for new construction in Egypt addressing all categories using the AHP as a step towards implementing the green concepts.

3 METHODOLOGY

Developing a new green building rating system, which adapts the environment in Egypt, needs to review and study various relative rating systems. Therefore, three rating systems were selected which are: *Green Pyramid Rating System (GPRS)*, LEED *V3 for new construction,* TARSHEED. A comparison was carried out between the selected systems according to the following: the key categories and sub-categories, along with their corresponding weights, the level of importance and their environmental impact. A final list of categories and sub-categories is established covering all the environmental aspects. A questionnaire was then established and answered by professionals in the industry to evaluate the importance of each element within the proposed system with the others. The scale ranges from 1 to 5 as shown in Table 1 where 1 indicates that the two elements are equal in importance.

Table 1. Scores for the significance of variables (Hazem *et al.* 2020).

Importance Scale	Importance Scale Definition
1	Equally important preferred
2	Moderately important preferred
3	Strongly important preferred
4	Very Strongly important preferred
5	Extremely important preferred

Table 2 shows how the questionnaire is handled. As shown below, provided options A & B, their relative significance can be assessed as following: (1) If option (B) is extremely important than option (A), then mark 5, as shown in row 1 in Table 2; (2) If option (A) is very strongly important than option (B), then mark 4, as shown in row 2 in Table 2.

Table 2. Questionnaire sample.

A Options	Extremely	Very Strongly	Strongly	Moderately	Equally	Moderately	Strongly	Very Strongly	Extremely	B Options
Water Use Reduction	5	4	3	2	1	2	3	4	X	Wastewater Reuse
Water Use Reduction	5	X	3	2	1	2	3	4	5	Water Efficient Landscaping

After that, the AHP approach was applied based on the filled questionnaire. AHP is a tool for decision-making, weighing and ranking of the criteria according to their importance. The AHP was implemented using the following steps:

(i) The filled questionnaire was emptied into a matrix where responses were changed into numbers 1, 2, 3, 4 and 5 and their reciprocals. A pair matrix comparison matrix for each criterion was established based on the importance of each value on the other alternatives (Hazem *et al.* 2020) See Table 3. The values in each column are then summed up.

Table 3. AHP comparison-paired matrix sample.

Item	1	2	3	4	5
1	1.00	3.00	1.00	2.00	3.00
2	0.33	1.00	0.25	0.25	0.25
3	1.00	4.00	1.00	2.00	4.00
4	0.50	4.00	0.50	1.00	4.00
5	0.33	4.00	0.25	0.25	1.00
Sum	3.17	16.00	3.00	5.50	12.25

(ii) As shown in Table 4, the resulting matrix is then normalized. Normalization means that the priority of the parameter has been calculated based on its contribution to the overall objective: (a) the values are summed in each column of the matrix of the pair comparison; (b) each part of the matrix of the pair comparison has been divided by the sum of the values in each column. As a standardized pairwise contrast matrix, the resulting matrix was referred to.

Table 4. AHP normalization sample.

	1	2	3	4	5	Weight
1	0.32	0.19	0.33	0.36	0.24	28.9%
2	0.11	0.06	0.08	0.05	0.02	6.3%
3	0.32	0.25	0.33	0.36	0.33	31.8%
4	0.16	0.25	0.17	0.18	0.33	21.7%
5	0.11	0.25	0.08	0.05	0.08	11.3%

(iii) Consistency analysis is performed to guarantee that the actual priority ratings are correct. According to Saaty, the questionnaire is not accurately reliable if the precision ratio is very high over 0.1, and it is better to readjust the contrasts (Saaty 2008). The following measures have been taken to calculate consistency: (a) The value in the first matrix column is multiplied by the first item 's priority. See Table 5; (b) To get a value vector called "Weighted Sum," values are added through rows; (c) weighted sum vector values are divided by the priority corresponding to the (sum / weight) value for each criterion; (d) The average of (sum / weight) is calculated and indicated as λ_{max}; € The Consistency Index (CI) is then calculated as shown in Eq. (1):

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

where *n* represents the number of compared items.

Table 5. AHP CI and CR calculation matrix samples.

	1	2	3	4	5	SUM	SUM/Weight
1	0.29	0.19	0.32	0.43	0.34	1.57	5.43
2	0.10	0.06	0.08	0.05	0.03	0.32	5.07
3	0.29	0.25	0.32	0.43	0.45	1.75	5.49
4	0.14	0.25	0.16	0.22	0.45	1.23	5.66
5	0.10	0.25	0.08	0.05	0.11	0.60	5.27

(iv) For all participant responses, geometrical mean (GM) is computed as shown in Eq. (2).

$$GM = (a_{1ij} \times a_{2ij} * \ldots\ldots * a_{kij})^{(1/m)} \quad (2)$$

where m is the number of participants.

4 RESULTS AND DISCUSSION

After applying the AHP analysis, a rating system is established consists of the following categories: (1) sustainable sites; (2) water efficiency; (3) energy efficiency; (4) products and resources; (5) indoor quality management; (6) waste management; and (7) innovation and added value. Table 6 presents the resulted checklist for the proposed system including the categories and the weighted subcategories. The results showed that the disposal subcategory under "waste management" category is the highest weighted element, followed by wastewater reuse falling under "water efficiency", then the reduction of the total material consumption in "materials and resources". This proves that water and waste management are the key challenges facing Egypt.

Table 6. Proposed checklist for the new construction.

Rating System for New Construction			
Checklist			
Sustainable Sites (SS)	**Weight**	**Materials & Resources (MR)**	**Weight**
Construction activity pollution prevention	0.243	Reduction of Overall Material Use.	0.295
Site Selection	0.238	Renewable and Manufactured Materials Using Renewable Energy	0.287
Community Services & Connectivity	0.176	Alternative Building Prefabricated Elements	0.213
Public Transportation Access & Pedestrian Access	0.137	Reduction of Overall Material Use.	0.295
Dedicated Bicycles Tracks & Parking	0.102	Environment – Friendly, acoustic and Thermal Insulating Materials.	0.129
Rainwater/storm Design (Quantity and Quality Control).	0.06	Regionally Procured Materials and Products.	0.077
Heat Island Effect (Green Space , Hardscape& Building).	0.044	**Indoor Environmental Quality (IEQ)**	
Energy & Atmosphere (EA)		Enhance Ventilation Performance.	0.264
Fundamental Commissioning of Building Energy Systems	0.189	Minimum Indoor Air Quality Performance	0.254
Minimum Energy Performance	0.185	Environmental Smoking Control.	0.197
Fundamental Refrigerant Management	0.17	Thermal Comfort.	0.143
Building Envelope Improvement	0.128	Visual Comfort.	0.087
Passive Heat Gain Reduction	0.107	Acoustic Comfort.	0.055
Renewable Energy Sources	0.08	Enhance Ventilation Performance.	0.264
Energy-Efficient HVAC Systems	0.06	Minimum Indoor Air Quality Performance	0.254
Efficient Artificial Lighting Systems	0.048	**Waste Management**	
Vertical Transportation	0.033	Disposal	0.384
Water Efficiency (WE)		Spaces for collecting & sorting of wastes	0.276
Wastewater Reuse	0.313	Specialized company contract for the waste disposal	0.155
Water Efficient Landscaping.	0.289	Recycling wastes onsite/offsite	0.116
Water Efficient Fixtures.	0.203	Storage and collection of recyclables	0.069
Metering & Leak Detection System.	0.071	Disposal	0.384
Innovation and Added Value (IN)			
Innovation and Added Value			
LEED Accredited Professional			

In the GPRS, the waste management falls under "management protocols" category, while in the proposed rating system, it is in a separate category due to its importance. The weight of the wastewater reuse in the GPRS is less than that in the proposed one. It is 25% while 31.3% in the proposed one, which is satisfying as water is one of the obstacles facing Egypt. Moreover, in GPRS, vertical transportation – which means that all lifts and escalators within the building are close to the main entrance- got higher weight than waste management which is not logic as waste is one of the significant issues facing Egypt.

5 CONCLUSION

Achieving sustainability is one of Egypt's major challenges due to the lack of research in this field. The already existing rating system cannot be applied in Egypt as it is based on the US one. This study is proposing a new rating system for new construction that suits Egypt's environment and culture. The resulting proposed rating system using AHP analysis showed that water and waste are the major issues facing Egypt nowadays. Accordingly, more efforts should be exerted towards achieving sustainability and greenness to face those environmental challenges and reducing their impacts.

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