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Developing Water Efficiency Evaluation Criteria Using AHP Towards Green Buildings in Egypt

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Abstract

Urban growth is susceptible to the effects of climate change, and those effects are anticipated to worsen in the years to come. Egypt experiences a roughly seven billion cubic meters of water shortfall each year. Egypt has issued GPRS (Green Pyramid Rating System) to measure and certify green buildings since its implementation in 2010, however, the application of GPRS is still limited as it assesses the building's sustainability performance and calculates the building credit ac-cording to water efficiency themes without supporting or recommending practices and criteria to achieve. This paper aims to create a water rating system for existing constructed buildings in Egypt and a computational code to relatively compare the existing sustainable practices, and finally to implement the rating system by identifying the essential sustainable practices and criteria. Three established global rating systems (LEED, BREEAM, CASBEE) and two local rating systems (GPRS, TARSHEED) were reviewed, and comprehensive water efficiency criteria were developed that include 15 factors grouped under 6 main categories: storm water management, reuse and recycling, management and operation, irrigation and landscaping, conservation, and monitoring systems. Then, a questionnaire was developed to assess the relative importance of each set in the criteria according to the 78 participants' answers that were analysed using Analytic Hierarchy Process (AHP). The main essential practices from the 15 to consider in existing buildings were processing water reduction, integrative water systems, and indoor efficient water use design. The results of this research could contribute to the update and development of the local sustainability rating systems (GPRS & Tarsheed) in terms of measures used to achieve water efficiency or the weights associated with each measure.

Keywords

Water efficiency, Rating System, Green Buildings, Sustainable Development, Analytic Hierarchy Process (AHP)

1. Introduction

Various industries impact the national sustainable development, among those is the construction sector. It has the utmost significance to sustainable development as it consumes energy, water, land, and materials to construct and operate projects and buildings (Jackson, 2022). Urban growth generates 71~76% of CO_2 emissions contributing to climate change due to intensive energy use and the induced heat stress, and consumes almost 40% of materials (Kahn, 2009). However, urban development is vulnerable to the impacts of climate change, and the impact is expected to intensify over the coming years. Hundreds of millions of people, especially slum dwellers, will be affected by the climate change events like rising sea levels, increased droughts, severe and more frequent storms and inland floods, and intense precipitation. Furthermore, climate change would threaten food security, and reduce water quality and quantity due to the extreme weather events increase and the quality of life by posing more health risks (Kahn, 2005). Various cities are attempting to address climate change and the imposed risks by producing related policies, hazard mitigations, and action plans, and adjusting existing urban planning regulations. Sustainable urban development emerges from the urgent need to mitigate the negative environmental impacts; thus, green buildings and sustainability concepts are introduced.

2. Literature Review

2.1. Green Building Evaluation

The sustainable development idea of "green construction" has gained prominence in this century and has taken on the task of balancing the long-term needs of the economy, the environment, and society (Fowler & Rauch, 2006). According to Fowler and Rauch (2006), there were countless building evaluation tools available that were made for various sorts of projects and concentrated on various facets of sustainable development. Life cycle analysis, life cycle costing, energy system design, performance analysis, productivity evaluation, indoor environmental quality evaluations, maintenance, and operational optimization, entire building design and operations tools, and more were some of these tools. By Novotny (2008), the application of sustainable water consumption and reuse infrastructure principles lead to the development of a sustainable urban water management system and its standards. The aims for sustainable urban water management covered all the interconnected water systems, such as systems for wastewater disposal, stormwater management, and water conservation (Kibert, 2004). Ali and Al Nsairat (2009) have highlighted that the design must intend to limit and lower the risks of failure and disasters caused by a predicted exponential rise in demand brought on by population expansion.

2.2. Sustainable Indicators

In the meanwhile, Rodríguez López and Fernández Sánchez (2011) developed the indicators that were presented to describe the sustainability of methods and technology for integrating water systems and to assess their impact. By enhancing infiltration to groundwater aquifers, stormwater retention, wastewater treatment, and treated effluent reuse, the indicators described by Rodríguez López and Fernández Sánchez (2011) aimed to produce a complete hydrological cycle. The system should include the application of guidelines, cooperation between municipalities, and the involvement of stakeholders in legalization.

Cheng (2003) identified the Water Conservation Measure, also known as the Water Saving Index, as a crucial index for the long-term management of urban water resources. It is the proportion of the water utilized within a building to the average quantity consumed. Afterward, Cheng (2003) suggested that the quantity of water utilized comprised the difference between the quantity of water used and the quantity of water saved by water-saving technologies, such as water-saving fixtures, rainwater collection, and greywater recycling and reuse. It also demanded an evaluation of each building's water usage. The water conservation index assisted in assessing each building's rate of water conservation and deciding if the structure could be recognized as a green building or whether it needs to include water-efficient methods in its design and renovation (Berk et al., 1993).

2.3. Rating Systems

To ensure the environmental quality of the buildings, rating systems were introduced and developed. Campagna and Frey (2008) outlined the main principles of rating systems development which included ensuring environmental quality through comprehensive, holistic, and balanced assessments of environmental consequences, measuring environmental quality, choosing a performance criterion for defining environmental quality, and quantifying and calibrating it, considering the social and economic benefits of achieving environmental goals, and creating a uniform assessment method.

Table (1) summarizes the rating systems established globally and locally and compares them. The international rating systems are well established and chosen according to the high number of certified buildings. For example, BREEAM has 2,214,150 registered and 534,100 certified buildings (BREEAM, 2015). Various rating systems include different aspects to ensure the implementation of sustainability of the building. For instance, LEED has six categories for which points are given Sustainable Sites, Energy and Atmosphere, Water Efficiency, Indoor Environment Quality, Material and Resources, and Innovation (USGBC, 2019). Another example, BREEAM has categories that cover important issues, such as low-impact design and the reduction of carbon emissions, design robustness, and climate change adaptation, as well as ecological value and biodiversity preservation (BREEAM, 2022). Moreover, EDGE was established by International Finance Corporation in 2014 and has three categories that cover important issues, such as water conservation, energy efficiency, and material use minimization (EDGE, 2017). Another global rating system used is CASBEE. It has four main categories that cover important issues, such as indoor environment design, local environment, and resource usage efficiency

Locally, GPRS was introduced in 2009 by The Housing and Building National Research Center after initiating Green Building Council (GPRS, 2011). The main objective is to raise awareness of the current environmental situation in Egypt. Whereas Egypt now experiences a 13.5 billion cubic meters per year (BCM/yr.) water shortage, which is expected to worsen over time (Mohie El Din & Moussa, 2016). Reusing drainage water is now being used to alleviate the water shortage, although this lowers the water's quality. As a result, the Egyptian government has developed legislation frameworks to protect its water resources, ensure the quality of its water, and reduce usage. Accordingly, GPRS provides "green" credentials after assessing buildings to support innovative solutions and interventions in building design, operation, and maintenance. However, water efficiency criteria in GPRS cover partially the water conservation practices and recommendations to be implemented for existing buildings as the main focus on the design and construction phases in the new buildings. Therefore, the paper aims to develop a set of water efficiency evaluation criteria for existing buildings to recommend water efficiency practices to be implemented.

3. Research and Methodology

This section discusses the methodology for this study. **Figure 1** shows a flowchart for the process.

3.1. Development of Comprehensive Water Indicators List (CWIL)

It is a collective list of distinct water-related standards discovered in the five Sustainable Buildings (SB) rating systems that were picked and introduced earlier. The list is developed by reviewing the rating systems, then identifying the water-related criteria, and excluding the the repeated criteria. The chosen criteria of SB rating systems are then used to identify and keep track of a variety of indicators for evaluating water use in buildings and their accompanying classifications. Afterward, the water themes are classified into three main categories: environmental, social, and economic. After reviewing the rating systems and categorizing the related water indicators, the coverage analysis was conducted to measure qualitatively the extent of the water indicators found in the various rating systems. **Appendix 1** shows the classification of the 15 water efficiency practices and which rating system has included them.

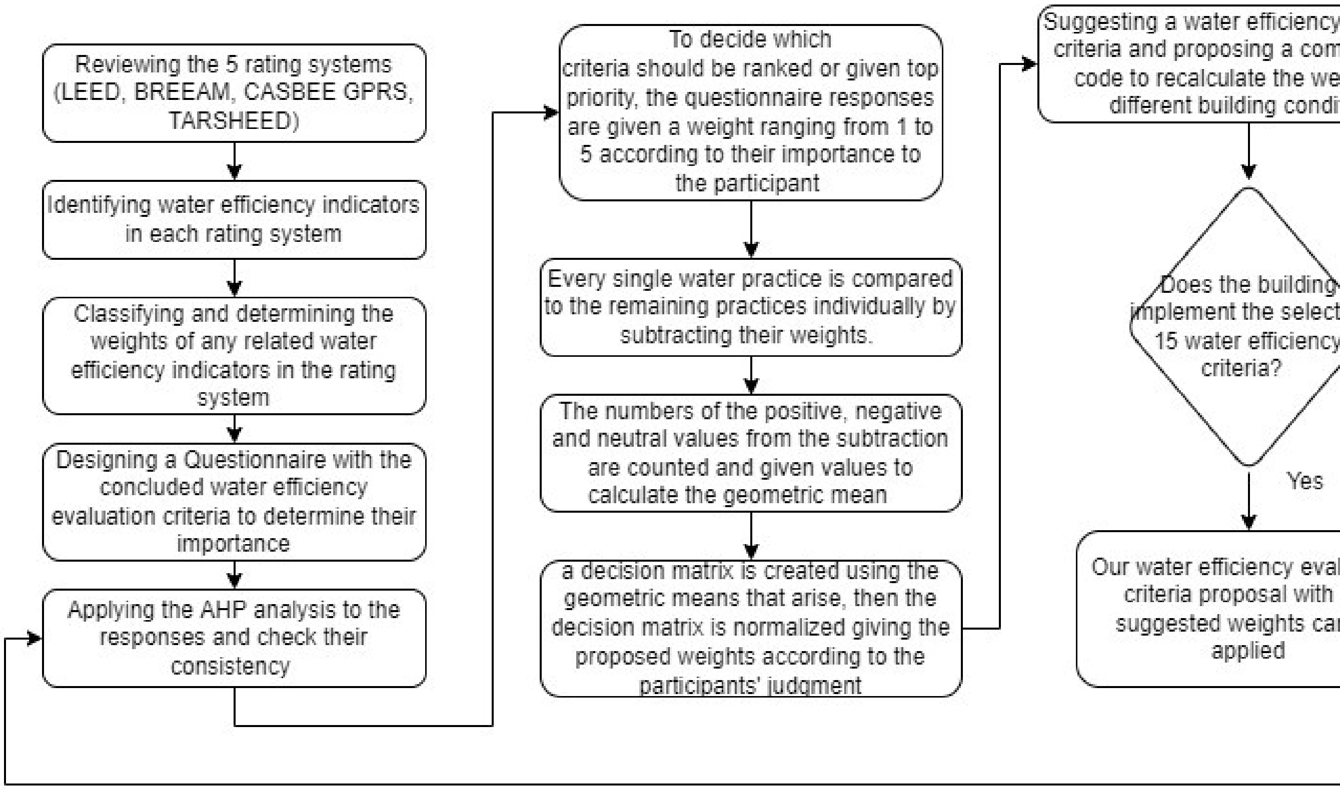

Figure 1. Methodology flowchart

Table 1. The selected rating systems introduction

Points of Comparison	LEEDs v.4.1 (USGBC, 2019)	BREEAM v.6 (BREEAM, 2022)	CASBEE (CASBEE, 2014)	EDGE (EDGE, 2017)	GPRS (GPRS, 2011)	TARSHEED (EGYPT GBC, 2015)
Name	Leadership in Energy and Environmental Design	Building Research Establishment's Environmental Assessment Method	Comprehensive Assessment System for Building Environmental Efficiency	Excellence in Design for Greater Efficiencies	Green Pyramid Rating System	--
Country	USA	UK	Japan	US	Egypt	Egypt
Release Year	2019	2022	2014	2017	2011	2015
Certification Levels Threshold	**Certified:** 40–49 **Silver:** 50–59 **Gold:** 60–79 **Platinum:** 80+	**Unclassified** (30%), **Pass** (>30%), **Good** (>45%), **Very Good** (>55%), **Excellent** (>70%), **Outstanding** (>85%).	**A:** 1.5 to 2.99, **S:** more than 3.0, **B-:** 0.5 to 0.99, **B+:** 1 to 1.49, **C:** 0 to 0.49.	**EDGE Certified**: 20% savings **EDGE Advanced**: 40% savings **Zero Carbon**: 100% savings	**Certified:** 40:49 **Silver Pyramid:** 50:59 **Golden Pyramid:** 60:79 **Green Pyramid:** ≥80	**Bronze**: 40-49 points **Silver**: 50-59 Points **Gold**: 60-69 Points **Platinum**: 70 Points and Above
Prerequisites	- Permanent Location for the project - Inclusive boundaries - Complying with the project size requirements	- Minimize legionellosis risk in Water Quality - Metering the main pipes for water consumption	- Expected life cycle of the building exceeds 40 years	- Minimum size of the single building exceeds 200 meters squared	- project Design and Implementation Plan presentation - Minimum Energy Performance level 10% - Energy monitoring and reporting for equipment >10KW - Ozone depletion avoidance	- a project must reduce energy, water, and habitat use by at least 20% in total

					- minimum water efficiency - water use monitoring - No exposure to hazardous material	
Water Efficiency Focus	- Reduction of indoor and outdoor water consumption - Indoor and Outdoor water metering - Reduction of makeup water used for cooling tower -Innovative wastewater technologies - Efficient landscape watering	- Water consumption reduction - Indoor and Outdoor water consumption monitoring - Water leak detection and prevention - Water Efficient Equipment	- Reduction of water consumption - Stormwater management - Water Quality and Health	-Stormwater management - Water efficient irrigation - Wastewater treatment and recycling - indoor and Outdoor Metering system -	- Indoor and outdoor water consumption reduction - Water features efficiency - Water leakage and monitoring system - Wastewater management	- Water consumption minimization (Indoor and outdoor) - Irrigation Efficiency - Efficient piping fixtures - Indoor and Outdoor water monitoring
Total Water Efficiency Weight	14%	10.9%	11%	30%	30%	16%

3.2. CWIL's Relative Importance Study Questionnaire Design

The questionnaire aims to determine the priority of water-related criteria in the implementation for building owners, engineers, environmental consultants, and contractors. The target is to create a list reflecting the reality and how flexible the criteria are to be implemented locally in Egypt. The engineering experts in Egypt were provided with the questionnaire using an online form. They were asked to provide their practical years of experience and their job title. The individuals who were asked to complete the survey were chosen based on meeting one or more, preferably all, of the following requirements:

- Holding a previous experience in sustainable development or exposure to green building concepts.
- Having a work experience in the construction and operation & maintenance of the existing building fields.
- Having a scientific research background in the related topic of this study.

The questionnaire was carefully created since it will be utilized in this study as a tool for group decision-making, ensuring that the choice (in our instance, the criterion priority) is logical and methodical. The questionnaire was made to be easy for respondents to complete while still providing adequate input parameters for the particular response analysis approach being employed. Therefore, employing pairwise comparisons across many criteria is the ideal method to handle the group decision-making process of this research. This offers a natural method of evaluating the relative importance of each of the criteria in each pair by comparing them in pairs.

3.3. Sample Size Calculation

The idea of sample size in statistics refers to deciding how many observations or replicates—repeated experimental conditions—should be included in a statistical sample to quantify a phenomenon's variability. To calculate the sample size, the margin of error, ε, was set to be 5%. To achieve this, it is solved for the resultant equation for sample size, n, using the confidence interval equation above with the term to the right of the minus sign set to the margin of error. The following equation can be used to determine the sample size (Abrami, Cholmsky & Gordon, 2001).

For finite population

$$n' = \frac{n}{1+\frac{z^2 * \hat{p}(1-\hat{p})}{\varepsilon^2 N}} \qquad (1)$$

Where;

n' is the sample size

z is the z score

ε is the error margin

N is the size of the population

$\hat{p}$ is the population proportion

The population size according to the registered environmental analysts in the ministry of environment is 115 persons (EEAA, 2022). To have a 95% of confidence level and a 5% error margin, the needed sample size is 81. The participants who answered the survey were 78. **Figure 2** and **Figure 3** show their years of work experience and job status, respectively. A summary of the voluntary background information has been included below the participants' contributions. Though not directly relevant, the information below is the survey's primary objective and offers a crucial and substantial look at the engineering scene in Egypt concerning sustainability and green construction.

Table 2. Weights of Qualitative Assessment

Rating system	Weights
very important	5
Important	4
Neutral	3
not important	2
not suitable	1

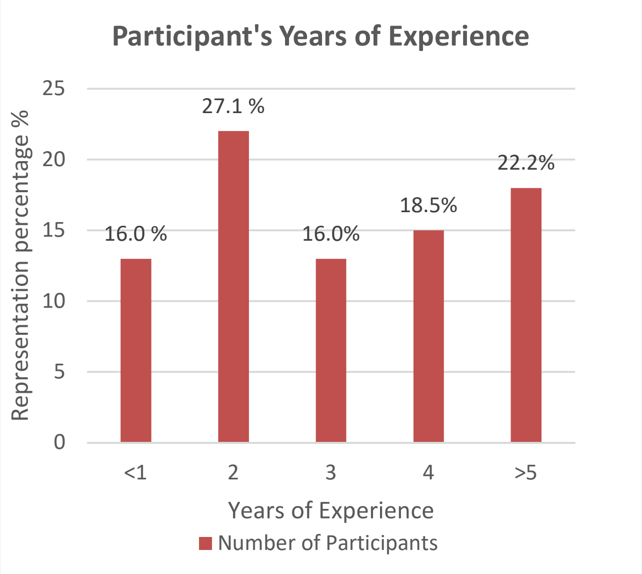

Figure 2. Participant's years of experience graph

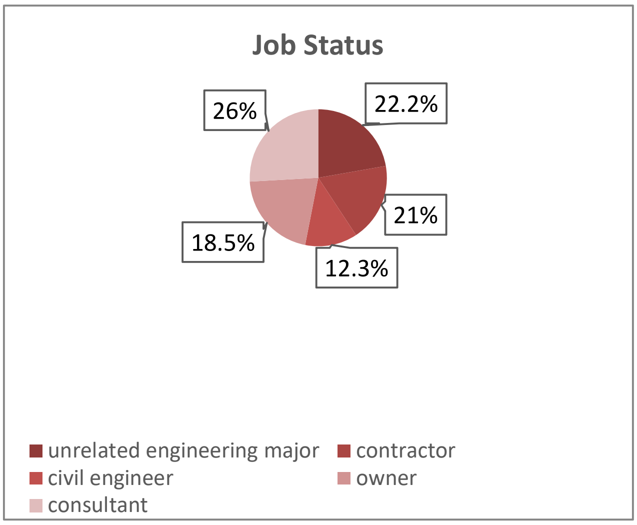

Figure 3. Job status of the participants

3.4. Analytic Hierarchy Process (AHP) Analysis

In this study, the approach of the Analytic Hierarchy Process is used to resolve the issue of identifying the relative relevance of a set of criteria based on group decision-making. The following steps were taken as follows:

1. The qualitative pairwise comparison keywords (i.e., "more important," "same importance," and "less important") are each given a corresponding number from a selected scale once the questionnaire results are entered into a spreadsheet. It is used to quantify the responses from the questionnaire by assigning the weights according to their importance.

2. A computation spreadsheet was made to assess the responses that were received and provide the final weights for the criterion.

3. To compare every criterion with another, the difference between the two criteria was calculated for every response collected. Then, the number of negative values, zero, and positive values were counted for every comparison.

4. The Geometric Mean (GM) was calculated after assigning weights for the negative (1/3), zero (1), and positive values (3), as shown below (McClelland & Reinsdorf, 1999).

$$GM = \sqrt{(3)^M * (1)^S * \left(\frac{1}{3}\right)^L} \qquad (2)$$

Where, M: a total of positive values;

S: a total of the no difference value;

L: a total of the less important values.

5. The resultant aggregate opinions are computed similarly and then mapped into a single decision matrix. The decision matrix is constructed by aligning the 15 themes in a row and a column, creating a 15*15 matrix. In **Table 3,** the calculated GM of one theme compared to other criteria is assigned in a cell. The value of the cell that represents a comparison between the same theme is assigned to be 1; therefore, the matrix diagonal is 1. Half of the matrix was filled, and the other half was composed of reversing the GM value as the comparison of the themes is repeated although being in a different order.

Table 3: Example of AHP decision matrix

Item Description	1	2	3	4
1	1	1.125	1.19	1.05
2	0.906	1	1.02	0.88
3	0.907	1.019	1	0.838
4	0.933	1.11	1.15	1
Sum	3.746	4.254	4.36	3.768

6. The decision matrix's normalized principal right eigenvector, which depicts the relative weights of the criterion, is then determined. Then, for every row, the summation was taken and transposed to be used for the dot product with the normalized values of the themes as shown in **Table 4**. The average eigenvalue of the decision matrix (λ) is calculated by summing the resulting dot products of the column sum vector (C) and normalized eigenvector (W) according to Saaty (1990).

$$\lambda = [C_1\ C_2 \ldots C_{15}] * \begin{bmatrix} W_1 \\ W_2 \\ W_{15} \end{bmatrix} \qquad (3)$$

Table 4: An example of AHP normalization

CRITERIA	1	2	3	4	Weight
1	1	1.125	1.193	1.050	5.19%
2	0.889	1	1.019	0.889	4.69%
3	0.838	0.980573	1	0.838	4.53%
4	0.952	1.124916	1.193	1	5.09%

7. The consistency of the decision makers' responses is often evaluated using a consistency ratio, or CR. The consistency ratio is dividing the consistency index (CI) by a variable known as the random index (RI) (Saaty, 1990).

$$CR = \frac{CI}{RI} \qquad (4) \qquad\qquad CI = \frac{\lambda - n}{n - 1} \qquad (5)$$

The RI is a variable that is also dependent on the number of criteria being considered. It is often calculated using tables provided by different AHP literature sources. The following is a look-up of **Table 5** for RI based on matrix order.

Table 5: RI index (Saaty, 1990)

N	3	4	5	6	7	8	9	10	11	12
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48

4. Results and Discussion

After applying the AHP analysis on the 15 criteria, every percentage was calculated and then the 15 criteria were grouped under 6 related themes as shown in **Table 6.** Every theme has its percentage according to its relative importance based on the questionnaire responses. The 6 categories are ranked descendingly as follows:

1) Water Conservation Practices (28.4 %)
2) Management and Operation (19.2%)
3) Irrigation and Landscaping (18.4%)
4) Stormwater Management (15.0%)
5) Water Reuse and Recycling (10%)
6) Water Consumption monitoring (9%)

Among the water efficiency criteria, the results suggest that water conservation practices are foremost in importance, achieving a weight of 28.4% (**Table 6**). This finding aligns well with the reviewed rating systems, which also ranked water consumption with the highest importance. On the other hand, stormwater practices scored highly in our results (15%), despite ranking on the lower end in the reviewed rating systems. However, this discrepancy could be due to the water scarcity in Egypt causing practitioners to view practices that reduce waste from alternative water sources as more important and considering the heavy rainfall events Egypt experienced in the past decade. Monitoring practices, however, showed low importance in our results, despite being ranked highly in the reviewed systems. This could be the lack of maintenance culture and follow-up systems in Egypt for not fully realizing the water leakage problems.

Table 6. Proposed water efficiency criteria with the calculated weight

Theme	Stormwater Management			Water Reusing & Recycling		Water Consumption Monitoring		Management & Operation	
Indicator	Using stormwater management measures (i.e. rain harvesting)	Applying protective measures against stormwater pollution	Contamination control to protect surface and groundwater bodies during construction & operations	Separating Grey Water from the wastewater collection system	Implementing a grey water recycling system	Introducing indoor and outdoor water metering	Applying for water monitoring and leak detection programs	Measuring periodically and evaluating potable water quality including biological contamination	Minimizing the processing water consumption
Percentage	5.19	4.71	4.63	5.18	5.06	4.81	4.94	9.33%	9.89%
Total percentage	15%			10%		9%		19.2%	
Theme	Irrigation & Landscaping			Water Conservation Practices					
Indicator	Implementing an efficient irrigation system	Designing efficient and environmentally friendly landscape	Introducing Porous Pavements	Applying indoor water reduction practices through design approaches	Implementing integrative water systems in building design processes for water conservation purposes	Implementing water-efficient features in the system to decrease the demand			
Percentage	9.65	4.17	4.66	9.86	9.66	9.04			
Total percentage	18.4%			28.4%					

Highlighting the 6 water categories, every category complements each other to establish water efficiency in buildings. Stormwater management aims to decrease pollution and contamination during building operations By regulating the flow of precipitation into streets, lawns, rivers, and other areas. Reusing water can improve water security, sustainability, and resilience while offering alternatives to current water sources. In order to find the source of a leak, a visual inspection of all water fittings in a building is not necessary because water monitoring can do so fast.

The CI was calculated to determine the participant's consistency in the answers. A consistency ratio value of 0 percent indicates entirely consistent replies, which is the ideal situation, while a value of 100 percent indicates completely random answers. Practically speaking, low CR values (10%) typically imply that survey respondents were responding consistently, but CR values over 10%, albeit acceptable in some settings, may suggest unpredictability in responses to the pairwise comparisons. **Table 7** shows the calculations. As noticed, the CR is lower than 10% which indicates that the results are consistent.

Table 7. Consistency Ratio Results

Consistency Index (CI)	0.001032
Random Index (RI)	1.48
Consistency Ratio (CR)	0.069726

5. Rating System Application Development

After developing the rating system and determining the weights for every criterion related to the water management practices in existing and newly constructed buildings, the application aims to modernize the assessment and facilitate the process. The application is based on the AHP statistical analysis. The application output is to determine and recommend the most suitable sustainable practices for the building after calculating the percentages of the applied practices and relatively comparing them according to the weights. The application was developed using the software MATLAB (Matrix Laboratory), which provides a good working platform, a nice programming environment, and a user-friendly programming language has been chosen as the analytical tools in this investigation. GUI application has been designed using App-Designer MATLAB R2021b to make the process more friendly to the End-user as shown in **Figure 4.**

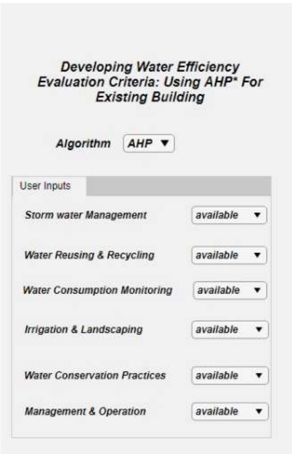

Figure 4. The interface of the application to choose the available systems and AHP algorithm

The main methodology is using the same equations mentioned in the above section. The user needs to insert the available systems (storm, potable, etc.) in the building which are already labeled for the main categories for the 15 criteria. It also includes the economic burden of potentially implementing the irrigation system, and sustainably designing water networks. The original weights are calculated for the complete availability of the 15 practices in the building. In Case Most of the buildings do have not all the practices due to their environment and remote locations, the application determines the weights of the water-related practices available in the building and redistributes their original calculated weights according to the main analysis, then a decision matrix is generated (**Figure 5**).

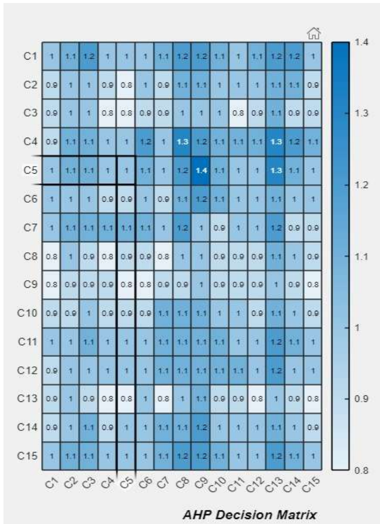

Figure 5. AHP decision matrix on the application after entering the building input

The application recalculates the weights of the criteria if there is a water practice missing in the building, which does not fit the building's environment. In addition, the application provides recommendations to be adopted in the building and which water practice needs the most to be reinforced. **Figure 6** shows an example of hypothetical conditions for a building and how the recommendations are based.

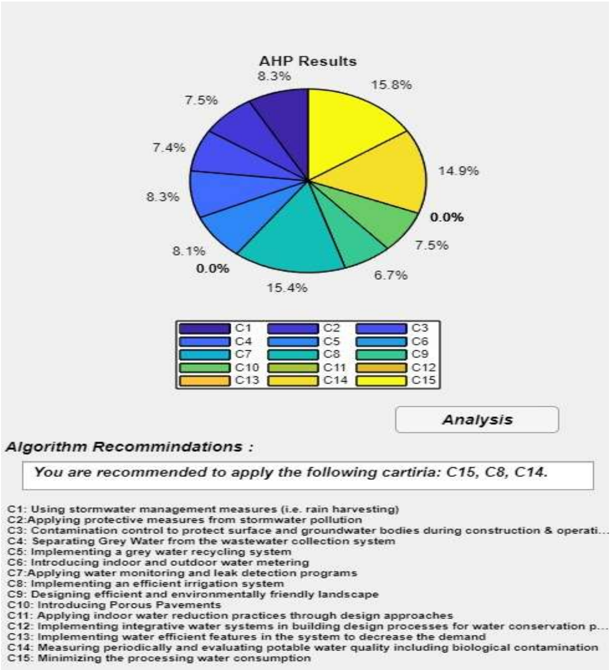

Figure 6. Algorithm results and recommendation

There are three steps in computing, as shown in the flowchart **Figure 7**.

- Programming in AHP. First, go to the user interface, and enter the values for the various levels of available categories.
- Compute the AHP decision Matrix and weights based on selected categories.
- Decision-making algorithm, give the user the recommendation of the highest three criteria.

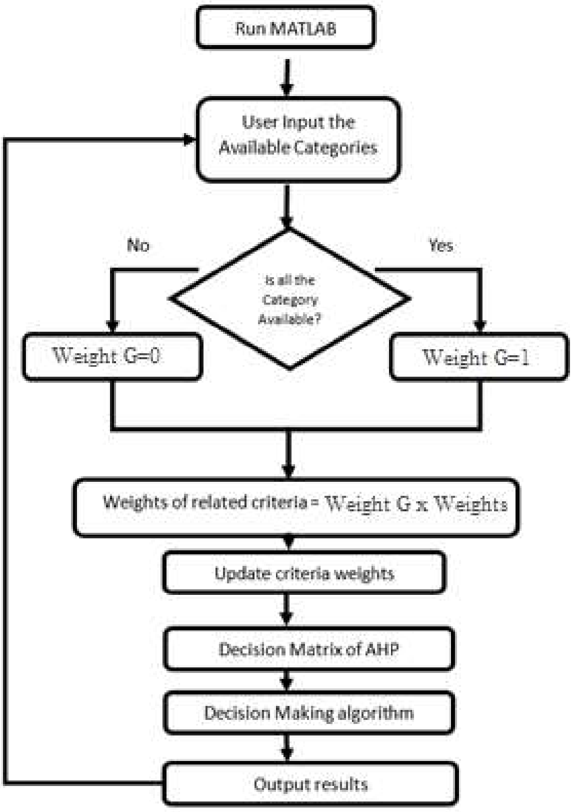

Figure 7. Application Flowchart

6. Conclusions

Creating water rating systems has as its primary objective to promote building operators, owners, and renters should adopt steps to increase the water conservation efficiency of their structures, such as employing and acquiring various water sources such as stormwater and grey water, installing water-efficient equipment, and automating the building a sound building operation and maintenance system, and putting in submeters for the biggest water-consuming building systems. The end objective is to control and enhance water continually and the efficiency of the structure over the course of its anticipated operating life.

With an emphasis on the instance of Egypt, this article reviewed regional initiatives to create building water efficiency rating systems. It was emphasized and discussed how the AHP technique contributed to the development of the weights of the rating system criteria. The results of a recent study were presented to suggest a criteria-based water efficiency rating system for existing buildings using the AHP method. The water efficiency elements in the currently used rating system, GPRS, were compared with the proposed water efficiency criteria shown in **Table 6.** The main points of GPRS regarding water efficiency are wastewater reuse, water consumption monitoring and leaking detection systems, and water conservative practices. It was demonstrated that the research efforts in Egypt were primarily focused on the development of sustainability rating systems for new constructions. The results were consistent, and the CR index was lower than 10% as recommended by AHP literature.

The water performance of existing buildings may be evaluated using the proposed water rating system. It is recommended that this rating system be used as a voluntary rating system for retrofit work on existing buildings. Therefore, this study's advice is to integrate the suggested rating system into an existing framework (GPRS or TARSHEED). To incentivize building owners and renters to enhance their buildings' voluntary water efficiency, Egypt's present water rules should be modified or replaced with new ones. This can be accomplished by offering building owners incentives to enhance the water performance of their structures, such as water consumption subsidies, tax breaks, or financing options. At the national level, enhancing the water efficiency of existing structures may help ease the financial burden of water system expenditures.

Although this study focused on Egypt, the technique is transferable to other developing nations. The AHP multiple criterion decision-making approaches has been demonstrated to be effective in prioritizing these criteria based on expert views after defining nationally applicable rating system criteria. Future studies may utilize the same technique to examine stakeholder preferences for future water efficiency improvement incentives as well as other elements of green buildings like energy efficiency, and material and resource utilization.

Table 8: Water Indicators Presence in the Current Rating Systems and in the Proposed Water Efficiency Criteria

No.	Water Indicators	Proposed Water Efficiency Criteria	GPRS
1	Stormwater management measures	5.19%	--
2	Applying protective measures from stormwater pollution	4.71%	--
3	Contamination control to protect surface and groundwater bodies during construction & operations	4.63%	--
4	Separating Grey Water from the wastewater collection system	5.18%	2.70%
5	Implementing a grey water recycling system	5.06%	7.20%
6	Introducing indoor and outdoor water metering	4.81%	5%
7	Applying water monitoring and leak detection programs	4.94%	2.50%
8	Implementing an efficient irrigation system	9.65%	--
9	Designing efficient and environmentally friendly landscape	4.17%	5.40%
10	Introducing Porous Pavements	4.66%	--
11	Applying indoor water reduction practices through design approaches	9.86%	2.50%
12	Implementing integrative water systems in building design processes for water conservation purposes	9.66%	--
13	Measuring periodically and evaluating potable water quality including biological contamination	9.33%	2.40%
14	Implementing water efficient features in the system to decrease the demand	9.04%	2.40%
15	Minimizing the processing water consumption	9.89%	5%

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Appendix 1

No.	Water Indicators	Aspect	Mentioned in Rating Systems	Weights
1	Stormwater management measures	Environmental	EDGE, CASBEE	5.5%
2	Applying protective measures from stormwater pollution	Environmental	EDGE, LEED	2%
3	Contamination control to protect surface and groundwater bodies during construction & operations	Environmental	CASBEE	3%
4	Separating Grey Water from the wastewater collection system	Environmental	EDGE, TARSHEED	--
5	Implementing a grey water recycling system	Environmental /Economical	EDGE, GPRS	7.20%
6	Introducing indoor and outdoor water metering	Environmental /Social	LEED, GPRS, TARSHEED	LEED: 3.5%
7	Applying water monitoring and leak detection programs	Environmental/Economical	LEED, BREEAM, GPRS, TARSHEED, EDGE	LEED: 2 %
8	Implementing an efficient irrigation system	Economical/Environmental	BREEAM, CASBEE	CASBEE: 4%
9	Designing efficient and environmentally friendly landscape	Environmental/ Social	BREEAM, GPRS, EDGE	BREEAM: 3%, GPRS: 5.4%
10	Introducing Porous Pavements	Environmental	CASBEE	1%
11	Applying indoor water reduction practices through design approaches	Environmental/Social	EDGE, CASBEE	2%
12	Implementing integrative water systems in building design processes for water conservation purposes	Environmental	LEED	2.5%
13	Measuring periodically and evaluating potable water quality including biological contamination	Environmental/Social	LEED, BREEAM, CASBEE, GPRS, TARSHEED	LEED: 2 % BREEAM: 1.5% CASBEE: 1% GPRS: 2.4%
14	Implementing water efficient features in the system to decrease the demand	Economical/Environmental	LEED, BREEAM, GPRS, TARSHEED, EDGE	LEED: 2.5% BREEAM: 4% GPRS: 2.4%
15	Minimizing the processing water consumption	Economical/Environmental	LEED	2%