A new index for assessing the contribution of energy efficiency in LEED 2009 certified green buildings to achieving UN sustainable development goals in Jordan

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Assessing the contribution of water and energy efficiency in green buildings to achieve United Nations Sustainable Development Goals in Jordan.

Abstract

Water and energy efficiency are given high priority in all green building assessment systems. However, a method to assess and improve their contributions to achieve the United Nations (UN) Sustainable Development Goals (SDGs) has not been developed. This research aims to fill this gap. At the time of this research, most certified green buildings in Jordan were under Leadership in Energy and Environmental Design (LEED) v2.2 new construction. The relationships between the LEED v2.2 "water efficiency" (WE) and "energy and atmosphere" (EA) standards and the UN SDGs were explored using a quantitative descriptive methodology. Structured questionnaire surveys yielded 55 responses from Jordanian building industry experts. Pearson's Chi-square and frequency tests were carried out to examine these relationships. We propose a new Comprehensive Contribution to Development Index (CCDI) to assess the contributions of the implementation of LEED v2.2 WE and EA to achieve the UN SDGs. The results show a positive relationship between LEED v2.2 prerequisites and credits in both WE and EA categories with the UN SDGs 6–9, 12–13, and 15, suggesting that the proposed CCDI is a reliable and robust tool for the evaluation of the contribution of water and energy efficiency in LEED v2.2- certified green buildings to achieving the UN SDGs in Jordan.

Keywords: Energy, water, green building, United Nations, sustainable development goal, LEED

1. Introduction

On September 25, 2015, 193 members of the United Nations (UN) adopted the UN sustainable development goals (UN SDGs), which aim to eliminate discrimination and inequality, end poverty, and overcome climate change by 2030 [1]. Numerous economic and social–developmental concerns, such as health, poverty, hunger, education, gender equality, climate change, water, sanitation, environment, energy, and social justice, are covered by the 17 UN SDGs [2].

The construction industry significantly contributes to national socioeconomic development. This industry uses a considerable amount of natural and energy resources. Hence, the active participation of this industry in a country's efforts to attain sustainable development is essential [3].

Worldwide, the construction and building sectors constitute 40% of the total energy use, 40% of waste, 30% of energy-related greenhouse gas emissions, and 12% of water consumption and employ 10% of the labor force. Many local and global challenges, such as demographic shifts, climate change, water, land use, and other resource shortages, are significantly affected by the built environment. Fast-growing regions in Asia, Latin America, and Africa are predicted to have additional 2 billion urban residents by 2030. This rapid population increase leads to a pressing demand for sustainable construction and buildings [4].

The society, environment, and economy are three areas that are considerably affected by the built environment. The increasing environmental consideration of the impact of buildings highlights the importance of conducting environmental assessments of buildings in the construction industry [5].

The construction industry is vital for social progress, economic growth, and successful environmental protection, which are the three elements of sustainable development [6]. “Green building,” as defined by the Environmental Protection Agency, is “the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction.” [7].

Governments worldwide have adopted green buildings as a key policy to avert energy crises and climate change [8]. The World Green Building Council stated that “green buildings can contribute to meeting the sustainable development goals;” information and infographics on the website of the World Green Building Council show how green buildings can contribute to achieving 9 of the UN SDGs [9].

Sustainable development may be achieved through the implementation and application of green-building-assessment tools [10]. Sustainable construction refers to construction that is economically, socially, and environmentally sustainable [11]. Developed by the United States Green Building Council (USGBC), the Leadership in Energy and Environmental Design (LEED) is a nongovernmental certification program, which has been widely adopted worldwide [12]. This program has helped to establish the green building rating system worldwide, with the goal of guaranteeing energy efficiency and decreasing the negative environmental impacts of buildings [13]. This rating system for green buildings promotes a unified approach to design and acknowledges the importance of building design features in improving sustainability. Such design features include reduced energy use, protected construction sites, improved indoor environment quality, the utilization of sustainable materials, and decreased water consumption [14]. Based on the success of LEED as a green building rating system, the LEED v2.2 (specifically reacting to new construction) was introduced in 2005. So far, this upgraded version has certified over 5,000 projects worldwide [15]. The LEED v2.2 rates projects in six categories: energy and atmosphere (17 points); indoor environmental quality (15 points); sustainable sites (14 points); materials and resources (13 points); water efficiency (5 points); and innovations and design process (5 points) [16]. The total sum of LEED points determines the certification level awarded to a specific project: Platinum (52–69); Gold (39–51); Silver (33–38); and Certified (26–32) [17].

The UN has classified Jordan as a lower–middle-income nation. The gross domestic product (GDP) per capita of Jordan in 2016 was 4087.9 US dollars. The population of Jordan increased from 5,597,000 in 2004 to 9,798,000 in 2016, with over 80% residents in urban areas. In 2016, the construction sector of Jordan contributed 4.4% to the GDP, equal to an additional 1,195.8 million JD. This sector also employed approximately 6.1% of the total Jordanian labor force. In the same year, the number of buildings with permits reached 7,576 [18]. Water scarcity is a serious concern in Jordan, a problem that affects every industry that requires water to sustain its production activities and thus achieve success [19]. The overdependence of Jordan on imported energy and its escalating energy demand have become serious challenges to Jordan’s ability to secure a stable energy supply [20].

Survival, economic growth, and human progress require two factors that are intricately linked: water and energy. Water is essential for production processes of energy sources (including electricity) such as raw-material extraction, cleaning processes, cooling thermal processes, crop cultivation for biofuels, and powering turbines. Energy is necessary to ensure that water resources are available for human consumption (including irrigation) through treatment, pumping, transportation, and desalination. The various resolutions regarding water and energy challenges should be organized into an integrated response because partial responses are bound to fail in the long term despite short-term success. The promotion of alternatives that solve energy problems but aggravate water scarcity, the improvement of the access to water at the expense of exacerbating energy problems or, worse, the advancement of alternatives that improve the access to energy and water but affect the environment should be avoided [21].

At the time of this research (September 2016), there were only four certified LEED buildings in Jordan based on data available on the USGBC website [22, 23, 24, 25]:

1) World Health Organization Building, LEED BD+C: New Construction v2 – LEED 2.2, certification awarded in December 2011 [22].
2) Dutch Embassy in Amman, LEED BD+C: New Construction v2 - LEED 2.2, certification awarded in October 2010 [23].
3) Middle East Insurance Building, LEED BD+C: New Construction v3 - LEED 2009, certification awarded in March 2014 [24].
4) ATG Head Quarter, LEED ID+C: Commercial Interiors v3 - LEED 2009, 2015

US Green Building Council, projects, ATG Head Quarter [25].

Because more than one LEED-certified building is required for this study and most of the certified green buildings in Jordan are under new LEED v2.2 construction, we selected the LEED v2.2 new construction to investigate the relationship between water and energy efficiency in green buildings and the UN SDGs.
The contributions of water and energy efficiency in green buildings to achieve the UN SDGs in Jordan have not been assessed before. This research attempts to fill this gap.

Our main objectives are:

1. to identify the contributions of the implementation of LEED v2.2 prerequisites and credits in the WE and EA categories to achieve the UN SDGs in Jordan
2. to develop an integrated index for the assessment of the contribution of water and energy efficiency in LEED-v2.2-certified green buildings to achieve the UN SDGs in Jordan

Following this introduction, Section 2 reviews the literature from which the hypotheses are derived. The research methods are presented in Section 3. The results and discussion are provided in Section 4 and Section 5 concludes this paper.

2. Literature review and hypothesis development

2.1 Relationship between LEED v2.2 credits in the WE category and the UN SDGs

Jordan is a middle-income country with insufficient supplies of water, oil, and other natural resources. It is classified as semiarid to arid country and its annual rainfall is less than 200 mm over 92% of the land area. The total land area of Jordan is 89,297 km^2, 92% of which comprises deserts/rangeland [26]. The water scarcity in Jordan leads to significant challenges with respect to its development. The country's climatic conditions, geography, and geopolitical environment add to such challenges. A serious challenge that affects the wellbeing, security, and economic future of all Jordanians is posed by water scarcity [26].

Jordan currently faces water scarcity. In the population–resource equation, water plays a dominant role. In Jordan, the water resources continue to decline as the country's population continues to rise. An imbalance has thus emerged between the rapidly increasing population, which also comprises refugees, and actual water availability. The severe water shortage in Jordan is a result of the lack of natural surface water resources in the region. Recent severe drought periods have further aggravated the problem [27]. The amount of water available to citizens is simply not enough to sustainably support the growing population.

As identified by the U.S. Green Building Council (USGBC), the WE components of the LEED rating system have the main objective to "reduce the amount of potable water consumed in buildings" [28]. The LEED WE category addresses the water issue by considering indoor use, outdoor use, specialized uses, and metering [28]. The water efficiency credits of LEED v2.2 (new construction) [28] are shown in Fig. 1.

Designers and builders can construct green buildings that use significantly less water than building based on conventional construction methods by incorporating native landscapes that eliminate the need for irrigation, installing water-efficient fixtures, and reusing wastewater for non-potable water needs [28].

Based on the Green Building Market Impact Report 2009, 1.2 trillion gallons (4.54 trillion L) of water have been saved through the LEED projects [29]. The LEED water efficiency credits motivate project teams to take advantage of every opportunity to significantly reduce the total water use.

Because Jordan is a water-scarce country and potable water is the highest-ranking priority, water efficiency would allow the country to reduce the water scarcity.

Based on the literature review ; (UN SDGs [1,2], Green building and sustainable development [3,4,5,6,7,8,9,10,11], LEED [12,13,14,15,16,17,22,23,24,25, 28, 29] Jordan Context [18], Water Shortage in Jordan [19,20,26,27], Water and Energy [21]); the study will test the following main hypotheses:

- H1: There is a significant relationship between the UN SDGs and LEED v2.2 credits in the WE category.

We also investigated the following sub-hypotheses:

- H1A: There is a significant relationship between SDG6 and LEED v2.2 credits in the WE category.
- H1B: There is a significant relationship between SDG8 and LEED v2.2 credits in the WE category.
- H1C: There is a significant relationship between SDG9 and LEED v2.2 credits in the WE category.
- H1D: There is a significant relationship between SDG12 and LEED v2.2 credits in the WE category.
- H1E: There is a significant relationship between SDG13 and LEED v2.2 credits in the WE category.
- H1F: There is a significant relationship between SDG15 and LEED v2.2 credits in the WE category.

Fig. 1 shows the proposed links between the implementation of the LEED-v2.2 WE credits and UN SDGs 6, 8, 9, 12–13, and 15.

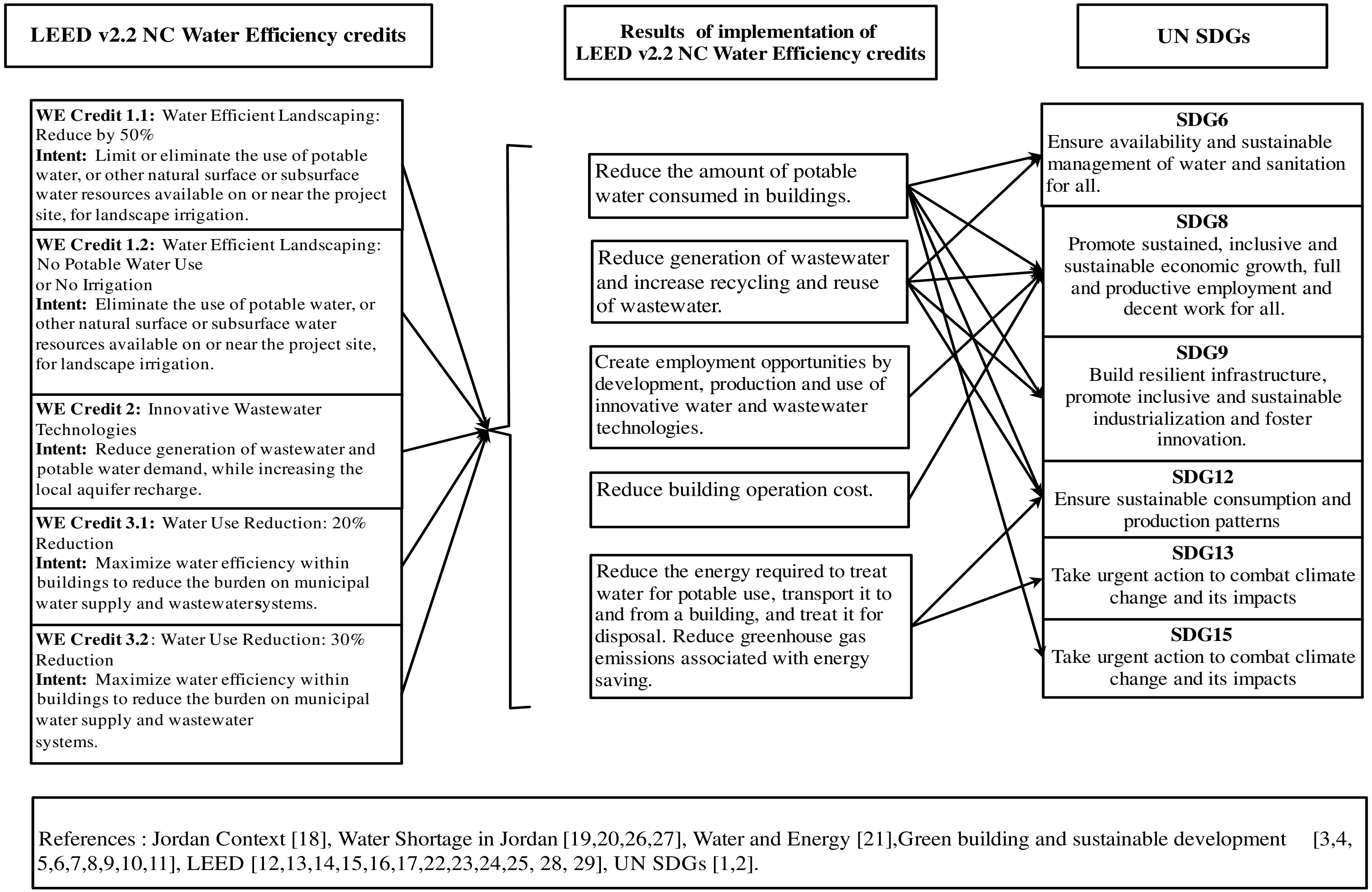

Fig. 1. Proposed links between the LEED v2.2 WE credits and UN SDGs.

2.2 Relationship between LEED v2.2 prerequisites and credits in the EA category and the UN SDGs

The demand for energy and electricity is on the rise in Jordan [26]. This demand becomes more complex by the limited availability of locally sourced fossil fuels, inadequate conversion capacities, and the absence of energy companies with strong financial capabilities. The rapid industrialization and population growth, which includes refugees from various regions, further aggravate the situation [27].

Projection results indicate that the consumption of electricity in Jordan will exceed the nation's capability for electricity generation [28]. More than 96% of Jordan's energy is imported in the form of crude oil products. In 2014, the cost of consumed energy represented 86.8% of exports, 27.7% of imports, and 17.6% of the GDP [20]. The per capita energy consumption between 2010 and 2014 increased from 1,204 to 1,272 kWh; in the same period, the per capita consumption of electricity increased from 2,101 to 2,318 kWh [20]. Jordan imported energy equivalent to 8,449,000 t of oil in 2014; the energy generated from locally available resources, that is, mainly natural gas and renewable energy, reached an equivalent of 265,800 t of oil [20].

The transportation sector is the major consumer of energy in Jordan; its energy consumption is approximately 46% of the total consumption. The residential sector, which consumes approximately 21% of the total energy ranks in second place; it is followed by the industrial sector with an energy consumption of approximately 20% of the total consumption [20].

Natural gas is the main source of electricity in Jordan and comprises approximately 70% of the total amount of electricity produced in the country. Heavy fuel oil and diesel are still utilized in some electric power plants [20].

In terms of electricity consumption, the residential sector in Jordan uses approximately 43% of the total electricity in the country, making it the leading electricity consumer. The residential sector is followed by the industrial sector with a consumption of 25%, the commercial sector with a consumption of 15%, the water pumping sector with a consumption of 15%, and street lights with a 2% consumption [20]. This distribution shows that buildings in Jordan consume approximately 58% of the total electricity in the nation [20].

The LEED v2.2 EA category approaches energy from a holistic perspective, addressing energy-use reduction, energy-efficient design strategies, and renewable energy sources. The LEED V2.2 EA prerequisites and credits are shown in Fig. 2. Focusing on design that reduces the overall energy needs in a green building is the starting point to achieve energy efficiency. Considerations must be made in various areas such as the building orientation, glazing selection, and choice of climate-appropriate building materials. Strategies, such as passive heating and cooling, natural ventilation, and high-efficiency HVAC systems, combined with smart controls further reduce the energy use of a building. The generation of renewable energy on the project site or the purchase of green power allows portions of the remaining energy consumption to be met with non-fossil fuel energy, lowering the demand for traditional sources [28]. The commissioning process is critical to ensure high-performing buildings. The early involvement of a commissioning authority helps to prevent long-term maintenance issues and waste of energy by verifying that the design meets the owner's project requirements and intended functions [28].

The LEED-certified green buildings address energy savings by reducing the amount of energy required for building operations and by utilizing clean and renewable energy. When buildings consume energy efficiently, the amount of greenhouse gas emissions from energy production is reduced. The environmental impacts of the energy use of buildings may be reduced by adopting electricity sources other than fossil fuels. The operating costs can be also reduced with improved energy performance based on renewable energy [28]. Based on the literature review; (UN SDGs [1,2], Green building and sustainable development [3,4,5,6,7,8,9,10,11], LEED [12,13,14,15,16,17,22,23,24,25, 28, 29] Jordan Context [18], Energy in Jordan [20,30,31,32]);the study will test the main hypothesis:

- H2: There is a significant relationship between the UN SDGs and LEED v2.2 prerequisites and credits in the EA category.

We also investigated the following sub-hypotheses:

- H2A: There is a significant relationship between SDG7 and LEED v2.2 prerequisites and credits in the EA category.
- H2B: There is a significant relationship between SDG8 and LEED v2.2 prerequisites and credits in the EA category.
- H2C: There is a significant relationship between SDG9 and LEED v2.2 prerequisites and credits in the EA category.
- H2D: There is a significant relationship between SDG12 and LEED v2.2 prerequisites and credits in the EA category.
- H2E: There is a significant relationship between SDG13 and LEED v2.2 prerequisites and credits in the EA category.

Fig. 2 shows the proposed links between LEED v2.2 EA prerequisites and credits and the UN SDGs.

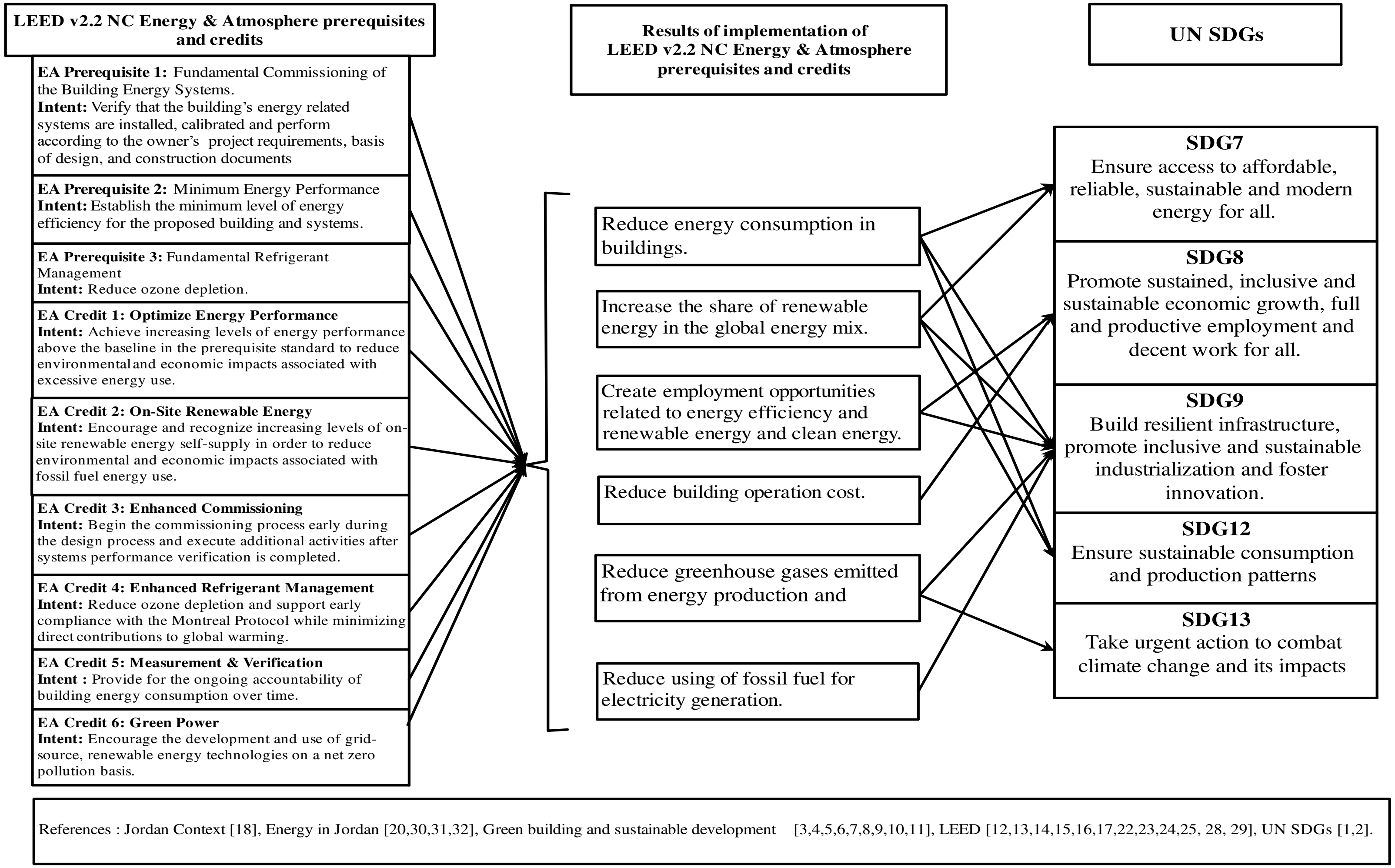

Fig. 2. Proposed links between LEED v2.2 EA prerequisites and credits and the UN SDGs.

2.3 Integrated relationship between LEED v2.2 prerequisites and credits in the WE and EA categories and the UN SDGs

Based on the United Nations World Water Development Report 2014, Water and Energy Volume 1, "Water and energy are strongly interlinked: water is required to produce, transport, and use all forms of energy to some degree and energy is required for the extraction, treatment, and distribution of water and its collection and treatment after use." The improvement of the water and energy efficiency would allow countries to reduce the resource scarcity and maximize the benefits provided by existing water and energy infrastructure [33].

Research on the water-energy nexus is increasing significantly [34]. Jiangyu et al. identified 70 studies on the water-energy nexus by conducting an extensive literature survey [34]. Siddiqi et al. developed a framework to bridge decision networks for integrated water and energy planning; this framework was successfully used in the case study for Jordan [35]. Water and energy resource challenges in Jordan require creative methods to manage these resources in an integrated sustainable manner. Integrated management of interdependent water and energy systems at the building scale is critical to achieve sustainable development. Hence, the connections between water and energy efficiency in green buildings should be considered in Jordan to achieve the UN SDGs. Therefore, this research aims to develop an integrated index for assessing and improving the contributions of water and energy efficiency in green buildings. Fig. 3 shows the proposed integrated links between LEED v2.2 EA prerequisites and credits and the UN SDGs.

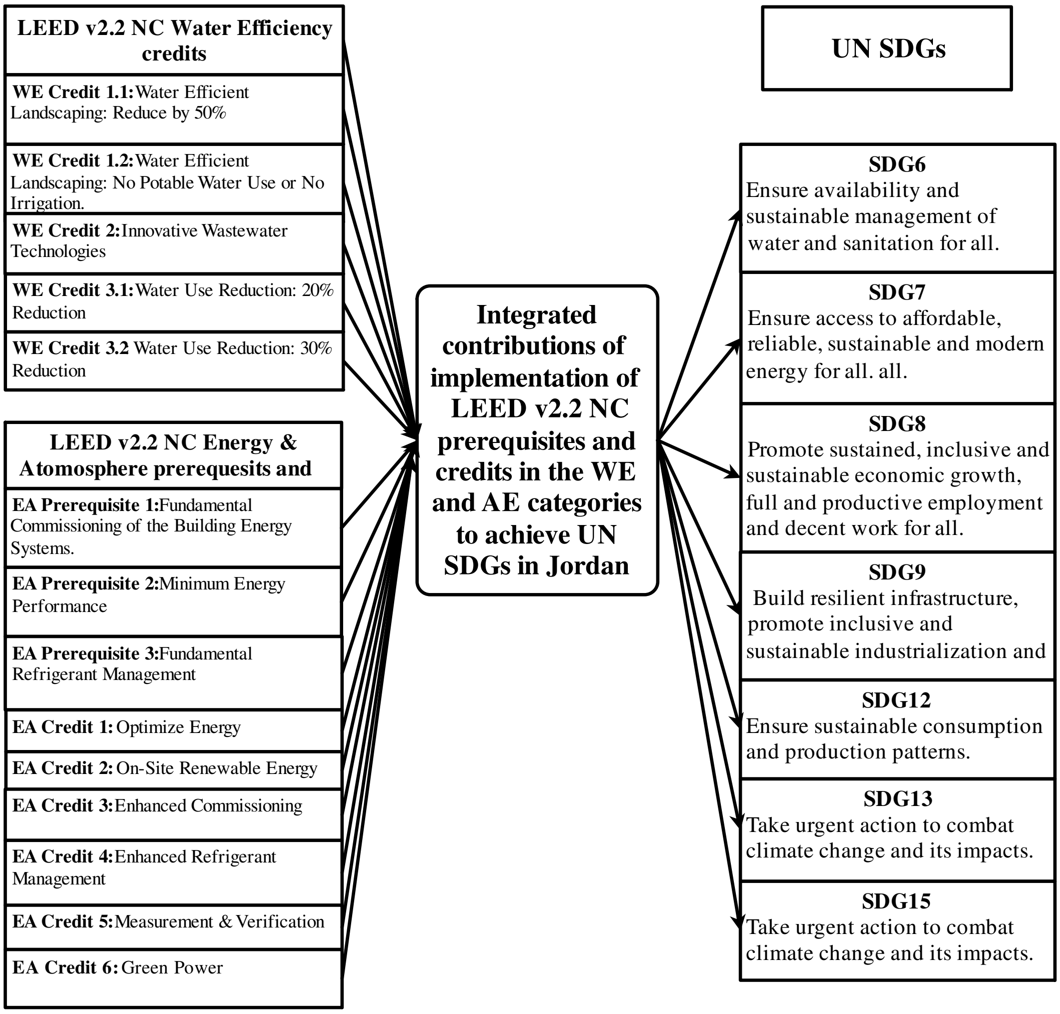

Fig. 3. Proposed integrated links between LEED v2.2 prerequisites and credits in the WE and EA categories and the UN SDGs.

3. Research methodology

This research is designed to explore if a relationship exists between LEED v2.2 prerequisite credits in two categories (WE and AE) and the UN SDGs and to develop a new index for assessing the contributions of water and energy efficiency in LEED v2.2-certified buildings to achieve the UN SDGs in Jordan. Based on Kothari [36], descriptive research can include surveys and other forms of empirical inquiry.

The research methodology includes the two main hypotheses developed based on the literature review, as discussed in Section 2. A questionnaire was developed and distributed to the targeted audience. Data were gathered through a survey and analyzed with frequency, Pearson's Chi-square, and Cramer's V tests. Contribution indices were constructed. A focus group discussion was conducted to validate the results. The contribution indices were used to assess the contributions of water and energy efficiency in the two pioneer LEED-v2.2-certified buildings to achieve the UN SDGs in Jordan.

3.1 Questionnaire development

A questionnaire survey was used as the primary tool for data collection. It included statements and questions on data, age, job role, experience, and views on the contributions of the implementation of LEED v2.2 prerequisites and credits in the WE and EA to achieve the UN SDGs in Jordan.

Generally, many response scale options were used by different researchers such as a dichotomous, three-point, five-point, and seven-point options. In most of the studies, the Likert five-point scale (1: strongly agree, 2: agree, 3: neither agree nor disagree, 4: disagree, 5: strongly disagree) was used to measure the level of agreement or disagreement. However, in most of these studies, categories 1 and 2 and 4 and 5 were combined to new categories "1: strongly agree/ agree" and "3: disagree/ strongly disagree," respectively. Category 3 (neither agree nor disagree) became category 2 because the aim of this study is not to test the degree of agreement regarding the relationship between each credit and prerequisite in the WE and EA categories and UN SDGs (the dichotomous scale is suitable to respond to the question if there is a significant relationship between LEED v2.2 prerequisites and credits in the WE and EA to achieve the UN SDGs in Jordan, as mentioned previously.)

A pilot study was conducted prior to the survey to test the comprehensibility and suitability of the questionnaire. The pilot study involved a team of three professors (academia), an associate professor, and three experts (consultancy firm and government authorities). All have experience with Jordan's built environment and green buildings. The questionnaire was finalized based on feedback from the pilot study.

3.2 Data collection method

The structured questionnaires were distributed to four groups of Jordanian building project experts (consultants, contractors, government officials, and academic experts). The main target was to select experts with professional qualifications, experience, knowledge on green building projects, and involvement in the Jordan Green Building Council. A total of 140 questionnaires were distributed and 55 participants completed the survey (39%). The 55 responses were adequate compare with previous studies related to green buildings [37–40]. Darko et al. investigated major issues influencing the adoption of green building technologies from the perspectives of 33 US green building experts [37]. Hwang and Ng identified challenges faced by 30 project managers who work on the execution of green construction projects and determined knowledge areas and skills that are necessary to respond to such challenges [38]. Zhoa et al. conducted a survey with 30 project managers who were experienced in green construction to identify the leadership characteristics and styles of project managers in green building projects in Singapore [39]. Hwang and Tan identified common obstacles encountered by 31 experts during the management of green construction projects [36]. However, based on the central limit theorem, that is, a sample size above 30, statistical analysis could still be conducted [41]. In this research, 36% of the respondents were from consultant companies, 31% from government authorities, 24% from contracting companies, and 9% from universities. The respondent demographics are shown in Table 1. Notably, there are few experts in Jordan who have more than 10 years of experience in sustainable construction or have a PhD in the field of sustainability. Available data and information on the two pioneer LEED-v2.2-certified green buildings in Amman (World Health Organization Building; Dutch Embassy) were collected.

Table 1. Respondent demographics

Items	Category	Consultants		Contractor		Government authorities		Universities		Overall	
		No.	%	No.	%	No.	%	No.	%	No.	%
Respondents’ gender	Female	11	65	4	29	7	37	3	60	25	45
	Male	9	53	9	64	10	53	2	40	30	55
Respondents 'age	20–30 years	2	10	1	8	1	6			4	7
	31–40 years	14	70	7	54	6	35	2	40	29	53
	>40 years	4	20	5	38	10	59	3	60	22	40
Respondents’ education	Bachelor	10	59	12	86	11	58			33	60
	Master or PhD	7	41	2	14	8	42	5	100	22	40
Respondents’ designation	Architect	2	10	1	8	1	6			4	7
	Senior architect	4	20	1	8	2	12			7	13
	Senior civil engineer	2	10	1	8	2	12			5	9
	Senior mechanical engineer	3	15	2	15	1	6			6	11
	Senior electrical engineer	4	20	2	15	2	12			8	15
	Project manager	1	5	3	23	1	6			5	9
	General manager	1	5	1	8					2	4
	Senior technical advisor	1	5			3	18			4	7
	Senior manger	1	5	1	8	2	12			4	7
	Managing director	1	5	1	8	3	18			5	9
	Assistant professor							2	40	2	4
	Associate professor							3	60	3	5
Respondents’ experience	<5 years	2	10	1	8	1	6	1	20	5	9
	5–10 years	5	25	3	23	4	24	1	20	13	24
	>15 years	13	65	9	69	12	71	3	60	37	67

3.3 Data analysis and hypothesis testing

The collected data were classified and tabulated prior to quantitative analysis (Table 2). The hypotheses were tested to indicate if a relationship exists between LEED v2.2 credits in the WE and AE categories and the UN SDGs using Pearson's Chi-square and Cramer's V tests. The independent variables are LEED v2.2 prerequisites and credits in the WE and AE categories. The dependent variables are the UN SDGs 6, 7, 8, 9, 12, 13, and 15. Null hypotheses (no relationship between variables) were rejected at the $p < 0.05$ level. The nonparametric Chi-square metric was chosen because it is based on frequencies instead of parameters such as the unavailable means and standard deviations; there is no need for assumptions regarding the type of the population and parametric values and nonparametric tests are appropriate for ordinal or nominal scales.

Table 2 Statistical design

#	Questions	Measurement level	Statistics
Q1	Gender	Nominal	Frequencies
Q2	Age	Scale	Frequencies
Q3	Designation	Nominal	Frequencies
Q4	Total years of work experience	Scale	Frequencies
Q5	Contributions of the implementation of LEED v2.2 WE credits to achieve the UN SDGs	Ordinal	Frequency, Chi-square, and Cramer's V tests
Q6	Contributions of the implementation of LEED v2.2 EA prerequisites and credits to achieve the UN SDGs	Ordinal	Frequency, Chi-square, and Cramer's V tests

3.4 Constructing the Contribution Indices

The composite index is a mathematical tool (simple or complex) that aggregates indicators, which is increasingly recognized as a practical method in policy analysis and public communication for the comparison of performances [42].

Generally, an aggregation method can be considered to be "simple" or "complex." We define an aggregation method as "simple" if an easily understandable mathematical function is used [42]. For example, the Human Development Index (HDI) developed by the United Nations Development Program is "a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living. The HDI is the geometric mean of normalized indices for each of three key dimensions" [43].

The development of the contribution indices in this research is based on the data collected in the survey regarding the opinion of Jordan's experts on the contributions of the implementation of LEED v2.2 credits prerequisites in the WE and EA categories to achieve the UN SDGs. Following equations are proposed:

The *Frequency Contribution of the Water Efficiency Index (FCWEI)* is an index that describes the contribution percentage of each LEED v2.2 WE credit (WE_l: $WE_{c1.1}$,

$WE_{c1.2}$, WE_{c2}, $WE_{c3.1}$, *and* $WE_{c3.2}$) to achieve each UN SDGs (SDG_h: SDG_6, SDG_8, SDG_9, SDG_{12}, SDG_{13}, *and* SDG_{15}).

$$FCWEI_{WE_l\&\,SDG_h} = Achievement\,\% \times \frac{n_{WE_l\&SDG_h}}{N_{WE_l\&SDG_h}} \times 100 \qquad (1)$$

The $FCWEI_{WE_l\&\,SDG_h}$ is the Frequency Contribution of the Water Efficiency Index; Achievement % is the percentage of the achievement of WE_l; $n_{WE_l\&SDG_h}$ is the number of expert responses agreeing that the implementation of WE_l can contribute to achieving SDG_h; and $N_{WE_l\&SDG_h}$ is the total number of expert responses on the contributions of the implementation of WE_l to achieve SDG_h in Jordan.
The *Frequency Contribution of Energy and Atmosphere Index (FCEAI)* is an index that describes the contribution percentage of each LEED v2.2 EA prerequisite and credit (EA_k: EA_{P1}, EA_{P2}, EA_{P3}, EA_{C1}, EA_{C2}, EA_{C3}, EA_{C4}, EA_{C4}, EA_{C5}, EA_{C6}) to achieve each UN SDG (SDG_i: *SDG7, SDG8, SDG9, SDG12, SDG13*).

$$FCEAI_{EA_k\&\,SDG_i} = Acheivement\,\% \times \frac{n_{EA_k\&SDG_i}}{N_{EA_k\&SDG_i}} \times 100\,, \qquad (2)$$

where the $FCEAI_{EA_k\&\,SDG_i}$ is the Frequency Contribution of Energy and Atmosphere Index; Achievement % is the percentage of achievement of EA_k; $n_{EA_k\&SDG_i}$ is the number of expert responses agreeing that the implementation of EA_k can contribute to achieving SDG_i; and $N_{EA_k\&SDG_i}$ is the total number of expert responses on the contributions of the implementation of EA_k to achieving SDG_i in Jordan.
The *Multidimensional Contribution of Water Efficiency Index (MCWEI)* is an integrated index that describes the overall contribution percentage of each LEED v2.2 WE credit (WE_l: $WE_{c1.1}$, $WE_{c1.2}$, WE_{c2}, $WE_{c3.1}$, *and* $WE_{c3.2}$) to achieve the UN SDGs 6, 8, 9, 12–13, and 15 in Jordan. The geometric mean of the *FCWEI* for each LEED v2.2 WE credit is used to calculate the *MCWEI.*

$$MCWEI = (FCWEI_{WE_l\&\,SDG_6} \times FCWEI_{WE_l\&\,SDG_8} \times FCWEI_{WE_l\&\,SDG_9} \times FCWEI_{WE_l\&\,SDG_{12}} \times FCWEI_{WE_l\&\,SDG_{13}} \times FCWEI_{WE_l\&\,SDG_{15}})^{1/6} \qquad (3)$$

The *Multidimensional Contribution of Energy & Atmosphere Index (MCEAI)* is an integrated index that describes the overall contribution percentage of each LEED v2.2 EA prerequisite and credit (EA_k: EA_{P1}, EA_{P2}, EA_{P3}, EA_{C1}, EA_{C2}, EA_{C3}, EA_{C4}, EA_{C4}, EA_{C5}, EA_{C6}) to achieve the UN SDGs 7–9, 12, and 13 in Jordan. The geometric mean of FCI for each LEED v2.2 EA prerequisite and credit is used to calculate the *MCEAI.*

$$MCEAI = (FCEAI_{EA_k\&\,SDG_7} \times FCEAI_{EA_k\&\,SDG_8} \times FCEAI_{EA_k\&\,SDG_9} \times FCEAI_{EA_k\&\,SDG_{12}} \times FCEAI_{EA_k\&\,SDG_{13}})^{1/5} \qquad (6)$$

The *Comprehensive Contribution to Development Index (CCDI)* is a comprehensive index that describes the overall contribution percentage of all LEED v2.2 WE credits and EA prerequisites and credits to achieve the UN SDGs 6–9, 12–13, and 15 in Jordan.

The mean *MCWEI* for each LEED v2.2 WE credit and *MCEAI* for each LEED v2.2 EA prerequisite and credit are used to calculate the *CCDI*.

$$
\begin{aligned}
&Comprehensive\ Contributions\ to\ Development\ Index\ (CCDI) \\
&\quad = (MCWEI_{WEc1.1} + MCWEI_{WEc1.2} + MCWEI_{WEc2} \\
&\quad + MCWEI_{WEc3.1} + MCWEI_{WEc3.2} + MCEAI_{EAp1} \\
&\quad + MCEAI_{EAp2} + MCEAI_{EAp3} + MCEAI_{EAc1} + MCEAI_{EAc2} \\
&\quad + MCEAI_{EAc3} + MCEAI_{EAc4} \\
&\quad + MCEAI_{EAC5} + MCEAI_{EAc6})/14
\end{aligned} \tag{7}
$$

This research introduces a new index to assess the contributions of the implementation of LEED v2.2 prerequisite credits in the WE and EA categories to achieve the UN SDGs.

3.5 Validation of the Results

Krueger, one of the leading researcher in focus group, described the focus group as "a carefully planned discussion designed to obtain perceptions on a defined area of interest in an open-minded, nonthreatening environment" [44]. Focus groups can be used both during preliminary or exploratory stages of a research project, where questions are explored and hypotheses are generated, and at later stages to assess the development, effectiveness, or impact of a program of activities [44].

A thorough manual on the use of focus groups in research has been published by the United Nations University and is available online. This manual describes a focus group as "a research approach that has proven to be extremely useful in a wide variety of settings to rapidly and economically provide information on the range of opinions, knowledge, beliefs, and practices of a population" [45].

A focus group approach has been chosen for the validation of the results in this research. Krueger suggested a number of participants between five and ten [46]. In this research, ten participants, both male and female, were selected based on their expertise, role, and experience. The participants are Jordanian building-project experts (consultants, contractors, government officials, and academic experts from universities). They have theoretical and practical experience in green building projects.

3.6 Application of the CCDI for the assessment of the contributions of LEED-v2.2-certified green buildings

To test the usability of CCDI for assessing the contributions water and energy efficiency in LEED-v2.2-certified green building to achieve UN SDGs in Jordan, the two pioneer LEED-v2.2-certified green building (the World Health Organization Building in Amman and the Dutch Embassy in Amman) were selected.

The World Health Organization (WHO) Building (Amman offices) earned the first Gold LEED v2.2. Certification for a green building in Jordan, with the USGBC's final review awarding 42 points. The four-story office building is located in a business zone next to a major road in Amman. The building area is approximately 4,000 m^2; existing infrastructure with close access to private and public transportation is utilized.

The Embassy Building of the Kingdom of the Netherlands in Amman earned the Silver LEED v2.2 Certification (34 points). An existing villa was converted into the offices of the Dutch embassy. The building area is 1,253 m^2 (including both existing and new areas for the main building and annexes).

4. Results and Discussions

4.1 Relationship between the UN SDGs and LEEDV2.2 credits in the WE category

The Pearson's Chi-square tests (Fig.4) show significant evidence of relationships between LEED v2.2 credits in the WE category and SDG6 [χ^2 (df = 4, N = 55) = 35.568, p < 0.000], SDG8 [χ^2 (df = 4, N = 55) = 32.387, p < 0.000], SDG9 [χ^2 (df = 4, N = 55) = 28.205, p < 0.000], SDG12 [χ^2 (df = 4, N = 55) = 20.398, p < 0.000], SDG13 [χ^2 (df = 4, N = 55) = 19.652, p < 0.000], and SDG15 [χ^2 (df = 4, N = 55) = 29.950, p < 0.000]. The results have a small p-value (<0.05), which is strong evidence against null hypotheses; therefore, we confirm all sub-hypotheses (H1A, H1B, H1C, H1D, H1E, and H1F) and thus the main hypothesis H1. These findings are in line with previous arguments in the literature that LEED-certified green buildings have considerable environmental, social, and economic benefits regarding water-saving measures and Jordan's challenges with respect to the water scarcity.

Opinion of Jordan's experts about the contribution of the implementation of LEED v2.2 credits in the WE category to achieving the UN SDGs.

WE credit	SDG6					SDG8					SDG9					SDG12					SDG13					SDG15				
	Agree		Disagree		Total	Agree		Disagree		Total	Agree		Disagree		Total	Agree		Disagree		Total	Agree		Disagree		Total	Agree		Disagree		Total
WE 1.1	33	60%	22	40%	55	28	51%	27	49%	55	38	69%	17	31%	55	29	53%	26	47%	55	30	55%	25	45%	55	29	53%	26	47%	55
WE 1.2	42	76%	13	24%	55	37	67%	18	33%	55	42	76%	13	24%	55	32	58%	23	42%	55	33	60%	22	40%	55	33	60%	22	40%	55
WE 2	48	87%	7	13%	55	42	76%	13	24%	55	50	91%	5	9%	55	36	65%	19	35%	55	39	71%	16	29%	55	44	80%	11	20%	55
WE 3.1	51	93%	4	7%	55	48	87%	7	13%	55	52	95%	3	5%	55	42	76%	13	24%	55	44	80%	11	20%	55	46	84%	9	16%	55
WE 3.2	54	98%	1	2%	55	51	93%	4	7%	55	54	98%	1	2%	55	48	87%	7	13%	55	48	87%	7	13%	55	50	91%	5	9%	55

Relationship between the LEED v2.2 prerequisites and credits in the WE category and UN SDGs.

Independence test			Decision	Results
Cross tabulation	Chi-square test	Cramer's V coefficient		
Crosstab WE * SDG6	χ^2 (df = 4, N = 55) = 35.568, p < 0.000	0.36	Reject null hypothesis	H1A confirmed: There is a strong relationship between SDG6 and LEED v2.2 WE credits
Crosstab WE * SDG8	χ^2 (df = 4, N = 55) = 32.387, p < 0.000	0.343	Reject null hypothesis	H1B confirmed: There is a strong relationship between SDG8 and LEED v2.2 WE credits
Crosstab WE * SDG9	χ^2 (df = 4, N = 55) = 28.205, p < 0.000	0.320	Reject null hypothesis	H1C confirmed: There is a strong relationship between SDG9 and LEED v2.2 WE credits
Crosstab WE * SDG12	χ^2 (df = 4, N = 5) = 20.389, p < 0.000	0.271	Reject null hypothesis	H1D confirmed: There is a moderate relationship between SDG12 and LEED v2.2 WE credits
Crosstab WE * SDG13	χ^2 (df = 4, N = 55) = 19.652, p < 0.001	0.267	Reject null hypothesis	H1E confirmed: There is a moderate relationship between SDG13 and LEED v2.2 WE credits
Crosstab WE * SDG15	χ^2 (df = 4, N = 55) = 29.950, p < 0.001	0.33	Reject null hypothesis	H1F confirmed: There is a strong relationship between SDG15 and LEED v2.2 WE credits

Fig.4 Relationship between the LEED v2.2 prerequisites and credits in the WE category and UN SDGs.

4.2 Relationship between the UN SDGs and LEEDV2.2 prerequisites and credits in the EA category

The Pearson's chi-square tests (Fig.5) reveal significant evidence of strong relationships between LEED v2.2 prerequisites and credits in the EA category and SDG7 [χ^2 (df = 4, N = 55) = 230.37, p < 0.000], SDG8 [χ^2 (df = 4, N = 55) = 111.148, p < 0.000], SDG9 [χ^2 (df = 4, N = 55) = 54.351, p < 0.000], SDG12 [χ^2 (df = 4, N = 55) = 135.46, p < 0.000], and SDG13 [χ^2 (df = 4, N = 55) = 78.05, p < 0.000]. The results have a small p-value (<0.05), which is strong evidence against null hypotheses; therefore, we confirm all sub-hypotheses (H2A, H2B, H2C, H2D, and H2E) and thus the main hypothesis H2. These findings support previous arguments in the literature that LEED-certified green buildings address energy savings by reducing the amount of energy required for building operations and by utilizing clean and renewable energy.

Opinion of Jordan's experts on the contribution of the implementation of LEED v2.2 prerequisites and credits in the EA category to achieving the UN SDGs.

EA Credits	SDG7					SDG8					SDG9					SDG12					SDG13				
	Agree		Disagree		Total	Agree		Disagree		Total	Agree		Disagree		Total	Agree		Disagree		Total	Agree		Disagree		Total
EAp1	45	82%	10	18%	55	50	91%	5	9%	55	47	85%	8	15%	55	32	58%	23	42%	55	35	64%	20	36%	55
EAp2	30	55%	25	45%	55	25	45%	30	55%	55	40	73%	15	27%	55	40	73%	15	27%	55	43	78%	12	22%	55
EAp3	5	9%	50	91%	55	22	40%	33	60%	55	37	67%	18	33%	55	11	20%	44	80%	55	51	93%	4	7%	55
EAc1	52	95%	3	5%	55	51	93%	4	7%	55	53	96%	2	4%	55	52	95%	3	5%	55	50	91%	5	9%	55
EAc2	53	96%	2	4%	55	52	95%	3	5%	55	54	98%	1	2%	55	53	96%	2	4%	55	54	98%	1	2%	55
EAc3	46	84%	9	16%	55	42	76%	13	24%	55	30	55%	25	45%	55	32	58%	23	42%	55	30	55%	25	45%	55
EAc4	3	5%	52	95%	55	28	51%	27	49%	55	33	60%	22	40%	55	37	67%	18	33%	55	52	95%	3	5%	55
EAc5	47	85%	8	15%	55	39	71%	16	29%	55	41	75%	14	25%	55	52	95%	3	5%	55	36	65%	19	35%	55
EAc6	28	51%	27	49%	55	52	95%	3	5%	55	45	82%	10	18%	55	48	87%	7	13%	55	52	95%	3	5%	55

Relationship between the LEED v2.2 prerequisites and credits in the EA category and UN SDGs.

Intendant test			Decision	Results
Cross tabulation	**Chi-square test**	**Cramer's V coefficient**		
Crosstab EA * SDG6	χ^2 (df = 4, N = 55) = 230.37, p < 0.000	0.682	Reject null hypothesis	H2A confirmed: There is a strong relationship between SDG7 and LEED v2.2 EA prerequisites & credits
Crosstab EA * SDG8	χ^2 (df = 4, N = 55) = 111.48, p < 0.000	0.474	Reject null hypothesis	H2B confirmed: There is a strong relationship between SDG8 and LEED v2.2 EA prerequisites & credits
Crosstab EA * SDG9	χ^2 (df = 4, N = 55) = 54.351, p < 0.000	0.33	Reject null hypothesis	H2C confirmed: There is a strong relationship between SDG9 and LEED v2.2 EA prerequisites & credits
Crosstab EA * SDG12	χ^2 (df = 4, N = 5) = 135.460, p < 0.000	0.523	Reject null hypothesis	H2D confirmed: There is a strong relationship between SDG12 and LEED v2.2 EA prerequisites & credits
Crosstab EA * SDG13	χ^2 (df = 4, N = 55) = 78.05, p < 0.001	0.397	Reject null hypothesis	H2E confirmed: There is a strong relationship between SDG13 and LEED v2.2 EA prerequisites & credits

Fig.5 Relationship between the LEED v2.2 prerequisites and credits in the EA category and UN SDGs.

4.3 Application of the Contribution Indices

Based on the results of the hypotheses tests, indices were developed to assess the contribution of the implementation of LEED v2.2 prerequisites and credits in the WE and AE categories to achieve the UN SDGs in Jordan. Fig. 6 shows the contribution indices of LEED v2.2 prerequisites and credits in the WE and EA categories.

Based on the proposed MCDWEI, the LEED v2.2 WE credits are ranked as "WEc3.2: Water Use Reduction: 30% Reduction" (93.9), "WEc3.1: Water Use Reduction: 20% Reduction" (88.9), "WEc2: Innovative Wastewater Technologies" (76), "WEc1.2: Water-Efficient Landscaping: No Potable Water Use or Irrigation" (73.4), and "WEc1.1: Water-Efficient Landscaping: Reduce by 50%" (57.3)

Based on the proposed MCDEAI, the LEED v2.2 prerequisites and credits in the EA category are ranked as "EAc2: On-Site Renewable Energy" (96.6), "EAc1: Optimize Energy Performance" (94), "EAc6: Green Power" (80), "EAc5: Measurement & Verification"(77.5), "EA Prerequisite 1: Fundamental Commissioning of the Building Energy Systems" (74.9), EAc3: Enhanced Commissioning (64.5), "EA Prerequisite 2: Minimum Energy Performance" (63.5), "EAc4: Enhanced Refrigerant Management" (39.6), and "EA Prerequisite 3: Fundamental Refrigerant Management" (33.9).

LEED BD+C: New Construction (v2.2) Water Efficiency (WE) and Energy & Atmosphere (EA)				SUSTAINABLE DEVELOPMENT GOALS							Contributions Index	
Prerequisits & Credits			Achieved	SDG 6	SDG 7	SDG 8	SDG 9	SDG 12	SDG 13	SDG 15	MCWEI / MCEAI	CCDI
WE -Credits	WEc1.1	Water Efficient Landscaping: Reduce by 50%.	100%	60		51	69	53	55	53	57.3	72.4
	WEc1.2	Water Efficient Landscaping: No Potable Water Use or No Irrigation.	100%	76		67	76	58	60	60	73.4	
	WEc2	Innovative Wastewater Technologies.	100%	87		76	91	65	71	80	76.0	
	WEc3.1	Water Use Reduction: 20% Reduction.	100%	93		87	95	76	80	84	88.9	
	WEc3.2	Water Use Reduction: 30% Reduction.	100%	98		93	98	87	87	91	93.9	
EA - Prerequisites & Credits	EAp1	Fundamental Commissioning of the Building Energy Systems.	100%		82	91	85	58	64		74.9	
	EAp2	Minimum Energy Performance.	100%		55	45	73	73	78		63.5	
	EAp3	Fundamental Refrigerant Management.	100%		9	40	67	20	93		33.9	
	EAc1	Optimize Energy Performance.	100%		95	93	96	95	91		94.0	
	EAc2	On-Site Renewable Energy	100%		96	95	98	96	98		96.6	
	EAc3	Enhanced Commissioning	100%		84	76	55	58	55		64.5	
	EAc4	Enhanced Refrigerant Management.	100%		5	51	60	67	95		39.6	
	EAc5	Measurement & Verification	100%		85	71	75	95	65		77.5	
	EAc6	Green Power	100%		51	95	82	87	95		80.0	

Examples of Calculations:

Frequency Contribution of Water Efficiency Index (FCWEI)

$FCWEI_{WEc1.1\&SDG6}$ =100%*(33/55)*100=60

Frequency Contribution of Energy & Atmosphere Index (FCEAI)

$FCEAI_{EAp1\&SDG7}$ =100%*(45/55)*100=82

Multidimensional Contribution of Water Efficiency Index (MCWEI)

$MCWEI_{WEc1.1}= (FCWEI_{WEc1.1\&SDG6} * FCWEI_{WEc1.1\&SDG8} * FCWEI_{WEc1.1\&SDG9} * FCWEI_{WEc1.1\&SDG12} * FCWEI_{WEc1.1\&SDG13} * FCWEI_{WEc1.1\&SDG15})^{1/6}$

$MCWEI_{WEc1.1}=(60*51*69*53*55*53)^{1/6} = 57.3$

Multidimensional Contribution of Energy & Atmosphere Index (MCEAI)

$MCEAI_{EAP1}= (FCEAI_{EAp1\&SDG7} * FCEAI_{EAP1\&SDG8} * FCEAI_{EAp1\&SDG9} * FCEAI_{EAP1\&SDG12} * FCEAI_{EAP1\&SDG13})^{1/5}$

$MCEAI_{EAP1}=(82*91*85*58*64)^{1/5} = 74.9$

Comprehensive Contribution to Development Index (CCDI)

$CCDI=(MCWEI_{WEc1.1}+MCWEI_{WEc1.2}+MCWEI_{WEc2}+MCWEI_{WEc3.1}+MCEAI_{WEc3.2}+MCEAI_{EAP1}+MCEAI_{EAP2}+MCEAI_{EAP3}+MCEAI_{EAC1}+MCEAI_{EAC2}+MCEAI_{EAC3}+MCEAI_{EAC4}+MCEAI_{EAC5}+MCEAI_{EAC5}+MCEI_{EAC6}) / 14$

$CCDI=(57.3+73.4+76+88.9+93.9+74.9+63.5+33.9+94+96.6+64.5+39.6+77.5+80) / 14 = 72.4$

Fig. 6. Relationships between the LEED v2.2 prerequisites and credits in the WE and AE categories and UN SDGs in Jordan.

4.4 Validation of Results

This section discusses the validation of the identified relationships between the UN SDGs and LEEDV2.2 prerequisites and credits in the WE and EA categories and the validation of proposed contribution indices.

4.4.1 Validation of identified relationships between the UN SDGs and LEEDV2.2 prerequisites and credits in the WE and EA categories

The results of this research on the relationship between the UN SDGs and LEEDV2.2 prerequisites and credits in the WE and EA categories in Jordan were presented during focus group discussions. All participants were asked to reply with a yes/no answer whether they think the results are reasonable and reliable.

The expert groups discussed the intent, cost, applicability, feasibility, and ease of implementation of the LEEDV2.2 prerequisites and credits in the WE and EA categories in Jordan. Furthermore, they discussed the targets of each UN SDG.

After a lengthy discussion, all experts agreed that the results are reasonable and reliable. Table 3 presents the responses of the focus group. Hence, the results were validated.

Table 3. Validation of identified relationships between the UN SDGs and LEEDV2.2 prerequisites and credits in the WE and EA categories

Question: What is your opinion of the results in this research? Are they reasonable?

Relationship between the UN SDGs and LEEDV2.2 prerequisites and credits in the WE and EA categories	**Focus group responses**			
	Yes		**NO**	
	Frequency	**%**	**Frequency**	**%**
There is a strong relationship between SDG6 and LEED v2.2 WE credits.	10	100	0	0
There is a strong relationship between SDG8 and LEED v2.2 WE credits.	10	100	0	0
There is a strong relationship between SDG9 and LEED v2.2 WE credits.	10	100	0	0
There is a moderate relationship between SDG12 and LEED v2.2 WE credits.	10	100	0	0
There is a moderate relationship between SDG13 and LEED v2.2 WE credits.	10	100	0	0
There is a strong relationship between SDG15 and LEED v2.2 WE credit.	10	100	0	0
There is a strong relationship between SDG7 and LEED v2.2 EA prerequisites and credits.	10	100	0	0
There is a strong relationship between SDG8 and LEED v2.2 EA prerequisites and credits.	10	100	0	0
There is a strong relationship between SDG9 and LEED v2.2 EA prerequisites and credits.	10	100	0	0
There is a strong relationship between SDG12 and LEED v2.2 EA prerequisites and credits.	10	100	0	0
There is a strong relationship between SDG13 and LEED v2.2 EA prerequisites and credits.	10	100	0	0

4.4.2 Validation of the Contribution Indices

The focus group was presented with contribution indices developed in this study. The expert group was asked to provide their opinion about the contribution indices (ease of understanding, robustness, and compatibility with Jordan conditions and environment).

The experts were also asked about their recommendations for further development. Table 4 presents the responses of the focus group.

All ten (100%) focus group members agreed that the contribution indices are easy to understand and compatible with Jordan's environment and conditions. They will provide a robust assessment of the contribution of the water and energy efficiency of LEED v2.2 certified-buildings to achieve the UN SDGs. They also agreed that the contribution indices will help to understand how water and energy efficiency in green buildings can contribute to achieving the UN SDGs in Jordan.

Nine (90%) focus group members agreed that the methodology used to construct the contribution indices is reliable. They recommended other researchers and policy makers to use this methodology to develop a new assessment method for the contribution of water and energy efficiency in green buildings for other versions of LEED or other green building assessment systems. Only one expert was not sure if this methodology can be used to construct contribution indices. Therefore, the contribution indices were validated.

Table 4. Validation of the Contribution Indices

	Question		**Frequency**	**%**
1	The contribution indices are … ?	Easy to understand	10	100
		Difficult to understand	0	0
		Neither easy nor difficult to understand	0	0
2	The contribution indices will provide a robust assessment for the contribution of the water and energy efficiency in LEED v2.2-certified buildings to achieve the UN SDGs.	Yes	10	100
		No	0	0
		Not sure	0	0
3	The contribution indices measures are compatible with Jordan's environment and conditions.	Yes	10	100
		No		0
		Not sure		0
4	The contribution indices will help to understand how water and energy efficiency in green buildings can contribute to achieving the UN SDGs in Jordan.	Yes	10	100
		No	0	0
		Not sure	0	0
5	The methodology used to construct the contribution indices is reliable and will guide researchers and policy maker in developing new assessment methods for the contribution of water and energy efficiency in green buildings for other versions of LEED or other green building assessment systems.	Wide use recommended	9	90
		Not recommended	0	0
		Not sure	1	10

4.5 Assessing the contributions of LEED-v2.2-certified green buildings to achieve the UN SDGs in Jordan

An assessment of the contributions of water and energy efficiency in the two pioneer LEED-v2.2-certified green buildings to achieve the UN SDGs in Jordan was conducted to determine the usability of the CCDI for the assessment and comparison of the contributions of different certified buildings to achieve the UN SDGs in Jordan.

Figs7 and 8 show that the LEED v2.2 WE and EA prerequisites and credits in the two pioneer LEED-v2.2-certified buildings (WHO building and Dutch embassy in Amman) contribute to achieving SDG6, SDG7, SDG8, SDG9, SDG12, SDG13, and SDG15 in Jordan. The CCDI values for the WHO building in Amman is 51.2, while that for the Dutch embassy in Amman is 39.6. This indicates that the WHO building in Amman contributes more to achieving the UN SDGs in Jordan. The MCWEI and MCEAI values significantly affect the CCDI value. One of the most interesting results is that the contributions of the water and energy efficiency in LEED green buildings to achieve the UN SDGs can be improved if priority is given to the implementation of WE and EA credits with high MCWEI and MCEAI values.

World Health Organization Building GOLD, AWARDED DEC 2011												
LEED BD+C: New Construction (v2.2) Water Efficiency (WE) and Energy & Atmosphere (EA)				SUSTAINABLE DEVELOPMENT GOALS							Contributions Index	
Prerequisits & Credits			Achieved	SDG 6	SDG 7	SDG 8	SDG 9	SDG 12	SDG 13	SDG 15	MCDI	CCDI
WE -Credits	WEc1.1	Water Efficient Landscaping: Reduce by 50%.	100%	60		51	69	53	55	53	57.3	51.2
	WEc1.2	Water Efficient Landscaping: No Potable Water Use or No Irrigation.	100%	76		67	76	58	60	60	73.4	
	WEc2	Innovative Wastewater Technologies.	100%	87		76	91	65	71	80	76.0	
	WEc3.1	Water Use Reduction: 20% Reduction.	100%	93		87	95	76	80	84	88.9	
	WEc3.2	Water Use Reduction: 30% Reduction.	100%	98		93	98	87	87	91	93.9	
EA - Prerequisites & Credits	EAp1	Fundamental Commissioning of the Building Energy Systems.	100%		82	91	85	58	64		74.9	
	EAp2	Minimum Energy Performance.	100%		55	45	73	73	78		63.5	
	EAp3	Fundamental Refrigerant Management.	100%		9	40	67	20	93		33.9	
	EAc1	Optimize Energy Performance.	40%		95	93	96	95	91		37.6	
	EAc2	On-Site Renewable Energy	0%		96	95	98	96	98		0.0	
	EAc3	Enhanced Commissioning	0%		84	76	55	58	55		0.0	
	EAc4	Enhanced Refrigerant Management.	100%		5	51	60	67	95		39.6	
	EAc5	Measurement & Verification	100%		85	71	75	95	65		77.5	
	EAc6	Green Power	0%		51	95	82	87	95		0.0	

Fig. 7. Contribution of an LEED-v2.2-certified building (WHO building in Amman) to achieving the UN SDGs in Jordan.

Dutch Embassy in Amman, Jordan SILVER, AWARDED OCT 2010												
LEED BD+C: New Construction (v2.2) Water Efficiency (WE) and Energy & Atmosphere (EA)				SUSTAINABLE DEVELOPMENT GOALS							Contributions Index	
Prerequisits & Credits			Achieved	SDG 6	SDG 7	SDG 8	SDG 9	SDG 12	SDG 13	SDG 15	MCDI	CCDI
WE -Credits	WEc1.1	Water Efficient Landscaping: Reduce by 50%.	100%	60		51	69	53	55	53	57.3	
	WEc1.2	Water Efficient Landscaping: No Potable Water Use or No Irrigation.	0%	76		67	76	58	60	60	0.0	
	WEc2	Innovative Wastewater Technologies.	0%	87		76	91	65	71	80	0.0	
	WEc3.1	Water Use Reduction: 20% Reduction.	100%	93		87	95	76	80	84	88.9	
	WEc3.2	Water Use Reduction: 30% Reduction.	100%	98		93	98	87	87	91	93.9	
EA - Prerequisites & Credits	EAp1	Fundamental Commissioning of the Building Energy Systems.	100%		82	91	85	58	64		74.9	
	EAp2	Minimum Energy Performance.	100%		55	45	73	73	78		63.5	
	EAp3	Fundamental Refrigerant Management.	100%		9	40	67	20	93		33.9	39.6
	EAc1	Optimize Energy Performance.	40%		95	93	96	95	91		37.6	
	EAc2	On-Site Renewable Energy	67%		96	95	98	96	98		64.4	
	EAc3	Enhanced Commissioning	0%		84	76	55	58	55		0.0	
	EAc4	Enhanced Refrigerant Management.	100%		5	51	60	67	95		39.6	
	EAc5	Measurement & Verification	0%		85	71	75	95	65		0.0	
	EAc6	Green Power	0%		51	95	82	87	95		0.0	

Fig. 8. Contribution of an LEED-v2.2-certified building (Dutch embassy in Amman) to achieving the UN SDGs in Jordan.

5. Conclusion

Governments across the world have developed strategies to meet UN SDGs and green buildings have an important role to play in this respect. Water and energy efficiency in building has a critical role towards achieving UN SDGs. Governments, designers and developers need to be better informed about the advantages of invest in water and energy efficiency measures in green buildings to maximize the contribution towards achieving UN SDGs. Presently, there is lack of information and understanding on the subject as none of the existing green buildings assessment tools describe the relationship between its water and energy efficiency indicators and UN SDGs. There is thus a need for a methodology to assess and improve the contribution of water and energy efficiency in achieving UN SDGs. This study attempts to bridge this gap in the scholarship. It is the first research to identify the contributions of the implementation of LEED v2.2 prerequisites and credits in the WE and EA categories to achieve the UN

SDGs. It proposes an index for the assessment of the contribution of water and energy efficiency in LEED-v2.2-certified green buildings to achieve the UN SDGs in Jordan. The proposed index can help governments, designers and developers to priorities their strategies and optimally allocate resources to achieve the UN SDGs through water and energy efficiency measures. The proposed index can be used by researchers in Jordan and elsewhere in the world to develop a new assessment method for the contribution of the water and energy efficiency in green buildings for other LEED versions or other green building assessment systems. It is found that the implementation of LEED v2.2 WE credit and AE prerequisites and credits contributes to achieving seven UN SDGs in Jordan: SD6, SDG7, SDG8, SDG9, SDG12, SDG13, and SDG15. The tests of all sub-hypotheses confirms the two main hypothesis: there is a significant relationship between the UN SDGs and LEED v2.2 credits in the WE category and there is a significant relationship between the UN SDGs and LEED v2.2 prerequisites and credits in the EA category. The contributions of water and energy efficiency in the two pioneer LEED-v2.2-certified green buildings to achieving the UN SDGs in Jordan were assessed. The CCDI values are 51.2 for the WHO building in Amman and 39.6 for the Dutch embassy in Amman. This indicates that the WHO building in Amman contributes more to achieving the UN SDGs in Jordan. The MCWEI and MCEAI help to understand which credit or prerequisite of the LEED v2.2 WE and EA categories contribute the most to achieving the UN SDGs. It is concluded that the indices are useful tools for the assessment of the contribution of the water and energy efficiency on the building scale level.

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