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Challenges in Low Energy Architecture : A Case Study from Egypt

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ABSTRACT

Energy-efficient architecture is critical for enhancing indoor air quality and preserving occupant comfort, particularly in Egypt, where the challenges of energy consumption in the building sector are prominent.This study aims to identify barriers to the implementation of Low Energy Building (LEB) principles in Egypt and propose actionable strategies for overcoming these challenges. Using a mixed-methods approach that includes a comprehensive literature review, SPSS analysis, SWOT analysis, semi-structured interviews, and a questionnaire survey, the factors limiting energy efficiency in the building sector were examined. The findings reveal nine significant barriers, with the most critical factors identified as design, technical solutions, expertise, and quality. The government building sector emerged as a prime candidate for intervention, highlighting the need for targeted policies to reduce energy consumption in this area. Furthermore, the study, compared the obtained results with LEED Certified building (Credit Agricole bank New Cairo City, Egypt) to verify the obtained results.

Index-words: *Low Energy Building (LEB), Energy Efficiency, Indoor air quality, Barriers to implementation, Sustainable architecture, Government policy.*

I. INTRODUCTION

The swift progress of the global economy and the quickening pace of urbanization have increasingly highlighted the issue of energy consumption in buildings. The building sector plays a major role in global energy usage, leading to considerable environmental issues and resource depletion. As a result, there is an urgent need to explore strategies for reducing energy demands in the design and operation of buildings, making this a crucial priority within the contemporary construction sector. Incorporating low-energy designs not only reduces energy usage and mitigates environmental effects but also improves occupant comfort and promotes healthier living spaces [1-5]. Furthermore, significant shifts in global climate and the depletion of non-renewable energy resources, integrating sustainability into design, has transitioned from an optional feature to a crucial necessity. Architects worldwide are now striving to create buildings that maximize energy efficiency and attain top scores in energy and green building certifications. Prestigious certification frameworks such as Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Method (BREEAM) are establishing high standards and clear objectives for forward-thinking designers. As a result, sustainable architecture has gained widespread prevalence, accompanied by the ongoing and swift advancement of new technologies aimed at enhancing its effectiveness [6-9]. In Egypt, the distribution of energy consumption across various sectors has shown some changes from 2020 to 2023. The residential sector accounted for 41.7% of the total energy consumption in buildings in 2020, with the industrial sector following at 27.8%. Other categories, including offices, clinics, and gas stations, contributed 8.5%, while the commercial sector made up 5.0%. Both the governmental and agricultural sectors represented 4.8% each, with water usage at 4.2% and public lighting at 3.1%, as illustrated in Fig. 1. In 2021, the residential sector maintained its share at 41.7%, again followed by the industrial sector at 27.8%, others at 8.5%, and the commercial sector at 5.0%. The governmental and agricultural sectors were both at 4.8%, with water consumption at 4.2% and public lighting at 3.1%. As indicated in Fig. 1, by 2023, the share of the residential sector indicates 36.2%. The industrial sector remained close behind at 27.5%, while the 'others' category increased to 12.0%. The commercial sector continued at 5.0%, and the governmental sector shows 13.5%. The combined contributions of water and agriculture accounted for 5.7%[10]. The consumption levels in Egypt's building sectors for 2020 and 2021 are comparable, as shown in Fig 1. An analysis of the consumption rates across all sectors in 2023 reveals that only the government building sector experienced an increase. In contrast, other sectors, such as residential buildings, experienced a reduction in energy consumption, while sectors like industrial buildings demonstrated no significant change. This indicates that the government building sector requires targeted interventions to mitigate its energy consumption. Consequently, this sector has been selected as the focus of the study, which encompasses the entire lifecycle of the building, from construction through to operation and maintenance.

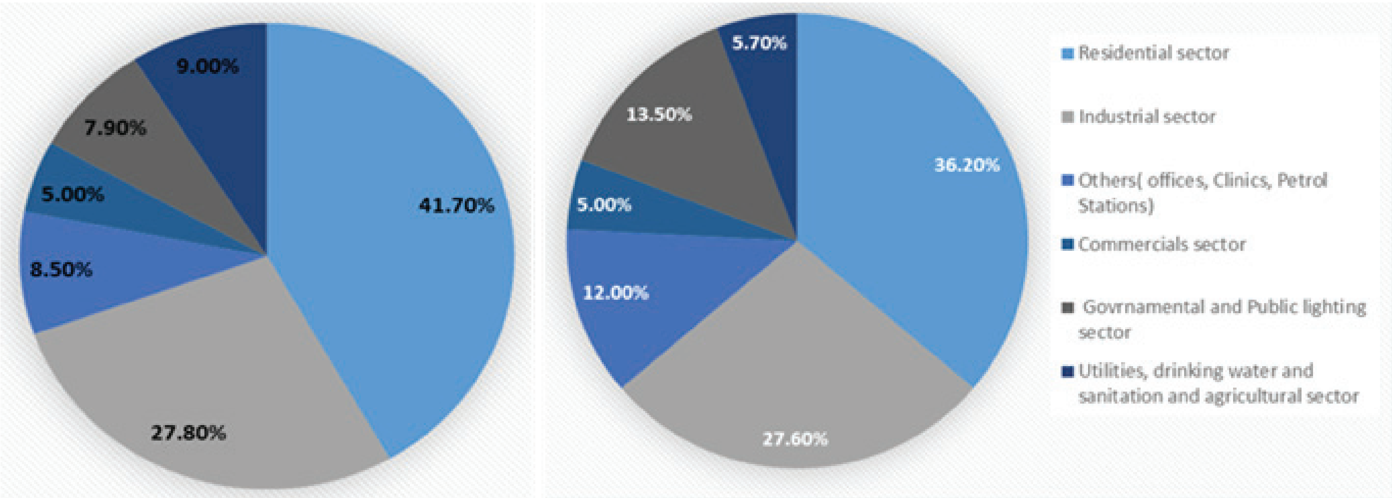

Fig. 1. Analysis of energy consumed in Egyptian buildings by sectors in 2020 & 2021 & 2023

To advance the development of low-energy buildings in Egypt, it is essential to address and mitigate potential weaknesses, including inadequate performance stemming from limited expertise, lack of durability and quality, inefficient operation and usage, as well as planning and design errors. Simultaneously, it is important to enhance and promote the strengths such as a favorable indoor environment, reduced operating costs, low life-cycle costs (LCC), and an expanding market [11-16].

Recent research has shifted focus toward identifying barriers and solutions for energy-efficient building practices tailored to Egypt's unique environment, highlighting the absence of comprehensive design guidelines for highly energy-efficient structures, such as near-zero and passive buildings [17-20]. Therefore, the objective of this study is to identify, address, and alleviate significant barriers to the implementation of energy-efficient buildings within the Egyptian context. The study is executed through a two-phase approach: initially, a comprehensive review of the existing literature was undertaken to delineate the principal barriers and challenges encountered in the realm of low-energy buildings (LEB). Subsequently, a structured questionnaire, derived from the barriers identified in the literature review, was distributed to participants to systematically collect data. Following the questionnaire, a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was performed. Further, the study, was extended to compare the obtained results with LEED's certified building (Credit Agricole bank in New Cairo City, Egypt) to verify our results.

II. METHODOLOGY

The research methodology employed in this study, as shown in Fig. 2, encompasses a questionnaire and SWOT analysis as essential analytical instruments, followed by an evaluation of energy-efficient buildings situated in Egypt.

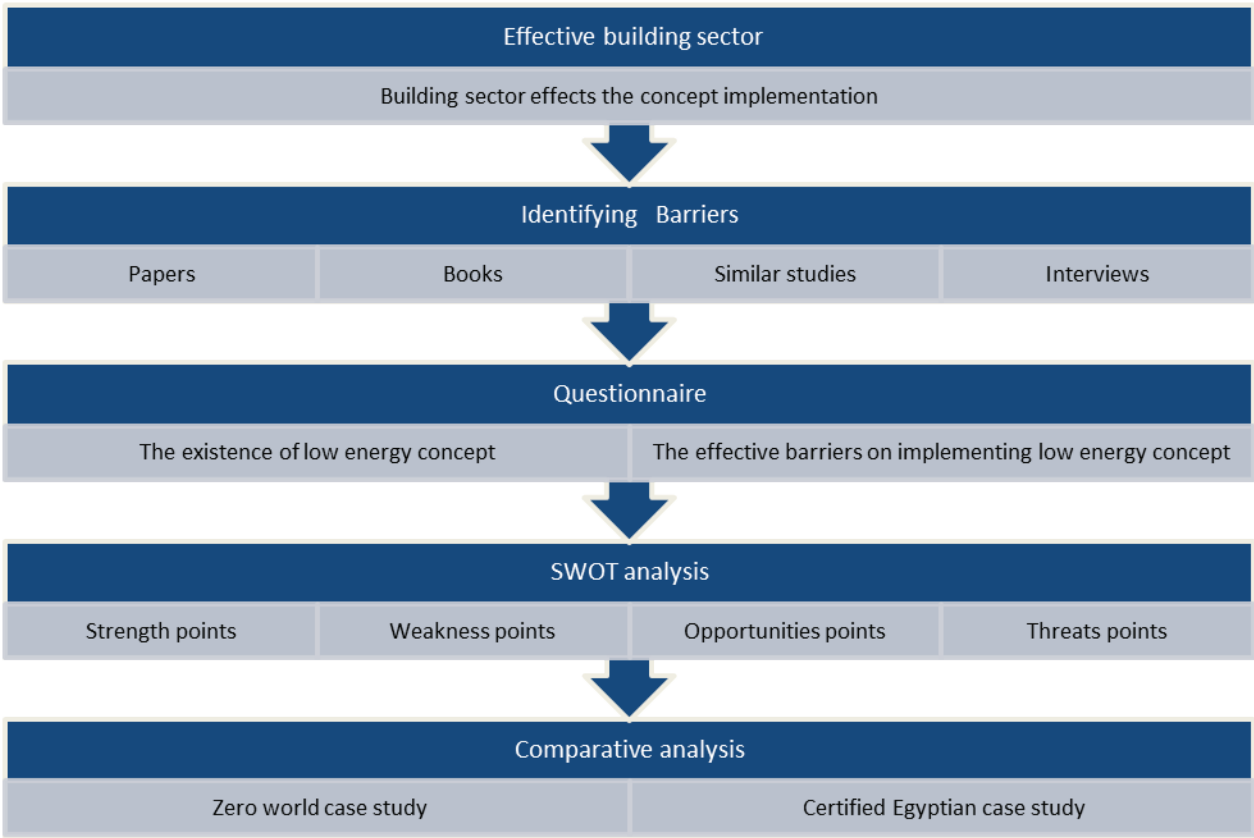

Fig. 2. Flow chart of mixed methods research methodology

Following the development of the initial survey draft, a pilot study was conducted, involving interviews with three experts—two professionals from the construction industry and one academic—each with over ten years of experience. The aim of this pilot study was to assess the survey instrument comprehensiveness, clarity, and relevance to the research objectives. Feedback obtained from this preliminary evaluation was used to refine and improve the questionnaire, ensuring its alignment with the goals of the study and enhancing its effectiveness for data collection. The questionnaire is designed as a structured survey instrument, organized into three sections comprising a total of 53 questions. Section (A) collects demographic information from participants, who include faculty members, students, and design architects associated with Egypt's construction industry. Faculty members were included in the survey due to their dual roles as academic professionals and practitioners in architectural design, project consulting, or contracting, which enhances their expertise on the survey topic and ensures practical, market-relevant insights. Students were included to assess their understanding and application of energy-saving principles as taught in universities. Design architects, actively engaged in construction and design, were selected to evaluate their comprehension and implementation of energy conservation concepts within Egypt's construction and design sectors. This diverse participant pool ensures comprehensive and representative data collection. While Section (B) assesses respondents' overall comprehension of low energy building (LEB) concepts, specifically examining the recognition of these concepts within the Egyptian context. Section (C) is designed to assess participants' perceptions of barriers to the implementation of low-energy initiatives, as identified through interviews and prior studies addressing challenges to energy efficiency in buildings within the Egyptian context. A range of obstacles were identified, spanning financial, technical, organizational, and other domains. However, the most frequently cited and impactful barriers, as extensively highlighted in the literature, include design limitations, quality concerns, cost constraints, technical solution availability, risk factors, contractor-related issues, knowledge gaps, market dynamics, and regulatory challenges. These barriers were prioritized due to their recurrent emphasis and significant influence on hindering the adoption of energy-efficient building practices in Egypt. Utilizing a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A hybrid approach, employing both paper-based and web-based questionnaire formats, was adopted to gather respondents' insights. The survey sampling targeted professionals engaged in the architectural domain, including project managers and accredited engineers, as well as academic practitioners, across both public and private sectors in Egypt. In total, 100 questionnaires were distributed electronically and in person during August, 2022, yielding 93 completed responses, thereby reflecting a response rate of 93%. Seven questionnaires were deemed invalid and were excluded from analysis.

For the validation of the questionnaire, the Cronbach's alpha test was employed. The gathered data underwent descriptive statistical analysis and ranking assessment utilizing (SPSS, version 26). In relation to the barriers assessed, the calculated Cronbach's alpha coefficient was found to be 0.872, which surpasses the acceptable threshold of 0.7. Consequently, the data derived from this study, utilizing a five-point Likert scale, is deemed reliable at a significance level of 5%, as illustrated in Table 1. To uncover the underlying structure of the barriers to low-energy building practices, an exploratory Factor Analysis (EFA) was conducted using SPSS (version 26). The EFA aimed to identify latent factors that explain the relationships between the variables. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.78, indicating that the data were suitable for factor analysis. Bartlett's Test of Sphericity was significant ($p < 0.001$), confirming that the variables were sufficiently correlated for EFA. Principal Component Analysis (PCA) with Varimax rotation was used to extract factors, and three factors with eigenvalues greater than 1 were retained, explaining 65% of the total variance.

TABLE I. CRONBACH'S ALPHA TECHNIQUE

Reliability Statistics	
Cronbach's Alpha	**N of Items**
0.872	69

Furthermore, a SWOT analysis is utilized to examine the strategic planning of businesses or industries. Originally embraced within the realms of business and marketing, this method has gradually found applications in a wide range of fields. Therefore, SWOT analysis serves as a valuable framework for researching strategic planning. In the present study, SWOT analysis was performed to assesses the internal characteristics (strengths & weaknesses) and the external conditions (opportunities & threats) pertaining to the operational landscape of an organization [21-24].

On the other hand, the Statistical Package for the Social Sciences (SPSS, version 26) was employed to analyze the collected data comprehensively. SPSS proved to be an invaluable tool for managing and processing our dataset, allowing us to perform a wide range of statistical procedures with ease and accuracy.

III. RESULTS AND DISCUSSION

The characteristics of the respondents of Section (A) from the questionnaire are shown Table II. Clearly, the obtained data indicate that 61.3% are males, 38.7% are females, 23.87% are academics and designers, 9.7% are students, and 66.7% are employed in construction companies. This occupational distribution encompasses a broad spectrum of fields pertinent to project construction, thereby enhancing the representativeness of the data. Additionally, 51.6% of the respondents possess project construction experience of up to five years, while 41.9% have between six to fifteen years of experience, and 6.5% have over thirty-one years. Consequently, the personnel composition of this survey appears to be well-structured, which in turn bolsters the credibility of the collected data.

TABLE II. ANALYSIS OF PERSONAL RESPONDENTS' INFORMATION

Gender	Number	Percent
Male	57	61.3 %
Female	36	38.7 %
Total	93	100.0 %
Years of experience	**Number**	**Percent**
0-5 year	48	51.6 %
6-15 year	39	41.9 %
31 year	6	6.5 %
Total	93	100.0 %
Education	**Number**	**Percent**
Architects working in construction companies	62	66.7 %
Academics	23	23.87 %
Student	9	9.7 %
Total	93	100.0 %

In the second segment of the questionnaire (Section B), the focus shifts to assessing the perception of the concept of barriers to low-energy building practices within the context of Egypt. This section is critical as it seeks to evaluate the respondents' awareness of the obstacles associated with the implementation of energy-saving principles in the country. Additionally, it aims to ascertain whether the previously identified items are indeed perceived as impediments to the adoption of energy-efficient building practices in Egypt. The methodology involved posing an initial generalized inquiry regarding the respondents' perspective on whether these components are perceived as barriers. Subsequently, the survey delves into a detailed examination of each individual component, soliciting opinions on their status as barriers. As illustrated in Table III, the findings indicate that respondents concurred that all nine components identified are perceived as barriers to the implementation of low-energy buildings.

In response to the second inquiry in this section, which asks, "Which of these barriers can be disregarded or accepted as negligible?" the data presented in Fig. 3 indicate that respondents uniformly identify each barrier as a hindrance to the implementation of low-energy buildings in Egypt, despite the variability in the perceived impact of each barrier. Notably, the barriers categorized as "cost" and "design" are recognized as the most significant impediments. Following these, the barriers related to "regulations," "market " "risk," "technical solutions" and "contractors" rank as secondary concerns. Finally, barrier categories including "knowledge," "quality," and knowledge are positioned at the lower end of the spectrum. The arrangement of these barriers along with the corresponding percentages attributed to each are further detailed in Fig. 3.

From the second question of this section, "Which of these barriers can be neglected/ accepted as barriers?" Table III illustrates that respondents agree that every item is a barrier to Egypt's implementation of low-energy buildings, even though the percentages of each barrier differ from one another. However, they also agree that (cost and design) are the most affecting barriers. After that (Regulations, Market, Risk, Function and performance and Technical solutions) are the second in arrangement. Then, finally comes (Knowledge, User and behavior, and Instruments of control) and are arranged in Table III according to the percent of each barrier as shown in Fig. 3.

TABLE III. ANALYSIS OF KNOWLEDGE REGARDING LOW-ENERGY BUILDING CONCEPT

In your opinion, are these nine items (Requirement/regulations, Knowledge, Market, Quality, Design, Technical solutions, Contractors, Costs, and Risks) are barriers for implementing low energy buildings		
	N	%
Yes	83	89.2%
No	10	10.8%
Total	93	100.0

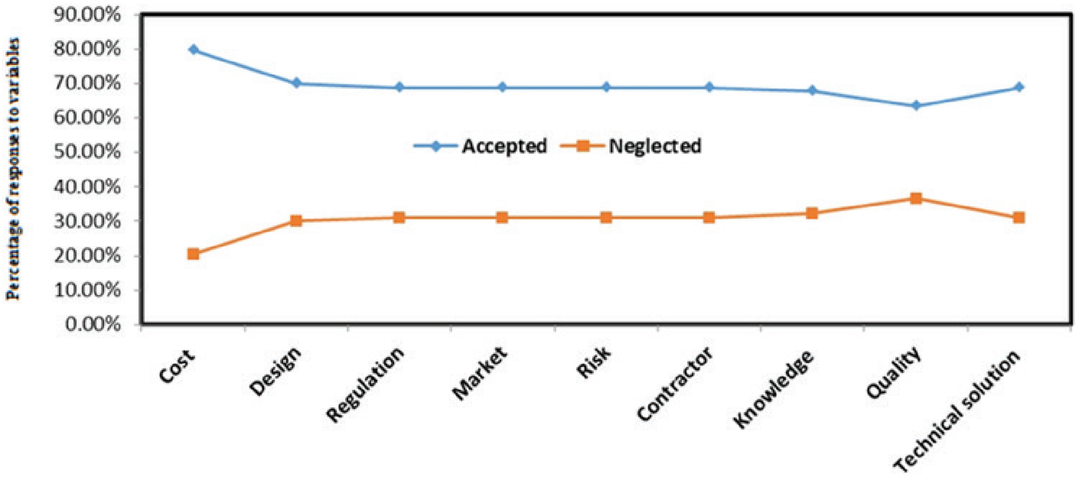

Fig. 3. Analysis of respondents' knowledge regarding low-energy building barriers concept

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Section (C) of the questionnaire focuses on determining the degree to which each element is thought to be a barrier to the application of buildings offered in Egypt. In Table IV, each element question contains a series of clarifying questions about the concept, meaning, and what is meant by the element. Correctness and clarity from which we can gather an honest and transparent view regarding whether or not these components are barriers. When analyzing the responses related to each barrier, the primary focus was to determine whether the identified items were perceived as barriers or not. The results indicated that cost emerged as the most frequently cited barrier, representing the highest percentage among all identified obstacles, and thus was assigned the highest priority. Then comes (Knowledge, Regulations, Market, and Contractors) in the second priority. Then after that (Risk, Quality, Technical solutions, and Design) are the third.

The results derived from the respondents' responses are also shown in Table 4. Each question was followed by a series of clarifying questions to ensure a higher level of confidence in the responses received. The statistical mean and standard deviation for each variable were then determined independently using SPSS, a statistical software application, to assess the responses. The table that shows the appropriate score either agree, completely agree, disagree, completely disagree, or neutral—for the acquired statistical mean was then compared to each response. To determine whether this factor is a barrier to Egypt's adoption of energy-efficient buildings, we then entered all the answers to the explanatory questions into the statistical analysis computer systems (SPSS) to produce a statistical average of the entire barrier.

TABLE IV. ANALYSIS AND INTERPRETATION OF RESULTS OBTAINED FROM RESPONDENTS

Question	Number	Mean	Std. Deviation	Degree
Knowledge				
A1. Students' information on how to build low energy houses	93	3.54	1.02	Agree
A2. Students' education regarding low energy houses	93	3.67	1.04604	Agree
A4. Changing that culture is a paradigm shift, a cultural change	93	3.7204	.97094	Agree
Mean of knowledge	93	3.6452	.88711	Agree
Market				
B1. Marketing, interest, market shares, discussion/data, all-encompassing perspective, and procedure	93	3.3118	1.07318	Neutral
B2. Long-term expectation for more low-energy building construction	93	3.2258	1.11442	Neutral
B4. Dependable low-energy building examples for students	93	3.3333	1.12611	Neutral
Mean of Market	93	3.2903	.91713	Neutral
Design				
C2. Designing low-energy buildings with customer adaptation in consideration	93	3.5376	1.07904	Agree
C3. Disagreements in low-energy building design	93	3.4731	1.01715	Agree
C4. Including designers and consultants early in the process should be considered	93	3.9247	1.04504	Agree
Mean of Design	93	3.6452	.88575	Agree
Technical solutions				
D2. Low-energy building system and product quality	93	3.7419	1.00977	Agree
D3. Low-energy buildings indoor air quality	93	3.6989	1.04033	Agree
D4. Low-energy building operation and utilization	93	3.6022	1.13386	Agree
Mean of technical solutions	93	3.6810	.96047	Agree

Cost				
E1. Estimates of low energy building costs, financing, and funding shortages	93	3.7097	1.08928	Agree
E2. Cost can often come at the expense of quality.	93	3.41	1.29	Neutral
E3. The advantage is worth less than the expense of access.	93	3.28	1.16	Neutral
Mean of Cost	93	3.47	.969	Agree
Quality				
F1. All stakeholders must receive feedback and quality impacts.	93	3.61	1.01	Agree
F2. The additional benefits of achieving energy savings must be objectively documented.	93	3.69	.967	Agree
F3. Assignment of duty for low-energy buildings	93	3.57	1.02	Agree
Mean of Quality	93	3.62	.905	Agree
Regulations				
H1. Codes, rules, and regulations H2. Contractors will face numerous challenges as a result of new government rules.	93	3.45	1.15	Agree
H1. Codes, rules, and regulations H2. Contractors will face numerous challenges as a result of new government rules.	93	3.45	1.15	Agree
Mean of Regulations	93	3.45	1.08614	Agree
Contractors				
I1. Inadequate training of retrofit subcontractors and contractors	93	3.73	1.10	Agree
I2. Restricted information availability for contractors and customers	93	3.55	1.06	Agree
I3. Better training for public contractors and builders is required.	93	3.90	1.01	Agree
Mean of Contractors	93	3.73	.93	Agree
Risks				
G1. Risks related to building technology and finances	93	3.71	1.06	Agree
G2. Problems associated with new low-energy building technologies	93	3.56	1.02	Agree
G3. Insufficient knowledge about the potential long-term failure risks of energy-efficient retrofitted structures	93	3.84	.99	Agree
Mean of Risks	93	3.70	.92	Agree

The findings from the questions in section B and C aimed at evaluating the extent to which certain factors are perceived as obstacles to the implementation of energy-efficient buildings in Egypt are illustrated in Fig. 4. This representation not only elucidates the responses gathered but also substantiates the level of agreement regarding these factors being viewed as barriers. In addition to the descriptive statistics, an Exploratory Factor Analysis (EFA) was conducted to identify the underlying dimensions of the barriers to low-energy building practices. The results revealed three key factors as shown in Table V:

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TABLE V. EXPLORATORY FACTOR ANALYSIS (EFA) OF BARRIERS

Question	Loading
Factor 1 (Knowledge and education)	
A1. Students' information on how to build low energy houses	0.82
A2. Students' education regarding low energy houses	0.78
A4. Changing that culture is a paradigm shift, a cultural change	0.75
Factor 2 (Market and cost)	
B1. Marketing, interest, market shares, discussion/data, all-encompassing perspective, and procedure	0.71
B2. Long-term expectation for more low-energy building construction	0.68
E2. Cost can often come at the expense of quality.	0.65
Factor 3 (Design and quality)	
C2. Designing low-energy buildings with customer adaptation in consideration	0.74
C3. Disagreements in low-energy building design	0.69
F1. All stakeholders must receive feedback and quality impacts.	0.72

While the three-factor solution provides a meaningful and parsimonious representation of the data, explaining 65% of the total variance, it is important to note that the initial investigation identified nine factors based on the literature review and theoretical framework. The discrepancy between the initial nine factors and the three-factor solution suggests that while the three factors capture the primary dimensions of the data, the remaining 35% of unexplained variance may reflect additional, more nuanced barriers. This indicates that the complexity of barriers to low-energy building practices may not be fully captured by the three-factor model alone. Future research could explore whether incorporating additional factors or refining the measurement of variables could provide a more comprehensive understanding of these barriers.

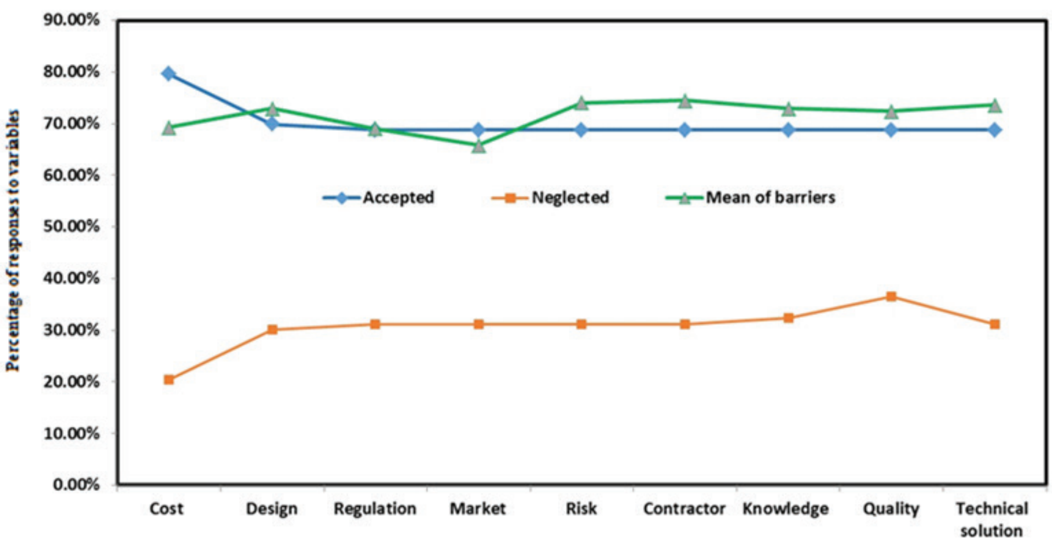

Fig. 4. Analysis of the results of the two sections

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On the other hand, according to the outcomes obtained from Table IV and Fig. 5, a SWOT analysis framework as illustrated in Fig. 6 has been developed based on our findings. In the initial phase, we established a general structure aimed at pinpointing the obstacles encountered by low-energy buildings (LEBs). Our analysis categorized the elements influencing the strengths and weaknesses of LEBs, which included factors such as Codes and regulations, Design, Financial and Technical solutions. Conversely, we identified those elements impacting the opportunities and threats related LEBs, such as Knowledge, Market, Risk, Quality and Contractors' availability.

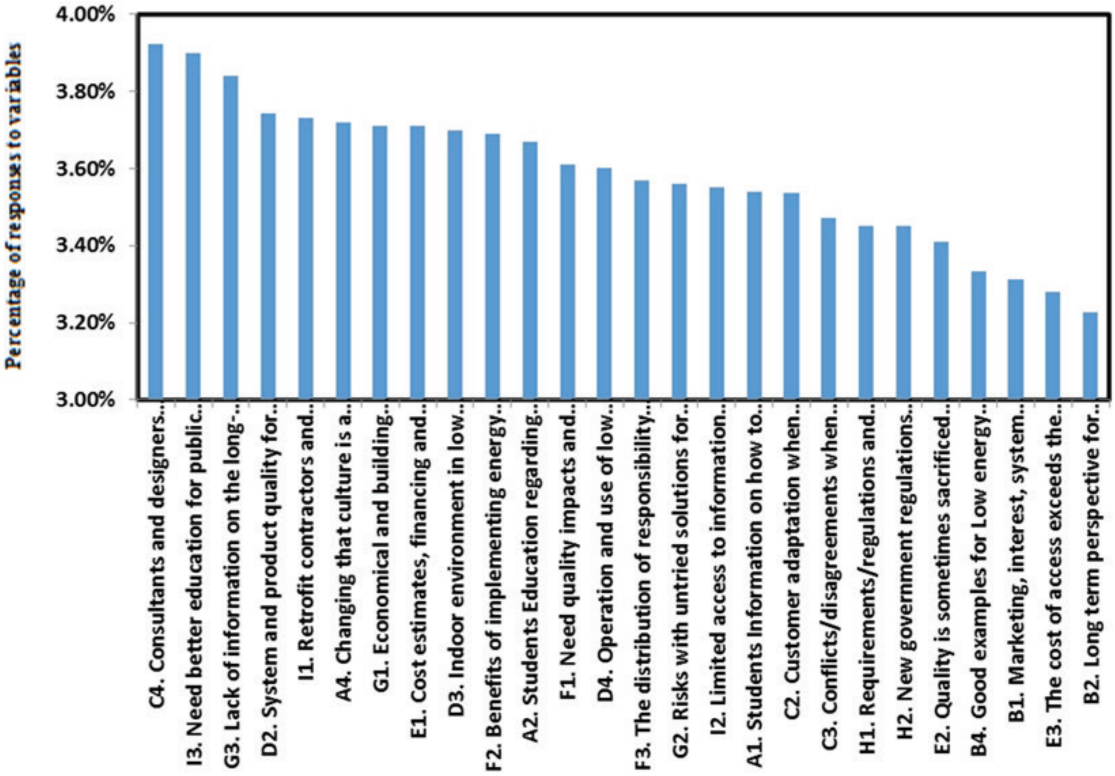

Fig. 5. Analysis of items according to importance

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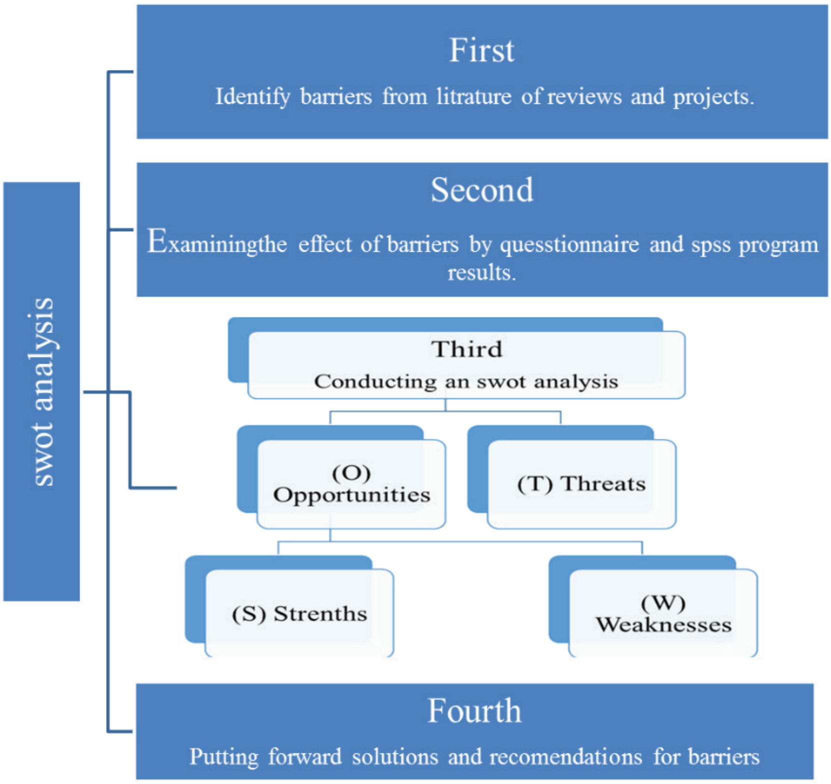

Fig. 6. The basic flow of SWOT analysis

In the second phase, we compiled a comprehensive list of the strengths, weaknesses, opportunities, and threats associated with LEBs (Fig. 7) drawing from a thorough literature review, governmental publications, and questionnaire. The questionnaire questions were refined and finalized following a collaborative brainstorming session among researchers. In the third phase of our study, we established a research approach that incorporates stakeholder analysis into the SWOT framework, drawing on the insights gained from our previous evaluation. Subsequently, in the fourth phase, we put forward a series of strategic action plans aimed at assisting the government in fostering Local Economic Benefits (LEBs). These plans are designed to optimize engagement with stakeholders while aligning with the overarching goals identified in the SWOT analysis. The findings from our SWOT analysis yielded four key insights. First, we identified several strengths that, if prioritized, could significantly address the challenges associated with low-energy buildings in the construction sector. Key strengths include enhancing product quality, improving indoor air quality, documenting the additional advantages of energy savings, and increasing students' knowledge regarding low-energy building practices and operations. Second, we highlighted various weaknesses that need to be addressed in order to overcome obstacles. Enhancing student education about the construction of low-energy buildings is essential, as is reducing disagreements over low-energy building designs. Additionally, better estimates of the costs associated with low-energy buildings, alongside finding solutions for financing and funding shortages, are crucial.

Third, the analysis uncovered several opportunities that, if leveraged effectively, could facilitate progress in resolving existing issues related to low-energy buildings. Finally, we identified threats that, if mitigated, could significantly reduce barriers to the implementation of low-energy buildings in Egypt. Addressing these threats can lead to a more sustainable and efficient construction landscape.

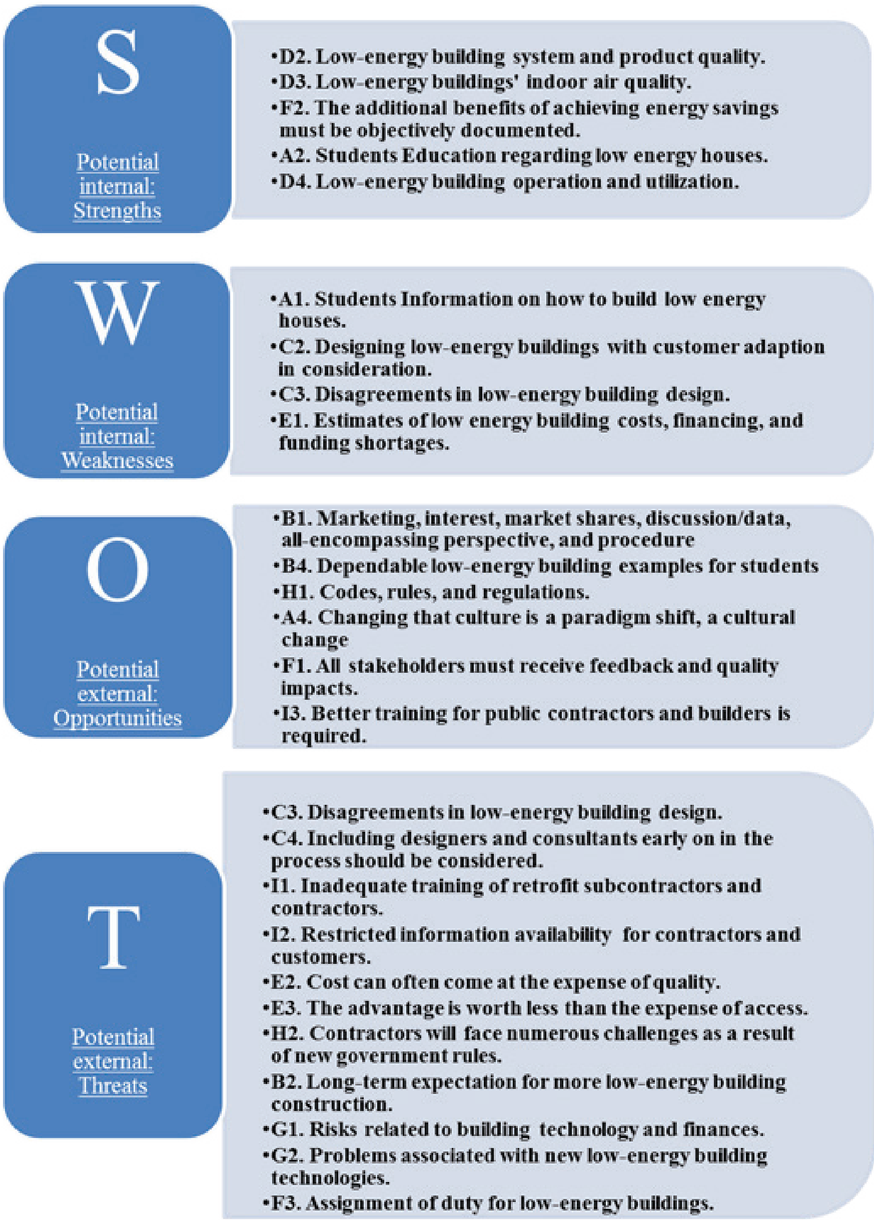

Fig. 7. SWOT analysis of items

Furthermore, to confirm the validity of our findings, we utilized Credit Agricole bank located in New Cairo City, Egypt, (a building that has achieved Platinum LEED certification) as a benchmark for comparison with our obtained results in accordance with the barriers identified in our study and is presented in Table IV. This comparison serves to strengthen our analysis and provides a context for evaluating the effectiveness of the identified barriers in sustainable building practices. To validate and contextualize our findings, we conducted a case study on the Credit Agricole Bank in New Cairo City, Egypt, which is exemplary in its adherence to LEB principles as evidenced by its Platinum LEED certification. By analyzing this case, we have a tangible reference point that allows us to explore how the identified barriers impact real-world applications of LEB strategies. Credit Agricole Bank proudly achieved platinum LEED certification for its headquarters, known as the Unity Building (Fig. 8). This certification reflects its iconic architecture and a strong commitment to reducing environmental and health impacts through meticulous choices in site selection, construction, operations, and maintenance. Designing a sustainable building is particularly challenging given the need to ensure employee comfort in the face of the severe climatic conditions of the site. In March 2016, the US Green Building Council awarded the building a LEED platinum rating, scoring 81 out of 110

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possible points. The design aimed to create an office that is both traditional in appearance and high-performing in function. The design team implemented several passive strategies, including optimal building orientation, overhanging roofs, recessed windows, and high thermal mass facades to minimize reliance on costly and complicated mechanical systems. Additionally, careful planning of the building operation and management was prioritized to boost energy efficiency and enhance workplace conditions. A key focus of the New Cairo Head Office is the effective use of energy resources, ensuring a comfortable working environment for employees. The facility features a modern branch equipped with a variety of amenities that foster collaboration, including fully equipped conference and training rooms, a theater with a capacity for 300 guests, a restaurant, a gym, a cafeteria, and beautiful landscaped green spaces [25-29].

(a) Master plan (b) Exterior View

Fig. 8. Credit Agricole bank New Cairo City, Egypt (Source: [30])

The analysis presented in Table VI examines Credit Agricole building in relation to the barriers identified in this study. The evaluation is divided into five categories: Energy consumption, water consumption, building water management, energy-saving measures, and efficient lighting systems. The building energy usage is optimized through the installation of highly efficient shading devices positioned above its openings and at the roof upper edge. This approach qualifies the building for five points under the SS.06 credit, as the landscape incorporates native plants originally found on the site prior to construction. Additionally, the presence of solar panels on the roof contributes to mitigating the urban heat island effect. These features indicate that the building has successfully navigated barriers related to design, technical solutions, costs, and market conditions, earning it LEED certification. Next, regarding water consumption, the building has addressed technical solution and cost barriers, achieving two out of four points allocated for credit related to water-efficient landscaping, primarily by utilizing native vegetation in the project. However, to earn the additional two points, the project must not utilize potable water at all, which it fails to meet due to the need for a drip irrigation system. The Credit Agricole building qualifies for 20 points in WE.03 as it achieves a 40% reduction in potable water usage. In terms of energy savings, the building scores 50-56, representing a 25-28% improvement, thereby overcoming barriers related to design, technical solutions, costs, market conditions, knowledge, and regulations. For efficient lighting, the Credit Agricole building is eligible for eight to ten points under EE.05 due to its provision of effective lighting systems. The actual points awarded depend on whether the lamp efficiency exceeds 60 lumens per watt, again indicating the successful navigation of barriers associated with design, technical solutions, costs, market, knowledge, and regulations. Overall, this analysis illustrates significant advancements in reducing obstacles to implementing energy-efficient buildings in administrative and governmental structures in Egypt for the following reasons:

TABLE VI. ANALYSIS OF CREDIT AGRICOLE BUILDING

Strategies	Credit Agricole Egypt headquarters	The barriers
Energy consumption	Highly efficient shading devices fitting were installed above the openings and at the upper end of the roof of the building.is also eligible for 5 points for SS.06 credit since the plants used in the project's landscape were the plants which were originally found on the site prior to construction, in addition to the solar panels on the roof which also protect the building from the heat island effect.	Design, Technical solutions, Cost, and Market
Wastes of building	Crédit Agricole achieve 2 out of the 4 points appointed to the water efficient landscaping credit due to the incorporation of native plants in the project. However, the credit requires no use of potable water at all to achieve the remaining 2 points. Hence, it is not eligible for the remaining 2 points since it requires a dripping irrigation system. Crédit Agricole qualifies for 20 points in WE.03 since it presents a 40% reduction in potable water.	Technical solution, and Cost
Water consumption	Water Efficiency (WE) 22 score rate 11 %.	Technical solutions, and Cost ends with no saving water
Energy saving by bills	Energy Efficiency (EE) 50-56 score rate 25-28 %.	Design, Technical solutions, Cost, Market, Knowledge, and Regulations
Efficient lighting	Crédit Agricole is eligible for 8 to 10 points for EE.05 by providing efficient lighting systems. The variation in achievable points depends on whether the lamp efficiency ranges are greater than 60 lm/W. The stairs in Crédit Agricole are centralized and daylit which economize lift use. The remaining 4 points (EE.06) for both projects depend on the energy efficiency label of the elevators.	Design, Technical solutions, Cost, Market, Knowledge, and Regulations

1. In contrast to private residences, where the owner has complete authority and can decline decisions for various reasons, including those barriers mentioned earlier, administrative or government buildings fall under governmental accountability. The government oversees their construction and associated costs. This enables the government to easily promote the concept of energy efficiency and raise public awareness within these structures. Consequently, the government has intensified efforts to educate the public on the foundational aspects of energy-efficient construction practices.

2. By providing reliable and practical examples, the government has inspired investors and decision-makers to integrate energy-saving principles from Egypt into other sectors of construction. Additionally, the government has encouraged investors and decision-makers to create and supply both raw materials and components that support the adoption of energy-saving practices in building projects.

3. Due to a rising demand in the labor market for engineers with advanced expertise and a solid grasp of energy-saving implementation, the government has called upon universities and educational institutions to incorporate energy-saving principles into their curricula. As a result, the government has effectively addressed and mitigated many of the obstacles to implementing energy-efficient buildings in Egypt through its application of these principles in government and administrative facilities. Consequently, Egypt is on track to be recognized as a nation that actively reduces energy consumption and promotes energy efficiency. In the future, it may also emerge as one of the countries that produce energy.

IV. CONCLUSION

This study analyzed barriers to constructing energy-efficient buildings in Egypt, initially identifying nine factors through literature review and questionnaire analysis. Design and technical solutions emerged as the most critical challenges, followed by knowledge, quality, cost, and market dynamics. However, Exploratory Factor Analysis (EFA) revealed a three-factor solution—Knowledge & Education, Market & Cost, and Design & Quality—explaining 65% of the total variance. These factors provide a meaningful framework for understanding the barriers, aligning with key themes in literature. The study findings highlight regulatory and design-related obstacles, underscoring the need for updated building codes and legislative reforms to align with environmental guidelines. While cost factors like global and life cycle costs are often prioritized, operational energy and occupant comfort receive less attention. Additionally, the embodied energy implications of retrofitting interventions are frequently overlooked, despite their importance for holistic sustainability. The remaining 35% of unexplained variance suggests that additional factors may exist, emphasizing the complexity of these barriers. Future research should explore these dimensions and refine measurement tools for a more comprehensive understanding. By addressing these barriers, Egypt can advance its energy efficiency goals and promote a sustainable built environment.

References

[1] A. Kadir and S. P. Low, "An overview of energy consumption in buildings: A case for energy efficiency measures," *J Clean Prod*, 2021, [Online]. Available: https://doi.org/10.1016/j.jclepro.2021.125116

[2] J. Zuo and G. Zillante, ""The role of green building in urban sustainability: A stakeholders' perspective." *International Journal of Construction Management*, vol. 18, no. 6, pp. 525–536, 2018, [Online]. Available: https://doi.org/10.1080/15623599.2018.1452985

[3] S. Azhar, "Sustainable building design: Strategies to minimize energy consumption." ," *Sustain Cities Soc*, 2019.

[4] IEA, "World Energy Outlook 2020 – Analysis," 2020. [Online]. Available: https://www.iea.org/reports/world-energy-outlook-2020

[5] A. Foucault and F. Branger, "Quantifying the impacts of building energy efficiency measures on occupant comfort and health," *Energy Build*, 2020.

[6] C. J. Kibert, *Charles J. Kibert, Sustainable Construction: Green Building Design and Delivery*, 3rd ed. John Wiley & Sons, 2016.

[7] T. Kelley, "The Impact of Building Certification Programs on Energy Efficiency and Sustainable Design.," *Journal of Green Building*, vol. 14, no. 2, pp. 37–49, 2019.

[8] T. Häkkinen and K. Belloni, "Barriers and drivers for sustainable building," *Building Research and Information*, vol. 39, no. 3, 2011, doi: 10.1080/09613218.2011.561948.

[9] J. Zuo and Z. Y. Zhao, "Green building research-current status and future agenda: A review," 2014. doi: 10.1016/j.rser.2013.10.021.

[10] "Ministry of Electricity and Renewable Energy," *Egypt's Energy Consumption Report 2020-2023. Cairo: Egyptian Government.*, 2023.

[11] M. S. Hossain and A. Parsa, "A review on energy-efficient building designs: A case study of residential and commercial buildings," *Sustain Cities Soc*, 2020.

[12] M. S. Abdel-Wahab and A. Elshorbagy, "Energy consumption trends in governmental and administrative buildings: The case of Egypt.," *Energy Reports*, vol. 7, pp. 123–134, 2021.

[13] A. Elshorbagy and M. A. Sharaf, "Addressing the gaps in energy performance assessment of residential buildings: Insights from Egypt," *Building Research & Information*, vol. 48, no. 7, pp. 830–841, 2020.

[14] A. A. Mohamed and T. A. Zayed, "Strategies for enhancing energy efficiency in existing public buildings in Egypt." *Energy Effic*, vol. 12, no. 5, pp. 1245–1260, 2019.

[15] M. M. Sabry and L. El-Feky, “Barriers to the implementation of energy-efficient technologies in government buildings: A case study in Egypt,” *J Clean Prod*, 2020.

[16] A. M. Dakhil and S. Ahmed, “Low-energy building practices in Egypt: Current status and future prospects,” *Renewable and Sustainable Energy Reviews*, vol. 81, pp. 1703–1717, 2018.

[17] M. M. Abdelhamid and A. A. El-Masry, “Evaluating the energy efficiency of residential buildings in Egypt: Current status and future outlook,” *Energy Reports*, vol. 6, pp. 1301–1310, 2020.

[18] H. Ali, “Barriers to the adoption of energy-efficient technologies in the Egyptian building sector,” *Renewable and Sustainable Energy Reviews*, vol. 138, 2021.

[19] F. H. Ghabban and A. Hammadi, “Passive design strategies in architecture: A study of sustainability in the Egyptian context,” *Sustainability*, vol. 11, no. 21, 2019.

[20] N. H. Mohamed, “The need for comprehensive design guidelines in promoting energy-efficient buildings in Egypt: A stakeholder perspective,” *International Journal of Building Pathology and Adaptation*, vol. 40, no. 4, 2022.

[21] T. Hill and R. Westbrook, “SWOT analysis: It’s time for a product recall,” *Long Range Plann*, vol. 30, no. 1, pp. 46–52, Feb. 1997, doi: 10.1016/S0024-6301(96)00095-7.

[22] G. Panagiotou, “Bringing SWOT into Focus,” *Business Strategy Review*, vol. 14, no. 2, pp. 8–10, Jun. 2003, doi: 10.1111/1467-8616.00253.

[23] R, Morais and C. J. Costa, “The Relevance of SWOT Analysis in Strategic Planning: A Review of the Literature,” *Journal of Business and Management*, vol. 23, no. 4, pp. 225–234, 2017.

[24] S. Ghazinoory, K. Abateneh, and M. Roshanzamir, “SWOT Analysis: A Case Study of a Hotel,” *International Journal of Business and Social Science*, vol. 2, no. 2, pp. 12–19, 2011.

[25] “US Green Building Council,” *LEED Platinum Certification for Credit Agricole Bank Headquarters*, 2016, [Online]. Available: https://origin.archi/en/credit-agricole-egypt-headquarters/

[26] M. Johnson and S. Li, “Sustainable Architecture: Designing for Climate Resilience. ,” *Journal of Environmental Design*, vol. 15, no. 3, pp. 245–258, 2017.

[27] “Green Building Research Institute. Passive Design Strategies for High-Performance Buildings.,” 2018, [Online]. Available: https://origin.archi/en/credit-agricole-egypt-headquarters/

[28] R. Smith and J. Chen, “The Impact of Building Orientation on Energy Efficiency in Commercial Buildings.,” *Energy Efficiency Reviews*, vol. 11, no. 2, 2019.

[29] T. Brown and A. Williams, “Well-Designed Workspaces: Amenities that Foster Collaboration and Productivity,” *International Journal of Workplace Studies*, pp. 45–60, 2020.