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Adapting LEED Green Building Rating System to Analyze Environmental Quality of Residential Multifamily Homes in Algeria, Case of Tebessa

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In Algeria, residential multifamily homes are designed and constructed on a quantitative scale, not qualitative ones. Besides, advanced countries developed several systems and tools to create green buildings that use processes that maximize health and comfort, improve environmental performance and minimize resource consumption. This paper presents two research sections. The first is to adapt the last version of Leadership in Energy and Environmental Design (LEED) 4.1 residential Building Design +Construction (BD+C) multifamily homes scorecard in the Algerian context. The study analyzes all criteria of nine axes on two parameters (Authority intervention, tools availability, and usability, including qualifications and local environment companies). The second part of this study is to evaluate three representative residential multifamily homes in the case study of Tebessa, with the previously adapted scorecard that resumes available credits and prerequisites. The final results indicate that (35/43) credits and (12/16) prerequisites are classed as eligible, and only 6 technical credits were achieved in the three chosen projects in Tebessa. That refers to a clear absence of adopting minimum easy and not high-profit solutions. This turn to a lack of responsibility of different stockholders to integrate environmental quality plan in all phases of the building life cycle.

Key words: Residential multifamily homes, Environmental quality, LEED, Algerian context, Adapted scorecard.

INTRODUCTION

Buildings as a living, breathing organisms, are powerful in their positive effect (health and Well-being) or their worst form (from asthma, cancer to obesity, to other social, economic, and environmental issues) (Potrč Obrecht et al. 2019, Anderson, Wulfhorst, and Lang 2015). Due to the new pandemic, people are spending the majority of their time at home and consequently, the quality of the indoor environment is becoming increasingly important (Fokaides et al. 2020). According to the Environmental Protection agency, achieving a healthier, safer, and improved quality of life by being environmentally responsible and resource-efficient throughout a building's life cycle is a fully complex design approach. That will help to resolve much of the negative impact caused by buildings and human practices on the environment and occupants. That subject has motivated developed countries to the development of hundreds of tools and systems in the world and created green-building standards and certifications, which took big steps in trying to solve the problem in its little details. Every day, green buildings became the nowadays subject and interest, which is constantly changing and progressing (Khoshbakht et al. 2018, Ravasio, Sveen, and Riise 2020). The national association of homebuilders (NAHB) present that: *"A green home incorporates strategies in design and construction that increase energy, water and resource efficiency, indoor environmental quality, and minimize environmental impacts on the site; and/or is certified by a third-party to the National Green Building Standard, LEED for Homes or any other green rating system".* (Nahb 2020)

International organizations have initiated houses evaluation systems such as Building Research Establishment Environmental Assessment Method (BREEAM) Home Quality Mark developed by the Building Research Establishment, Leadership in Energy and Environmental Design (LEED) homes developed by the US Green Building Council (USGBC), and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) for homes developed in Japan. (Illankoon et al. 2017, Bernardi et al. 2017, Matsui 2017, U.S.G.B.C 2021b).

However, in the field of architecture, for a half-century, in Algeria we still build anyhow from an energy and environmental point of view, especially in the sector of Habitat. The traditional building design system has been the most adapted, the beginning with the site selection and plan, all the way through the building's entire life cycle. Skipping the negative impact that buildings have on their occupant's health and the natural environment, precious natural land escape, vegetation, and non-renewable resources have been consumed and some depleted. These issues have been considered someone else's problem and no one should worry about them. Building systems were viewed as separate elements, design decisions were based on just budget and schedule considerations.(Hacène, Sari, and Benyoucef 2011, Krimo, Cherif, and Djamel 2015)

Since its independence in 1962, Algeria has been facing accelerated urbanization. In parallel with the development of industrial activities, the harmful effects on the environment have increased and disturbed the country's ecological plan. This urban growth is also reflected in an upheaval of the country's socio-economic data: which manifested a strong demand for housing. This led to building large residential areas to produce the maximum number of houses in the shortest possible term. That includes the minimum of comfort essential. These residential areas contain multi-family buildings comprising several dwellings on several levels, which are inspired by the large housing estates built in Europe after the last world war. The population and the public authorities were concerned about the quantitative aspects neglecting qualitative ones. This has caused negative consequences not just on the environmental and social points but also on the identity of the country, which has transformed the living environment and caused several problems. (Mokhtar 2017). There are many economic and political obstacles to the renovation and improvement of the quality of life and the environment of these dwellings. Despite the political and legislative will to integrate sustainable development approaches and be a part of the COPs with the objective of contributions of all governmental and non-governmental partners, a policy also projected on the outlines of higher education environmental disciplines. (Radio_Algerie 2016)

Moreover, in developed countries, the residential green building market in rating systems is prioritized (Pedersen et al. 2021, Tleuken et al. 2021) and plays an interesting role to improve the quality of life and benefit not just in efficiency but also in creating healthier communities that support environmental, social and economic well-being(Mahmoud, Zayed, and Fahmy 2019). Green homes are designed to minimize resource consumption, reduce life cycle costs, protect occupant health, improve productivity, reduce waste and pollution, and enhance productivity(U.S.G.B.C 2021a).

Since that first launching, only a few building rating or certification systems are widely acknowledged and more efficient advanced tools than others. LEED has continued to grow to become now the most widely used green building program (Figure 1). That maintains a high level of awareness, credibility, and good reputation among developers and users worldwide.

In 2019, more than 480,000 residential units are LEED-certified globally, and another 1.1 million are in the pipeline. Among these units, 30% are qualified as "affordable housing" in their markets. (Stanley 2019b)

Besides that, the LEED Green building system is chosen to be reviewed and based on in this paper between these following top classified systems according to the number of countries members universally (Figure1).

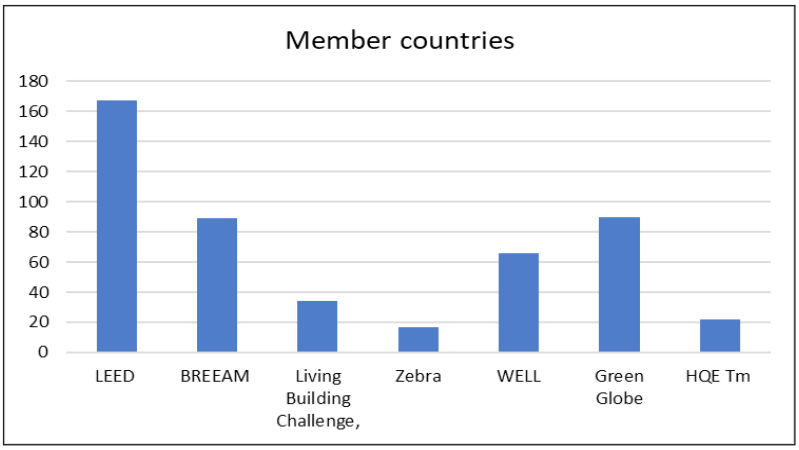

Figure 1. Top classified green building systems according to the universally member countries (Bajja 2016, BRE 2021, IWBI 2021, Stanley 2019a, Post 2020, Lukas Kranzl, Maarten de Groote, and Sebi 2016, U.S.G.B.C 2021a)

Structure of Current LEED 4.1v Residential Multifamily Homes to Promote Environmental Quality

In 2019, USGBC announced the launch of a new update LEED 4.1 Residential (Table1):

Table 1. Classification of home types according to Previous and new update LEED 4.1 Residential [26]

Previously existing LEED 4 for homes rating systems	New LEED 4.1 for homes rating systems
LEED for Low-rise homes LEED for Midrise Homes LEED for Core and Shell LEED for New Construction	LEED v4.1 Residential: New Single-family homes LEED v4.1 Residential: New Multifamily homes New Multifamily homes core and shell.

The greenness of a LEED Residential multifamily homes project is based on a 100-point scale with an additional 10 bonus points in four levels of certification: (certified 40-49 points, silver 50-59pt; Gold 60-79 and platinum 80+ pts). In each project, there is a variety of design strategies and products that are used together to contribute to improved comfort, health, well-being, energy, and water-saving, green and healthy materials through a streamlined approach. To measure the environmental quality of the project, each rating system has performance criteria organized as categories in nine axes: [integrative process (IP), Location and Transportation (LT), Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), indoor environmental quality (IEQ), Innovation (I), Regional Priority (RP)]. Within each category, credits and prerequisites are ranked from highest to lowest weighting depending on their ability to impact different: environmental and human health, to best address: social, environmental, and economic outcomes. (U.S.G.B.C 2019)

AIMS OF THE STUDY

This study aims at two main objectives. The first is to analyze the potential utility of adapting the evaluation system framework of residential multifamily homes LEED 4.1 in the Algerian context, to promote a new culture of environmental quality and durability.

The second is to review to what extent the design of residential multifamily homes in Tebessa meets green building principles in the current time. Our analysis approach is not to evaluate a project already realized out of environmental quality standards, but to accompany an approach of a decision aid to readjust the project at each stage of its conception, in the nine axes defined by the USGBC as an international referential.

Data Analysis

Guidance and Technical documentation of the latest version of the LEED v4.1 rating system was reviewed to identify LEED prerequisites, credits, and weighting to analyze each parameter and indicator in each credit of all different categories (IP, LT, SS, MR, EA, WE, IEQ, I, RP).

Collect data from administrative documentation of different residential projects, two types of documents were verified: documents of technical systems [Master Plan of Urban Planning and Development (PDAU), Land Use Plan (POS)] and administrative documents (legislation, norms, ratios, and regulations of urban and habitat planning). Besides, investigating local authorities, applicable laws and standards, review policies, and environmental local companies.

MATERIALS AND METHODS

This section is mainly composed of two parts. Starting by adapting the LEED v4.1 residential multifamily homes scorecard to the Algerian context. Among the indicators listed in that scorecard, we analyzed all prerequisites and credits of the nine categories listed above focusing on two parameters:

Authority involvement: the measurement or standard of how we design and construct a building is the building code, which is the law it has many different scales: the local government, building-specific policies, state policies, requirements, rules, and regulations that projects have to meet.

Availability and usability: local environmental companies, local renewable energy and qualifications, budget, and existing infrastructures are the main criteria for the analysis of each environmental concept in the nine categories.

Prerequisites and credits in each category are classed as:

- "Ineligible" credits and prerequisites that are not qualified to be realized in the Algerian context and do not meet the requirements within current circumstances. They will be eliminated.

- "Eligible" credits and prerequisites meet the stipulated requirements that fit or are proper to be chosen to study in the Algerian context.
- "Maybes" credits and prerequisites, that need to be clarified and need further investigations.

The second part of this research is to evaluate three residential multifamily projects chosen as representative prototypes in the local region of Tebessa, using the LEED 4.1 residential multifamily homes scorecard adapted to the Algerian context resulting from the previous part of this study to highlight what credits could be available in that three representative projects.

The Representative Case Study Projects, Description

The second part of the study was conducted on three residential multifamily homes in Tebessa. The selection of the representative projects is based on a set of parameters after consulting many existing projects, to ensure that the selected case studies are representative samples (table 2). Selection parameters mainly consider the type of building (residential multi-family homes), the period of building, rise levels, materials and techniques of construction and design process, following the review of technical and administrative documentation at the Office of real-estate promotion and management (OPGI).

Table 2. Selected case studies showing selection parameters (O.P.G.I. 1990, 2013)

	1000 multifamily dwellings LPL Doukane	AADL Boulhaf Eddir	18 multifamily homes Djbal Anoual
Construction period	2020's	2020's	1980's
Rise level	6 levels	10-11 levels	3 levels
Construction materials	reinforced concrete structure walls and slabs in hollow blocks	load-bearing walls and slabs in reinforced concrete	load-bearing walls and slabs in reinforced concrete
Situation	Inside the urban fabric	New extension core	Extension peripheral area
Pictures			

RESULTS

Adapting LEED V 4.1 Residential Multifamily Homes Scorecard in the Local Algerian Context

The LEED scorecard (also called the LEED checklist) is a critical component that we analyzed first to track which prerequisites and credits are useful and eligible in the Algerian context in residential projects. The typical LEED scorecard has a "yes" column, a "maybe" column, and a "no" column (Table 3) shows the results of the adapted scorecard in the Algerian context.

Examples of Adaptation of Credits/Prerequisites (Table 3)

- Credit listed in the "Yes" column:

SS. Credit: Heat Island Reduction: to minimize effects on microclimates, and human and wildlife habitats. Options of this credit are eligible to attempt in the Algerian context because it requires just measurements in the phase of Design, which are:

Non-roof and roof: measuring the percentage area with shading or no absorptive material for a minimum of 75% of roof surface; or calculate compliance of solar reflective index and solar reflectance meeting specific criteria, using different strategies as:

- Sunroof measures by providing shade with vegetated structures.
- High reflectance Roof (specific minimum solar reflectance index value, by roof slopes).
- Install vegetated Roof using native or adapted plant species. (U.S.G.B.C 2019)
- Materials and technic for these measurements are available for any designer in Algeria.

- Credit listed in the "Maybe" column:

LT. Credit: Bicycle facilities: to attend this credit, plan bicycle storage, and bicycle trails and lanes within 3 miles of the project boundary that connect to diverse uses, a school or employment centre, or a rapid transit stop are required. Given the fact of the absence of bicycle storage or network in Algerian cities, adopting them could be easy on the existing road structure, so this credit is classified as "Maybe" to clarify and needs further investigations with a serious authority motivation(U.S.G.B.C 2019).

- Credit listed in the "No" column:

LT. Credit Electric vehicles: Absence of electric vehicles, charging infrastructure for electric vehicles in stations or on-site parking although the Algerian Minister of Industry announced a plan to import electric cars and equip charging infrastructures in stations. That plan needs a great deal of time, and complex social and economic study to be reached all across the Algerian territory, then adopted in the residential multifamily homes projects (PSA 2021a, PSA 2021b).

Table 3. LEED 4.1 Residential multifamily homes scorecard analysis in the Algerian context (U.S.G.B.C 2021c, MHESR 2022, El Hassar et al. 2002, Imessad et al. 2017, PSA 2021b, U.S.G.B.C 2019, UNGA 2016, ECA and UN-Habitat 2014, U.S.G.B.C 2021e, Bouraiou et al. 2020, MHU 2007)

Category	Credits (C) Prerequisite (P) Options (O)	Yes	May be	No	Why?	points
Integrative Process (1 point)	Integrative Process	○			✓	C 1
	Installation Contractor Training	○			✓	O 1
	Integrative Process	○			✓	O 1
Location and transportation: (15 points)	LEED FOR NEIGHBORHOOD DEVELOPMENT LOCATION			○	No LEED for Neighbourhood Development Projects exists in Algeria	C 15
	SENSITIVE LAND PROTECTION	○			✓	C 1-2
	Previously Developed Land	○			✓	O 2
	Avoidance of Sensitive Land	○			✓	O 1
	HIGH PRIORITY SITE	○			✓	C 1
	Historic District	○			✓	O 1
	Priority Designation	○			✓	O 1
	Brown Field Remediation		○		Depends on the possibility of local, state, or national authority to get a contract with a local expert (such as BG consulting engineers) to choose a brownfield where soil or groundwater contamination has been identified and requires its remediation	O 1
	SURROUNDING DENSITY AND DIVERSE USES	○			✓	C 1-5
	Surrounding Density	○			✓	O 1-3
	Compact Development	○			✓	O 1
	Diverse Uses	○			✓	O 1-2
	ACCESS TO QUALITY TRANSIT	○			✓	C 1-3
	BICYCLE FACILITIES		○		Depending on the ability to plan and provide bicycle network and storage, on the urban and architectural scale	C 1
	REDUCED PARKING FOOTPRINT	○			✓	C 1
	Reduce Parking	○			✓	O 1
	Car share;	○			✓	O 1
	Unbundling Parking		○		Counts on authority to intervene on selling parking separately from all property sales or leases.	O 1
	ELECTRIC VEHICLES			○	Absence of charging infrastructure for electric vehicles in stations or on-site parking at the current time.	C 2
	Electric Vehicle Charging			○	ineligible	1
	Electric Vehicle Charging Infrastructure			○	ineligible	1

Sustainable Sites (9 points)	CONSTRUCTION ACTIVITY POLLUTION PREVENTION		○		Depends on contracts with a local environmental agency to : - Create and implement an erosion and sedimentation control plan for all construction activities associated with the project that must conform specific requirements of this agency.	P
	Site Assessment	○			✓	C 1
	Protector Restore Habitat	○			✓	C 1
	On-site restoration	○			✓	O 1
	Financial support		○		Depending on the local authority	O 1
	Open Space	○			✓	C 1
	On-site open space	○			✓	O1
	Access to open space	○			✓	O1
	Rainwater Management	○			✓	C 1-3
	Percentile of rainfall Events	○			✓	O 1-3
	Zero Lot Line projects only	○			✓	O 1-3
	Permeable Lot Area	○			✓	O 1-3
	Heat Island Reduction	○			✓	C 1-2
	Light Pollution Reduction	○			✓	C 1
Water efficiency (12 points)	Water Use Reduction	○			✓	P
	BUILDING-LEVEL WATER METERING	○			✓	P
	Water Use Reduction	○			✓	C 1-10
	Total water use reduction	○			✓	O 1-10
	Outdoor and indoor water use reduction	○			✓	O 1-9
	Outdoor water use reduction	○			✓	O 1-3
	Indoor water use reduction	○			✓	O 6
	Water metering	○			✓	C 1-2
	Meter water subsystems	○			✓	O 1
	Meter Dwelling Units	○			✓	O 1
Energy and Atmosphere (34 points)	Fundamental Systems Testing and Verification		○		Depending on the presence of qualified professionals in the project's design, construction, and verification tea.	P
	Minimum Energy Performance	○			✓	P
	Energy Metering	○			✓	P
	Fundamental Refrigerant Management	○			✓	P
	Enhanced Commissioning	○			✓	C 1-6
	Residential Dwelling Units	○			✓	O 1-2
	Supply Air-Flow testing	○			✓	O 1
	Pressure balancing	○			✓	O 1
	Enhanced commissioning		○		Depending on the eligibility of commissioning authority qualifications.	O 3
	Enhanced and Monitoring based commissioning	○			✓	O 1
	Envelope Commissioning	○			✓	O 2

	Optimize energy performance	○			✓	C 1-18
	Energy performance compliance	○			✓	O 1-9
	New Buildings Institute Multifamily Guide	○			✓	O 1-13
	Dwelling Unit Energy Simulation	○			✓	O 1-18
	Whole building energy monitoring and reporting	○			✓	C 1
	Grid harmonization		○		Depends on existing demand response programs on the local scale	C 1-2
	Renewable energy		○		Depends on existing off-site renewable systems, new ones, energy attribute certificates (EACs), or carbon offsets.	C 1-5
	Enhanced refrigerant management	○			✓	C 1
	Domestic Hot Water Pipe Insulation	○			✓	C 1
Material and Resources (13 points)	STORAGE AND COLLECTION OF RECYCLABLES			○	Absence of a local recycling program to recycle materials of the entire building.	P
	CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT PLANNING			○	Absence of a local construction and demolition waste management program	P
	BUILDING LIFE-CYCLE IMPACT REDUCTION	○			✓	C 2-5
	Historic Building Reuse	○			✓	O 5
	Renovation of Abandoned or Blighted Building	○			✓	O 5
	Building and Material Reuse	○			✓	O 1-4
	Whole-building Life-Cycle Assessment	○			✓	O 1-4
	ENVIRONMENTALLY PREFERABLE PRODUCTS		○		Depending on its options eligibility	C 1-6
	Environmentally Preferable Products		○		It depends on local specific material existence in the Algerian context (bio-based product with reclaimed material…)	O 1-6
	BPDO - Environmental Product Declarations		○		Depends on the eligibility of using multisource of different products that meet specific environmental declarations and criteria.	O 1-2
	BPDO - Sourcing of Raw Materials		○		Depends on the eligibility of adopting international manufacturing sources of raw materials that do not exist locally in Algeria.	O 1-2
	Material Ingredients		○		Depends on the eligibility of adopting international manufacturing sources of raw materials that use specific programs considering that do not exist locally in Algeria.	O 1-2
	CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT			○	Absence of certified commingled recycling facilities for construction and demolition materialising the local area	C 1-2

	Diversion			○	Ineligible	O 1-2
	Reduction of Total (Construction and Demolition) Waste Material		○	○	Ineligible	O 2
Indoor Environmental Quality (16 points)	MINIMUM INDOOR AIR QUALITY PERFORMANCE	○			✓	P
	COMBUSTION VENTING	○			✓	P
	GARAGE POLLUTANT PROTECTION	○			✓	P
	RADON-RESISTANT CONSTRUCTION	○			✓	P
	INTERIOR MOISTURE MANAGEMENT	○			✓	P
	ENVIRONMENTAL TOBACCO SMOKE CONTROL	○			✓	P
	Compartmentalization	○			✓	P
	ENHANCED COMPARTMENTALIZATION	○			✓	C 1
	NO ENVIRONMENTAL TOBACCO SMOKE	○			✓	C 1
	ENHANCED INDOOR AIR QUALITY STRATEGIES	○			✓	C 1-4
	Walk-Off Mats	○			✓	O 1
	Filtration	○			✓	O 1
	Enhanced Local Exhaust	○			✓	O 1
	Balanced Whole-Dwelling Unit Ventilation	○			✓	O 2
	LOW-EMITTING MATERIALS		○		Depending on the eligibility of VOC (volatile organic compound) calculation emitting in used interior materials	C 1-4
	INDOOR AIR QUALITY ASSESSMENT	○			✓	C 1-2
	THERMAL COMFORT	○			✓	C 1
	Radiant Comfort	○			✓	O 1
	ASHRAE Standard or local equivalent	○			✓	O 1
	ISO Standards	○			✓	O 1
	DAYLIGHT AND QUALITY VIEWS	○			✓	C 1
	Daylight	○			✓	O 1
	Quality views	○			✓	O 1
	ACOUSTIC PERFORMANCE	○			✓	C 1-2
	HVAC Background Noise	○			✓	1
	Envelope Acoustic Performance	○			✓	1
Innovation (6 points)	Innovation	○			✓	C 1-5
	LEED Accredited Professional	○			✓	C 1
Regional Priority (4 points)	Regional Priority	○			✓	C 1-4
	Renewable energy		○		Depends on existing off-site renewable systems, new ones, energy attribute certificates (EACs), or, carbon offsets.	C
	Outdoor water use Reduction	○			✓	C

	Heat island protection	○			✓	C
	Indoor Water use Reduction	○			✓	C
	Optimize energy performance	○			✓	C
	Thermal Comfort	○			✓	C

Anticipated (Yes), to Clarify (May be) and Denied (No) Credits/Prerequisites

To address regional aspects, 80% of credits and prerequisites are classed as eligible (Figure 2), 35/ 43 credits, and 12/16 prerequisite: 88/110 points are available. Detailed as:

- Integrative process: two options requirements are eligible to achieve in the local context, one point/1pnt.
- Location and transportation: 5/8 are achievable, and 12/15 points could be earned. One credit and two options need to be clarified. Two credits are denied.
- Sustainable Sites: 6/6 credits are achievable, and 9 points/9 points could be earned. One prerequisite and one option need to be clarified.
- Water efficiency: 2/2 prerequisites eligible 2/ 2 credits are achievable, 12 points/12 points could be earned.
- Energy and atmosphere: 3/4 prerequisites eligible, 5/7 credits are achievable, 27/34 points. One prerequisite, 2 credits, and one option need to be clarified.
- Materials and resources: 0/2 prerequisites, 1/3 credits achievable, 2-5/13 points. Two prerequisites and one credit are denied. One credit with four options needs to be clarified.
- Indoor environmental quality: 7/7 prerequisites, 7/8 credits, 12/16 points. One credit needs to be clarified.
- Innovation: 2/2 credits eligible 6/6 points.
- Regional priority: 6 credits have been identified in the Algerian region 5/6 achievable 4/4 points.

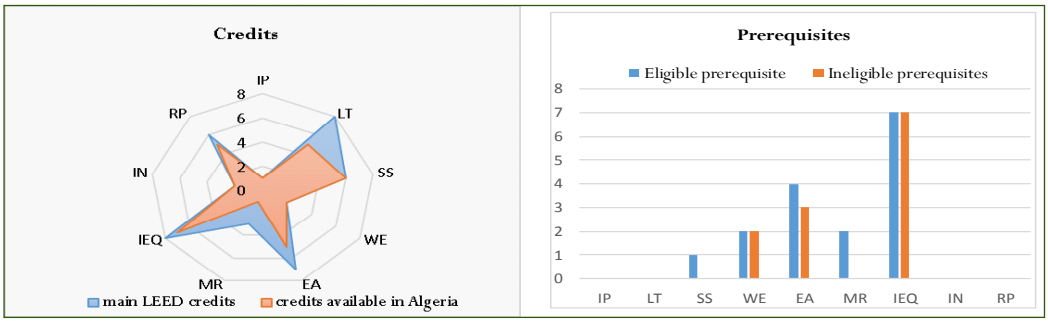

Figure 2. Rate of available credits and prerequisites for Algerian context to the main LEED v4.1 credits.

(LEED Scorecard Analysis of Three Prototype Residential Multifamily Homes)

This section is an application of the adapted scorecard to the Algerian context on the three selected projects situated in Tebessa. According to the review of the technical and administrative documents (OPGI, DUAC Tebessa, DT) of the cited projects, the results are presented in (Table 4).

(OPGI, DUAC Tebessa, DT) of the cited projects, the results are presented in (Table 4).

Table 4. Results of eligible credits/prerequisites from the adapted scorecard applied to the three selected residential multifamily homes.

Categories	AAdl Boulhaf Eddir (Project01)	1000 multifamily dwellings LPL Doukane (Project02)	18 multifamily homes Djbal Anoual (Project03)
IP	/	/	/
LT	High priority site (priority designation) - ACCESS TO QUALITY TRANSIT	High priority site - ACCESS TO QUALITY TRANSIT	HIGH PRIORITY SITE (priority designation)- ACCESS TO QUALITY TRANSIT

SS	Open Space (on-site open space)	Open Space (on-site open space)	Open Space (on-site open space)
WE	Meter Dwelling Units	Meter Dwelling Units	Meter Dwelling Units
EA	Energy metering	Energy metering	Energy metering
MR	/		
IEQ	Quality views	Quality views	Quality views
IN	/	/	/
RP	/	/	/

Just a few credits and the same credits were achieved in the three analyzed Projects (Table 5, Figure 3)

Table 5. Results of the application of the adapted LEED v4.1 scorecard of residential multifamily homes in the three case studies

Category	Credit achieved	Credit Requirements proved
LT	access to quality transit	More than 72-weekday trips and more than 30-weekend trips of bus and streetcar share are available on site.
	High Priority Site	Priority Designation: The project is located in a qualified opportunity zone.
SS	Open space	30%> of the total site area provides outdoor space, physically accessible. With 25% minimum of the 30% total space planted with vegetation.
WE	Water metering	Meter dwelling units: installed a permanent water meter for each residential dwelling unit that measures total potable water use for the unit.
EA	Whole building energy monitoring and reporting	Installed energy meters to measure all building consumption.
EQ	Quality views	At least 50% of the occupied spaces in each resident, unit have one window that includes flora, fauna, or sky/objects at least 25 feet from the exterior of the window. Qualifying windows must provide a clear image of the exterior.

Total results: 6/43 credits are achieved from the original LEED-certified class and 6/35 are achieved from the adapted checklist in the Algerian context (Figure 3).

Figure 3. Comparative analysis of the adapted scorecard and eligible credits/prerequisites in the three residential multifamily home projects.

DISCUSSION

The Adaptive Checklist

The results of the analysis using the adaptive checklist for the Algerian context show three kinds of credits, eligible prerequisites, and credits (Yes), prerequisites and credits that need clarification and Investigations (Maybe), and ineligible prerequisites and credits (No). As shown in the method, the analysis was based on the possibility of achieving the credit goal and scoring according to two main parameters: Firstly, the legal side, i.e. the presence of a

law or recommendations in the specifications of the projects that require the integration of certain measures ensuring the credit, this represents the willingness of decision-makers to integrate environmental quality in the processes of realization of the projects. Secondly, the human, material, or contextual means to achieve the objectives of the credit including existing infrastructure facilities, and qualifications.

- Adaptive checklist: why do results show that?

Consequently, the adapted checklist indicates "Yes" to the prerequisites and eligible credits that can be achieved under the current circumstances, and that its requirements are proper to be studied. This means that the mentioned credits fit into the applied regulations, the existing infrastructure is easily controlled by the designers within the existing resources, and their realization does not require additional efforts or specific measures. Other prerequisites and credits are mentioned as "Maybe", their achievement needs clarification and Investigation, and more efforts, infrastructures, or resources are needed to make that goal achievable. Such as Fundamental Systems Testing and Verification prerequisite in the Energy and atmosphere category: it requires qualified professionals out the project's design, construction and verification team that is available on the Algerian scale, so it is achievable.

The last category of "No" indicates the ineligible prerequisites and credits that cannot be achieved within the present circumstances due to one or a set of conditions; either the existing regulations do not take into account the concept or are difficult to control by designers and developers, in most cases, the existing infrastructure does not support the development of the concept, or the realization requires an additional budget and specific measures far from everyone's reach. Such as electric vehicle credit, which is ineligible at the current time. Despite the launch of a new program to integrate electric cars at least in the next 10 years in Algeria and equipping hundreds of gas stations with charge posts which explain that: to provide electric vehicles and charging infrastructure and equipment on the level of multifamily residential projects is far to be possible shortly.

According to the previous results that represent the adaptive LEED 4.1residential multifamily homes scorecard in the Algerian context, the majority of Credits and prerequisites are classed as eligible 35/43 credits and 12/16 prerequisites, which indicates that the circumstances are suitable for the construction of multi-family residential buildings that fit with LEED V4.1 green building standards. Three Credits and one prerequisite need to be clarified and investigated with five ineligible credits/prerequisites in the current period. Comparing these results with worldwide adaptive experiences, it seems very optimistic compared to the Indian experience, which presents seven credits possible out of 43 and 6/16 prerequisites according to the adapted checklist presented by USGBC (U.S.G.B.C 2021d).

LEED Scorecard Analysis on the Case of Study (The Second Part of the Study)

In this case study, results show that there was no difference between the three projects, despite the difference in the period of realization, the living environment, and levels. The few Credits achieved in the three projects are classed more as just technical goals, which means that the traditional process of building residential multifamily projects in Algeria lacks not just environmental quality standards, but also comfort, life quality, and well-being requirements. The absence of 91% of the environmental quality requirements in projects is presented in each category as:

Integrative Process

Due to the conventional process used in the Algerian projects and the limitation of green professionalism, the three projects in this study do not meet any credit of the integrative process category. Building systems were consulted as separate sections – site, structure, systems, and design decisions were each based on just budget and schedule considerations. Skipping the final performance on the environmental quality of the building. The integrative system requires collaboration among key stakeholders and design professionals from the building's design to completion. Thinking project teams are responsible for the connection of the small systems to become a more complex system in which all parts act on each other as a whole building design.

As a requirement: in the pre-design, installation contractor training after hiring them including such trades (plumbing, mechanical systems, insulation, framing, and air sealing) is required. That may be presented for the relevant segment with the presentation of the builder's site supervisor. Alternatively, adapt the integrative design from the beginning in pre-design and continue throughout the design phases by the process of discovery that analyses (Energy-Related Systems, Water-Related Systems). Implementation by developing a project team letter and an exemplary performance including in its site selection, social equity, health & well-being.

The United Kingdom's Office of Government Commerce (UKOGC) estimates that the integrative process shows that single projects using integrative project teams can achieve a saving of 2-10% in the cost of construction(El Asmar, Hanna, and Loh 2013).

Location and Transportation

Selecting the proper location of a building, including consideration of the orientation affects local ecosystems and a wide range of environmental factors; including transportation methods, energy use, land use, maintenance costs and preservation, erosion, and rainwater management. Therefore, LEED intends to have a smart location and linkage to each project's surroundings for this smart growth. In this study, even though the three projects owed High Priority site credit through priority designation assigned as a qualified opportunity zone by a local program administered at the national level. Projects one and two were located in sensitive lands, which is considered an irresponsible decision that led to high land development costs, and affects a wide range of environmental factors. Site selection influences the connections to nearby areas or the community reaction to the project and can control how the rest of the project has to be designed. Even so, the final location decision-making is established by a state director, despite specialist consultancy, which leads to limited professionalism in decision-making. Furthermore, access to quality transit credit was achieved in the three projects, which reduce motor vehicle use, thereby reducing greenhouse gas emissions, air pollution, and other environmental and public health harms by chance.

Sustainable Sites

To evaluate sustainable options and inform related decisions about site design, the site assessment starts before design and applies as the integrative design while minimizing environmental impacts. The whole development footprint must be taken into account. Furthermore, the loss of valuable topsoil is one of the biggest environmental impacts on the site during the construction process. Creating and implementing an erosion and sedimentation control plan for all construction activities is a prerequisite.

Despite the importance of site assessment analysis that influences the whole project design, in the case study projects, open space credit is the only credit achieved the intent to create exterior open space that encourages physical activities, encourages social interaction with the environment, and passive recreation. Otherwise, before design, a site survey or assessment that includes (topography, hydrology, climate, vegetation soils, and human use) are reviewed skipping the evaluation of health effects, sustainable options, space preservation, and minimizing construction impacts including (heat island reduction, rainwater management by using low-impact development techniques, landscape productive areas, and light pollution reduction). The absence of these requirements on the Algerian projects level shows a lack of responsibility that causes buildings harmful effects that may stay for decades.

Water Efficiency

Water as a precious resource cannot be taken for granted. Water supply is becoming more unpredictable than before. LEED system requires an efficiency first approach, then looking for other ways to reduce water use to further reduce demand and need, which is required to reduce aggregate water consumption by 20% from the baseline, besides tracking water consumption by metering building-level water. In the study projects, water-metering credit that requires installing a permanent water meter for each residential dwelling is the only credit achieved as a technical goal for just tracking water consumption. Which explains the limitation of awareness about the importance of water management that should be taken very seriously by all stakeholders.

Energy and Atmosphere

The energy and atmosphere category contains the most points available as having a big impact on the environment, since the whole building approach to building design not only saves energy over time or uses only more environmentally friendly energy, but also reduces the demand.

Before it can save energy, a LEED project team needs to determine (establish) an energy performance target, analyze efficiency measures during the design process, and use energy simulation analyses for past similar buildings and efficiency opportunities.

Fundamental commissioning and verification are required besides engaging qualified professionals in different activities, to further support a project design and construction that meets the requirements for durability, energy, water, and indoor

environmental quality. Furthermore, to support energy management and seek extra energy savings opportunities, LEED requires whole building energy special monitoring and reporting. Also, to increase participation in demand response, grid harmonization is required by designing buildings and equipment for participation. Moreover, to reduce greenhouse gas emissions, increasing the use of grid-source renewable energy technologies, and carbon mitigation projects are required. Additionally, LEED intends to reduce ozone depletion by enhanced refrigerant management.

In the three study projects, only the technical credit of energy metering was achieved. Despite, the availability of qualified professionals and environmental programs that performs simulation analyses, verifications, and monitoring, energy conservation and saving are unheeded in residential projects. Otherwise, in Algeria, there is a large potential in renewable energy regarding wind-solar, geothermal, and biomass energy. (Harrouz et al. 2017) Algeria got been engaged willingly in different renewable energy plans as the establishment of the National Agency for the promotion and rationalization of energy use (APRUE), which aims to produce 40% of electricity from renewable energies by 2030. Despite that, the sector of residential multifamily homes did not benefit from any environmental energy plans. Since 1997 Algeria acquired a set of Regulatory Technical Documents (DTR) that aims to contain energy consumption and improve the energy efficiency of built-up areas, which was adapted in multifamily habitat design without any updating of new environmental standards revision at the national or international level. Although the existence of national programs and plans such as the National Renewable Energy Development Centre (CDER) or international green labels and standards.

Materials and Resources

Sustainable materials are materials that reduce demands on ecosystems during their life cycle through use and disposal. In LEED sustainable buildings, affect the triple bottom line (Economic prosperity; Social responsibility; Environmental stewardship) through the requirements: starting with the storage, collection of recyclables, and planning of construction, ending with demolition waste management.

Otherwise, to encourage adaptive reuse and reduce the lifecycle impacts of those materials and products. LEED encourages engaging in historic building reuse, renovation of the abandoned or blighted buildings, or whole-building Life-cycle assessment. Besides, environmentally preferable materials are required that meet specific criteria. In the LEED rating system, the sustainable attributes of the product are considered; not specific products that contribute to earning project points. In study projects, no prerequisite or credit is achieved. Most of the goals are not legible in the Algerian context due to the absence of certified commingled recycling facilities for construction and demolition materials in the local area and limiting cooperation with government or international green organizations despite their availability. Besides, other goals depend on the eligibility of adopting international manufacturing sources of raw materials that use specific programs considering that do not exist locally in Algeria.

Indoor Environmental Quality

The health, comfort, and performance of occupants are affected by the quality of the air and environment inside buildings, based on pollutant concentrations and conditions. Indoor air can be two to five times more polluted than outdoor air (The United States Environmental Protection Agency). Many variables affect the IEQ: temperature, humidity, lighting, acoustics, air quality, and control systems. All aspects of the building process are involved to have a good IEQ. In the study projects, security and material quality were the only goals considered during the design and construction. This means that the indoor environmental quality in residential multi-family homes in Algeria is completely neglected, which refers to a lack of understanding and responsibility about the green building systems concepts and occupant health including owners, architects, engineering, and stakeholder.

Otherwise, LEED work to make sure to minimize the transfer of air between units to limit occupants' exposure to indoor air pollutants by enhanced compartmentalization, and install ventilation systems that comply with specific Labels and criteria.

In addition, it is required to use low-emitting materials with specific criteria. On the other hand, to promote occupants' comfort and well-being, thermal and acoustic comfort should be provided. Design heating, ventilation, and air conditioning (HVAC) and building envelope should meet the requirements and environmental standards. Besides, to connect building occupants with the outdoors, LEED requires introducing daylight and views into the space and reducing electrical lighting. In the end, after construction: it is indispensable to perform air cleaning, a flush out, and air testing in the unit before dwelling occupancy.

Innovation

Innovation is a flexible category, with unnecessary points; it is used for extra performance and creativity. This category encourages having LEED accredited professional (AP) participants on the project team.

Regional Priority

Regional Priority intends to address geographically specific environmental, public health priorities, and social equity. RP acknowledges a database with different regions in the world that have different needs with selected existing credits in the rating system as a priority. According to USGBC, there are seven available credits in the Algerian territory, and six are eligible on the local scale, which increases the chances of intervention. (U.S.G.B.C 2021e)

CONCLUSION

Future studies aiming to develop a local assessment tool for Green Building Rating System may consider developed examples in other countries for interventions and inspiration. Despite the availability of sustainability requirements on the level of residential multifamily homes in the Algerian context, there is a clear major absence of adopting the minimum right solutions, which means the basic actions that can be free or at a low cost might lead to large changes in results. Otherwise, not all green goals may be achievable for the budget or schedule, a list of prioritized actions and interventions may put the project on track. The results of the analysis show that, despite the possibility to adapt 80% of credits and prerequisites of LEED v4.1 residential multifamily homes in the Algerian context, the analyzed projects in Tebessa didn't achieve any environmental quality goals but technical ones. The major weakness is in design decisions and goals where each is based on budget and/or follows an accelerated schedule consideration, without taking into account the final performance of the completed building. Sustainability principles were completely neglected in the design process. Residential multifamily homes are designed in a standardized way, they are readjusted, on regular basis. Although Algeria has ratified the international environmental conventions and they are gradually adapting its legislative framework to meet the commitments made. Effective strategies for managing the environment and natural resources are still to be developed seriously.

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