Evaluating the Effectiveness of Sustainable Energy-Efficient Design in School Buildings in Urban Areas of Aswan: A Case Study of Fares Village School

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Abstract
This research presents a proposed methodological study for evaluating the effectiveness of sustainable design in school buildings in hot, arid urban areas, using the case study of the Fares Village School in Aswan, designed by the renowned Egyptian architect Hassan Fathy in 1957. The proposed methodology relies on computer simulation using Design Builder V 7.0 software to measure the energy efficiency and thermal performance of the building under the harsh climatic conditions characteristic of Aswan. The research analyzes the school's design features, which rely on natural passive cooling strategies, such as the use of thermal mass in thick mud-brick walls, domes and vaults, an internal courtyard, a natural ventilation system, and the "Salsabil" (water basin) element designed by Fathy for air cooling. This research aims to develop a methodology for evaluating the effectiveness of traditional energy conservation methods in educational facilities in the hot climate of Upper Egypt, specifically in Aswan Governorate. The results indicate that the traditional design of the Fares Village School in Aswan Governorate, designed by the architect Hassan Fathy, is highly energy-efficient compared to conventional school designs. Therefore, we conclude that this building represents an innovative and sustainable design that should be documented and preserved to enhance its future performance with minimal intervention. The researcher suggests integrating sustainable passive design techniques, based on traditional architectural designs, into the standards of the General Authority for Educational Buildings. Furthermore, the proposed methodology should be applied on a large scale to evaluate school buildings in various climatic regions of Egypt.

Keywords: Sustainable design, energy efficiency, school buildings, hot and dry climate, energy simulation, passive cooling.

1. Introduction

The last two decades have witnessed a growing interest in environmental sustainability issues within the construction sector, with buildings now responsible for approximately 50% of global energy consumption and nearly a third of greenhouse gas emissions (UNEP, 2020) [1] . In this context, school buildings have emerged as a vital sector requiring the application of sustainable design standards, not only due to their energy consumption but also because they represent an educational environment that impacts students' health and academic achievement, as well as their exemplary role in disseminating a culture of sustainability among future generations.

The Arab Republic of Egypt is characterized by a wide climatic diversity, ranging from a temperate Mediterranean climate in the north to a hot, arid desert climate in the south. Aswan Governorate is among the hottest regions in Egypt, with summer temperatures exceeding 46°C, accompanied by high levels of solar radiation and low relative humidity (Mahmoud, A. et al. 2015)[2]. The severe climate conditions represent a major challenge for school buildings which have to provide the right conditions for an effective studying process for both students and teachers all year around. That means intensive use of climate control systems generating excessive consumption of energy.

In this respect the traditional architecture of Upper Egypt, in particular the works by the famous Egyptian architect Hassan Fathy, is the example of the use of innovative methods of coping with difficult climatic conditions and sustainable design. The architectural style developed by Fathy is based on the use of local resources (like mud bricks), local building methods, and passive cooling methods. He stated that "building an Oriental house in Europe or a European house in the desert is out of question. It's unreasonable to transfer the architectural knowledge gained in one country to another without taking into account their local climate".

The Fares Village School (1957) is one of the most famous Fathy's buildings and is a sample of building rural schools in Egypt using the previous ideas in one concept. The building has no mechanical cooling systems and employs natural ventilation because of the high expense and noticeable difficulty of installing any cooling. The building is considered to have unique and rare architectural and environmental value.

2. Research Problem

The research problem arises from the lack of the adequate scientific approach for appraising how sustainable design helps attain energy efficiency in the construction of schools in hot, dry cities of Egypt the provided reasons:
There is a growing need for energy in schools which relates to the wider use of air conditioning systems in response to increased temperatures.
Traditional construction methods (like the Fares school), showed significant success in adjusting to hot and dry climate utilizing passive cooling methods but have not been studied quantitatively.
The General Authority for Building Construction uses standard designs which do not consider local climatic conditions, causing energy consumption growth and lowering the level of thermal comfort.
The abandonment of considered heritage buildings (like Fares school) endangers their future as they are essential source of inspiration.
The situation is further complicated by the lack of a specific method for assessing sustainable architecture in educational institutions that can be applied to evaluate existing buildings and provide quantitative information about their performance and energy efficiency.

3. Research Questions

This research aims to answer the following questions:
- **Main Question:**

How can a scientific methodology be developed to evaluate the application of sustainable design in school buildings in urban areas with hot, dry climates, using a case study of the Fares Village School (designed by Hassan Fathy) with computer simulation?

- **Sub-questions:**

What sustainable design strategies (passive and active) are suitable for school buildings in the hot, dry climate of Aswan?
What are the design and architectural characteristics of the Fares Village School, designed by Hassan Fathy, and to what extent do they align with the principles of sustainable design?

How can the thermal performance and energy efficiency of the Fares School be measured using the Design Builder V 7.0 simulation software?

4. Research Objectives

This research aims to achieve the following objectives:
- **Main Objective:**

To propose a scientific methodology for evaluating the application of sustainable design in school buildings in hot, dry regions, using a case study of the Fares Village School with computer simulation using the Design Builder V 7.0 software.

- **Sub-Objectives:**

To analyze the climatic characteristics of Aswan and identify suitable design strategies for school buildings in this climate. A study and analysis of the design and architectural characteristics of the Fares Village School, identifying its sustainable design elements.

Working to utilize the traditional design of the Fares Village School in Aswan Governorate and providing recommendations for developing educational building design standards in Egypt.

5. Research Hypothesis

Sustainable design elements using passive design strategies in Fares Village School (wall thickness, inner courtyard and natural ventilation, domes, and windcatchers) reduce energy consumption compared to the standard model.

6. Importance of research

The significance of this research can be understood in several ways, which can be summarized as follows:
First: Theoretical and Knowledge Level: This research addresses the gap in the body of knowledge in relation to environmental and thermal performance assessments of traditional school buildings in hot and dry climates through that will serve as scientific evidence in the future research.

Second: Applied and Practical Level: This research puts forward a methodology that can be used widely to evaluate the energy efficiency of school buildings. It can be applied in renovating and upgrading existing buildings as well as designing new buildings.
Third: Policy and Legislative Level: This research effectively bolsters the application of passive design methods in the regulations of the General Authority for Educational buildings and stimulates a re-examination of existing model standards which fail to take into account the specificities of climate conditions.

The Fourth Criterion: Heritage and Culture Level. This work is useful for registering the architectural and environmental significance of the Fares School and contributes to its preservation as an example of sustainable architecture in Egypt, particularly amidst its demolition attempts.

7. Research Methodology

This study utilizes a mixed approach combining:
A theoretical analysis of the literature related to the subject of the study along with a descriptive-analytical approach that focuses on understanding climatic characteristics of Aswan and factors affecting the Fares School. Also, a quantitative experimental approach makes use of Design Builder V 7.0 applications to design the existing school and compare its work with the model of the traditional school designed in the same climate.

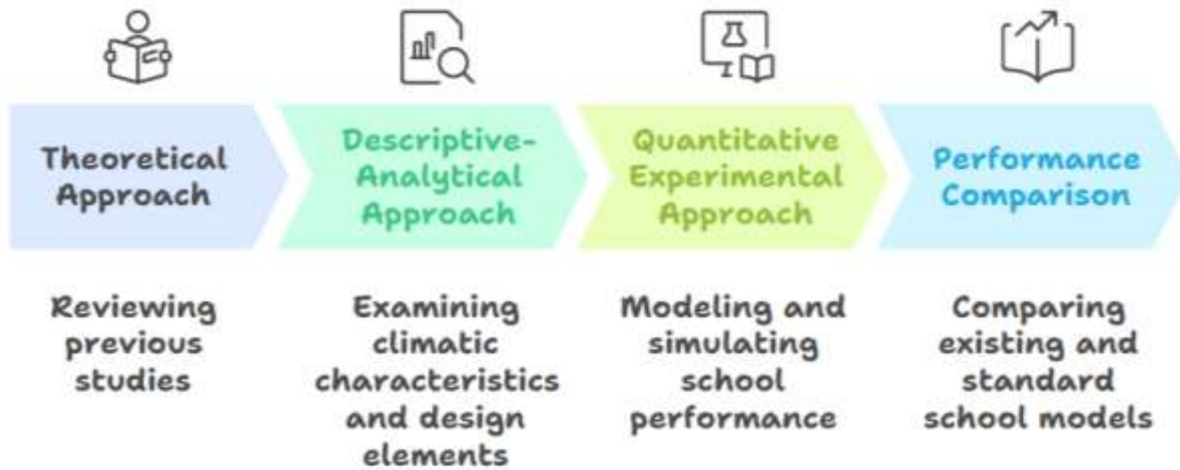

Figure (1) Research Methodology

8. Literature Review

numerous previous studies have dealt with issues of energy efficiency and thermal performance in school buildings in Egypt, either through assessing the current state of things or offering solutions based on computer simulation. The design of the famous Egyptian architect Hassan Fathy, and especially the Fares country school, is among the most discussed example of innovative architectural solutions in hot and arid climate. Despite its architectural and historical importance, there are few research works that focus specially on the Fares School which was designed by Hassan Fathy in 1957 in the village of Fares, Aswan Governorate among researchers. Most sources available deal with the school from historical or descriptive angle, with no quantitative studies of its environment and thermal performance. In (2016), for example, Saleem and others conducted a pioneer study of thermal comfort and energy consumption within public primary schools in Egypt. The study aimed at establishing thermal states of the classrooms and verifying how the existing thermal conditions comply with comfort standards. The study shows that there is a significant gap that needs to be filled regarding thermal conditions and comfort standards. The research has shown that public primary education institutions in Egypt represent the most applicable sector for energy efficiency initiatives because of the repetitive nature of their design models and the possibility of generalizing the proposed solutions. In his research work, Mohamed (2009) studied the eco-efficiency of public schools in Egypt with a particular focus on thermal comfort. The study indicated the lack of eco-efficiency in these institutions as far as thermal comfort is concerned due to insufficient thermal insulation, unsatisfactory natural ventilation, and heavy dependence on industrial air-conditioning systems. The study suggests using passive design techniques in schools to achieve thermal comfort with minimum operational costs. In a more recent study, Azmy (2024) assessed the impact of classroom design and orientation on the quality of the indoor environment in Egyptian schools. The results showed that building orientation and the design of openings significantly affect levels of natural light and ventilation, which in turn impacts the quality of the indoor environment and students' academic performance. The study aimed to determine the extent to which classroom shape and orientation in Egypt affect the quality of its indoor environment and thermal performance, as well as achieving good classroom ventilation. William et al.'s (2021) study addressed the technical and economic evaluation of building envelope improvement measures in an educational building in Egypt. This study analyzed the energy savings resulting from implementing rehabilitation measures in an educational building located in Egypt through dynamic simulation of the building's performance. The purpose of this study was to develop a decision-making matrix for the selection of the best building envelope option that will satisfy thermal insulation properties, costs, and ecological parameters. Rashed & Elmansoury (2023) proposed a thermal renovation approach to the schools existing in hot dry climate and utilized an integrated methodology of digital modeling to improve energy efficiency of buildings for education in hot climate. The study provided a methodological framework which is applicable to education buildings in hot dry climate. It provided a concept of how to achieve a reduction of 35% in annual energy use in newly constructed schools and 21% of energy use in renovated schools. As per the findings, rehabilitation of existing schools is viable and efficient, even in the extreme climatic conditions of a place like Hurghada. The study suggests that while the older buildings in the community need interventions focusing on the building envelope, the newer buildings could be more effective if fitted with the latest innovations in technology, such as the automated energy management systems and renewable sources of energy, such as photovoltaic panels with battery storage. The study conducted by Bernardo et al. (2017) used a calibrated energy simulation model based on Design Builder and EnergyPlus software to assess the performance of the school. The aim of the investigation was to prepare an energy simulation model for the school building that would investigate the effect of optimized ventilation system on its thermal performance and energy efficiency. The study emphasized the importance of calibration to ensure the accuracy of the simulation results and their applicability to design decisions. The study by Mohamed, M. A., & Mansour, S. S. (2021) used Design Builder 6.0 software to simulate classrooms in the hot, dry climate of Qena Governorate. This software is internationally recognized for its use in environmental analysis of buildings due to the accuracy of its results compared to actual energy consumption. The main findings indicate that the reduction in energy consumption between the base glass and the double-glazed, emission-reducing nano-glass (6 mm and 13 mm air) glass is more than 30% compared to the base glass. Archnet discusses the school as a prototype for rural schools, describing the design elements adopted by Fathy, including the natural ventilation system and the use of a traditional water feature. The source indicates that the Fares School represents an advanced model of Fathy's spatial planning and organization, as it integrates several previous ideas into a single, cohesive design. Fathy designed the school as a prototype for rural schools throughout Egypt. Several media outlets have covered the story of the school and its restoration crisis, such as the Al-Ahram Gate report (2020), which discussed the school's architectural design in detail, and the Youm7 report (2020), which reviewed the details of the restoration crisis. According to research conducted, Fares village had been depending on this school for meeting their educational requirements from the 1950s until 2015 when it was declared abandoned after its condition deteriorated and restoration attempts failed. To speed up this repair, in September 2020 the Aswan Governor issued an order with 9 million Egyptian pounds earmarked for this reconstruction project Abdelsalam's study (2014) is devoted to analyzing the integration of culture and sustainability in the projects of Hassan Fathy. The main purpose of this research is to analyze the idea of introducing the idea of sustainability and culture in the architecture of Hassan Fathy. It exhibits the architect's efforts to create the architectural design of buildings that combine the ideas of sustainability and culture of the certain society. The author emphasizes the successful outcomes of the concepts applied by Hassan Fathy addressing the main issue human sustainability in architecture when developing his designs. He presents such techniques as controlling the internal temperature using a water courtyard and green plants, applying very thick external walls, and using natural resources in building.

The analysis of the previous studies yields the following findings:

Firstly, past research yields many valuable insights into the energy efficiency and thermal productivity of educational establishments in Egypt in connection with the assessment of the existing state of affairs and proposals for enhancing it.

Secondly, computer simulation has already proved to be an effective means of assessment of thermal productivity and energy efficiency of educational establishments using Design Builder software, thus leading to its use in practice.

Thirdly, studies devoted to the architecture of Hassan Fathy testify to the effectiveness of his method of achieving thermal comfort cheaply and making it an important reference point for modern designs.

Lastly, while the Fares School is of considerable architectural and historical importance, there is little publication on the subject in terms of academic literature, with almost no quantitative evaluation regarding the school's environmental and thermal performance.

This research investigates the gap characterized by:

1. The lack of empirical studies which integrate the architectural assessment of the Fares School with the assessment of its environmental and thermal characteristics via computer simulation.
2. The lack of unified methodology for evaluating sustainable design of school buildings in hot and arid regions, drawing from lessons learned from the Fares School as a heritage model.
3. The necessity for developing specific performance criteria applicable for school buildings in hot and arid climate, considering local climatic conditions and how the buildings are being used.

9. Case Study**: Fares Village School**

- A Brief History of the School

Fares Primary School is considered to be one of the most significant designs made by the eminent Egyptian architect Hassan Fathy (1900-1989).It was built in 1957 in the village of Fares, near Kom Ombo in Aswan Governorate, at the invitation of the Egyptian Ministry of Education, which was impressed by Fathy's experience in designing the new village of Gourna.

Fathy designed the school as a prototype for rural schools throughout Egypt. The school incorporated many of Fathy's earlier ideas into a single, integrated design.

Figure (2) Fares Village School https://www.archnet.org/sites/2608 2-12-2025

The school was built at a very low cost of only 6,000 Egyptian pounds, using local materials and traditional building techniques, with the participation of the villagers in the construction process. The school served the residents of Fares village from the 1950s until 2015, when it was evacuated due to its deteriorating structural condition.

- Geographical Location and Climate

The Fares School is located in the village of Fares, which belongs to the city of Kom Ombo, approximately 50 kilometers north of Aswan. The region is characterized by a hot, dry desert climate, where:

Figure (3) Fares School is located in Fares village in Aswan.

• **Temperature:** During the summer season, temperatures fall between the range of 40°C to 45°C, occasionally reaching peaks of 48°C. The temperatures in winter will get low, close to 8°C to 10°C.

As illustrated in Figure (4) Temperature for Fares village in Aswan. Climate consultant 6.0

• **Humidity**: Majority of the year the humidity is lower, around 20-40%, contributing to high efficiency of evaporative cooling.
• **Solar Radiation**: High throughout the year, where the solar radiation during summer reaches 800 watts/m².
• **Wind**: The wind direction is north-west for most of the year and the wind speed varies between 3-5 m/s.
• **Rainfall**: The rainfall is scanty and negligible with less than 5mm of rainfall per year.

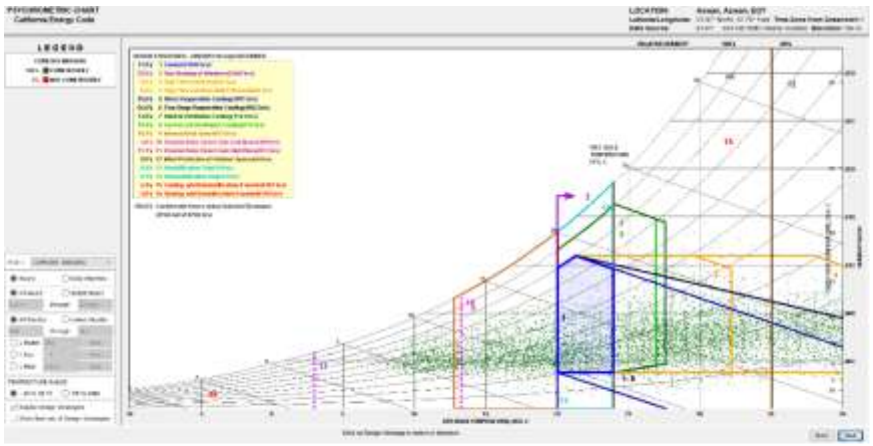

Figure (5) Psychrometric map for Fares village in Aswan. climate consultant 6.0

- Architectural Features of Fares School

Fares School has a distinctive architectural design that exemplifies Hassan Fathy's ideology on sustainable and green architecture. The school's architectural characteristics contain:

- **Planning and Spatial Organization**

The school's planning arranges its layout in such a way that, on one side, the administrative offices and common places (mosque, library, conference hall) look east and west and, on the other, the classrooms face north and south and are sheltered from the sun by a centralized open courtyard. The school is U-shaped, with the arms forming a central courtyard that is open.

- **The architectural plan of the school illustrates:**

• 9 classrooms: situated in wings, which are parallel to one another and where each classroom is designed as a square room with a dome.
• Library: to stimulate reading and knowledge accumulation.
• Arts shop: for creative works.
• Administrative offices: for administration matters of the school.
• Teachers' houses: To offer accommodation for teachers.
• Multipurpose hall: For gatherings and activities.
• Open-air theater: For shows and celebrations.
• Mosque: Looking towards Mecca, with a carved mihrab.

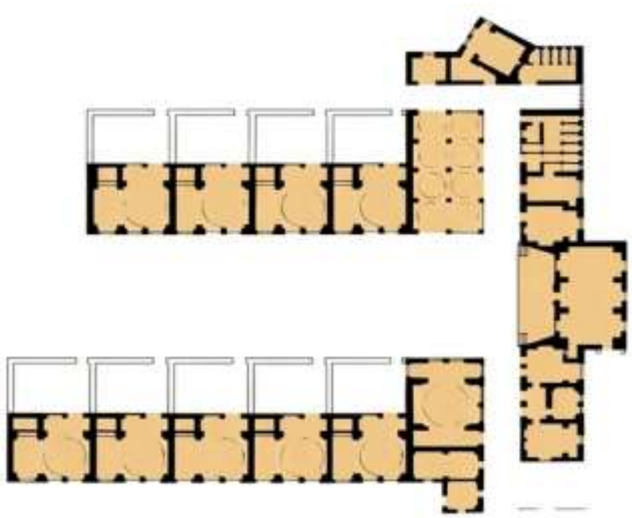

Figure (6) plan Of Fares Primary School
https://archive.org/details/diwan_20170917_0900 3-12-2025

10. Passive Design Strategies in Hassan Fathy's Fares Village School

In the school of Fares, Hassan Fathy used various passive cooling techniques to ensure the thermal comfort and natural ventilation without mechanical systems. Some of these techniques are as follows:

1- Thick Mud Brick Walls (Adobe Walls)

Fathy applied mud bricks made of local clay to construct the walls where their thickness varies between 40 to 60 cm. Such walls act as thermal mass so that they absorb heat during the day and slowly release it at night, thus controlling temperature fluctuations inside the classrooms. Studies have demonstrated the effectiveness of this strategy in temperature regulation, finding that the use of high thermal mass mud bricks in traditional buildings maintains an internal temperature between 2.7°C and 6.7°C lower than the external temperature. Fathy actively advocated for the use of local technologies and materials in Egypt as a means of improving the lives of farmers through cost-effective passive conditioning solutions.

Figure (7) Thick Mud Brick Walls in Hassan Fathy's Fares Village School
https://c20society.org.uk/building-of-the-month/faris-school-egypt 1-12-2025

2- Domes

Each classroom was covered by a dome, a traditional architectural element in Islamic and Nubian architecture. Domes contribute to the even distribution of heat load, increase ceiling height which helps hot air rise, provide space for upper ventilation openings that allow hot air to escape, and reduce the roof surface exposed to solar radiation compared to flat roofs. Domes and vaulted ceilings were used extensively in Fathy's work to provide indoor thermal comfort.

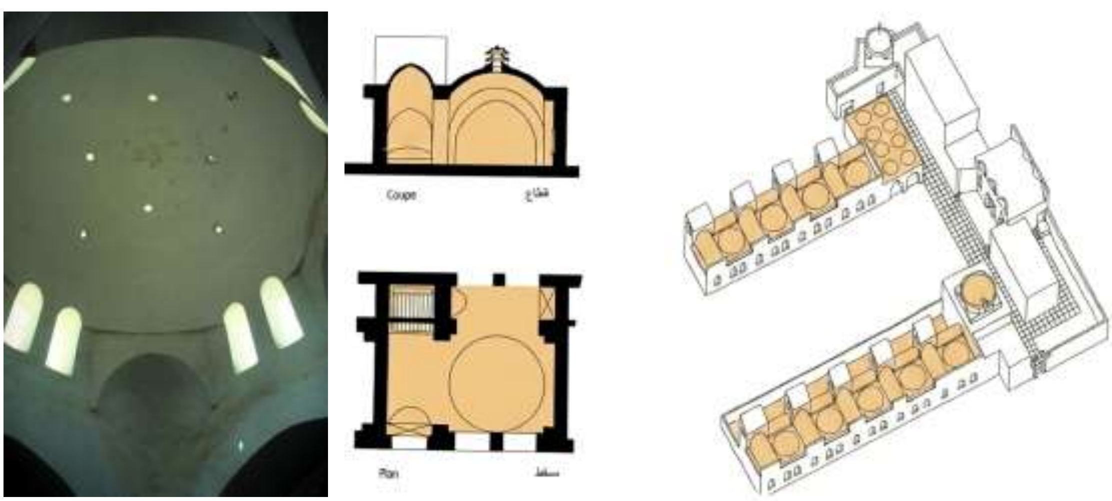

Figure (8) Domes covers every classroom. in Hassan Fathy's Fares Village School
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3- Windcatchers (Malqaf)

Fathi designed a windcatcher (a sloping tower for catching wind) for each classroom, an architectural element inspired by Islamic architecture. The windcatcher captures the prevailing wind and directs it into the classroom, passing the air over water basins (Salsabil) to cool it through evaporation, creating natural air currents that ensure air renewal, and expelling the hot air through the top openings, thus creating a natural convection cycle. The windcatcher was designed to improve ventilation requirements by capturing air from above, where it is cooler, stronger, and less contaminated with sand and other particles, and directing it into the building.

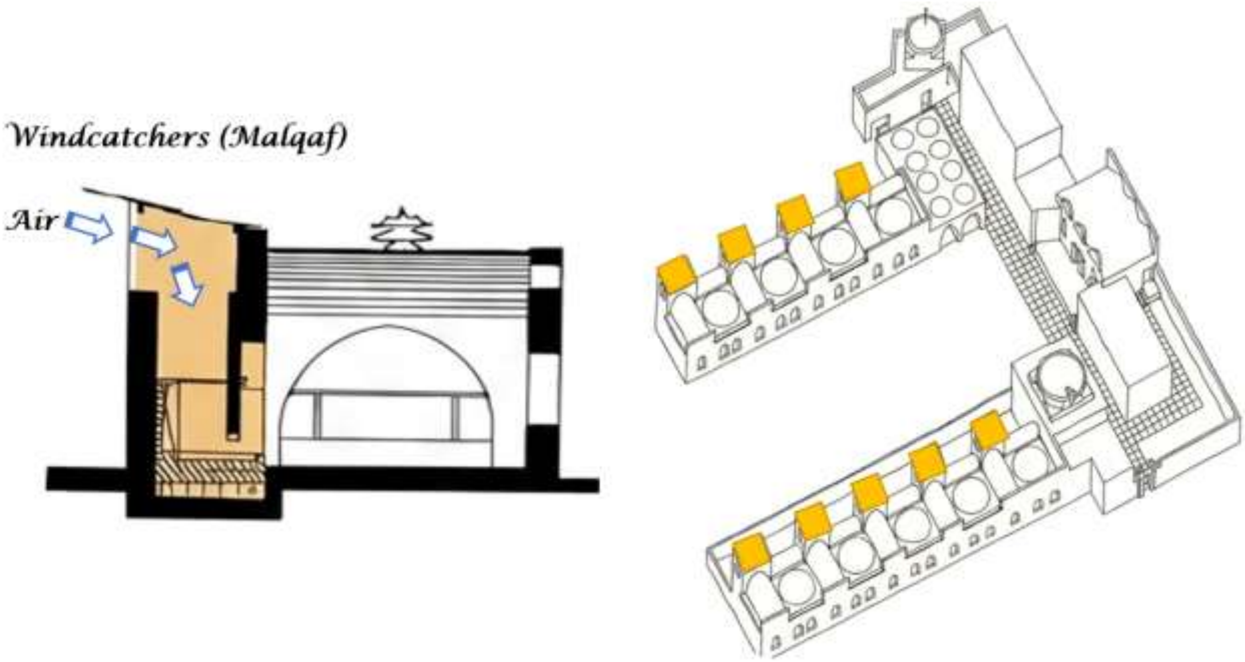

Figure (9) Windcatchers (Malqaf) in every classroom. in Hassan Fathy's Fares Village School
https://archive.org/details/diwan_20170917_0900/page/n7/mode/2up 1-12-2025

4- Salsabil (Water Basins)
It was planned to place water basins (Salsabil) in each classroom, but this was never implemented. The Salsabil concept relies on evaporative cooling, where air coming from the windcatchers passes over the water's surface, causing some of it to evaporate, thus lowering the air temperature and humidifying the atmosphere. The Salsabil was intended to be placed in the rectangular, domed spaces attached to each classroom. Fathi described the Salsabil as a fountain or water basin placed to increase the humidity of the dry desert air.

5- Cross-Ventilation:
The classrooms were designed with opposing casement windows to allow for cross-ventilation, in addition to overhead vents in the domes. Fixed circular windows (lounets) were also designed to provide natural light without excessive heat. Fathy relied on natural ventilation as the primary solution due to the extreme difficulty and high cost of providing mechanical cooling systems.

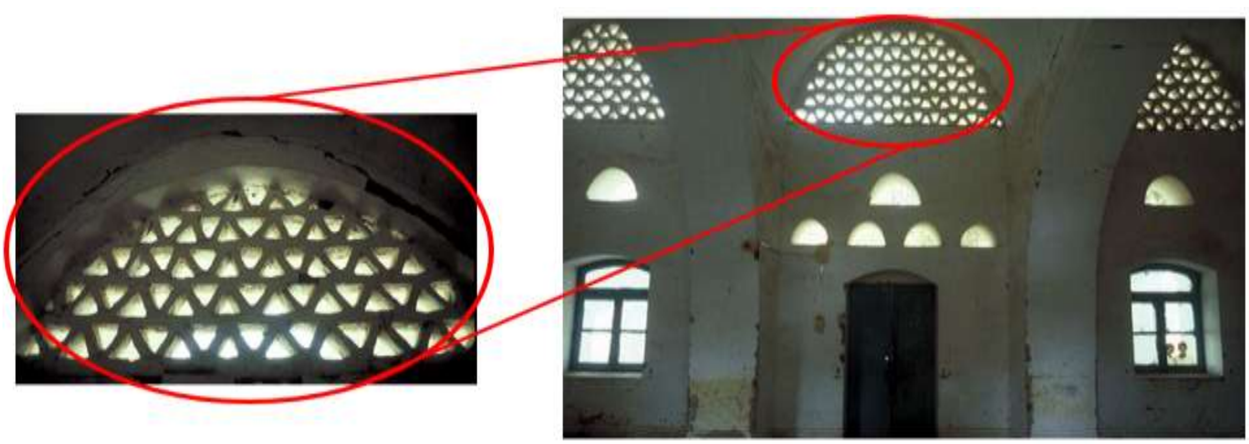

Figure (10) Cross-Ventilation in every classroom. in Hassan Fathy's Fares Village School
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6- Central Courtyard

The central open area at the school operates as a filter in managing air movements and creating a place to engage in some outdoor activities in a shielded area. Such a design is based on the style of the Muslim and Nubian architecture. Fathy incorporated thick walls and traditional courtyard forms to provide passive cooling, building upon the structural mass of the older buildings. Interior courtyards have traditionally been used as a passive cooling strategy in traditional buildings in desert climates.

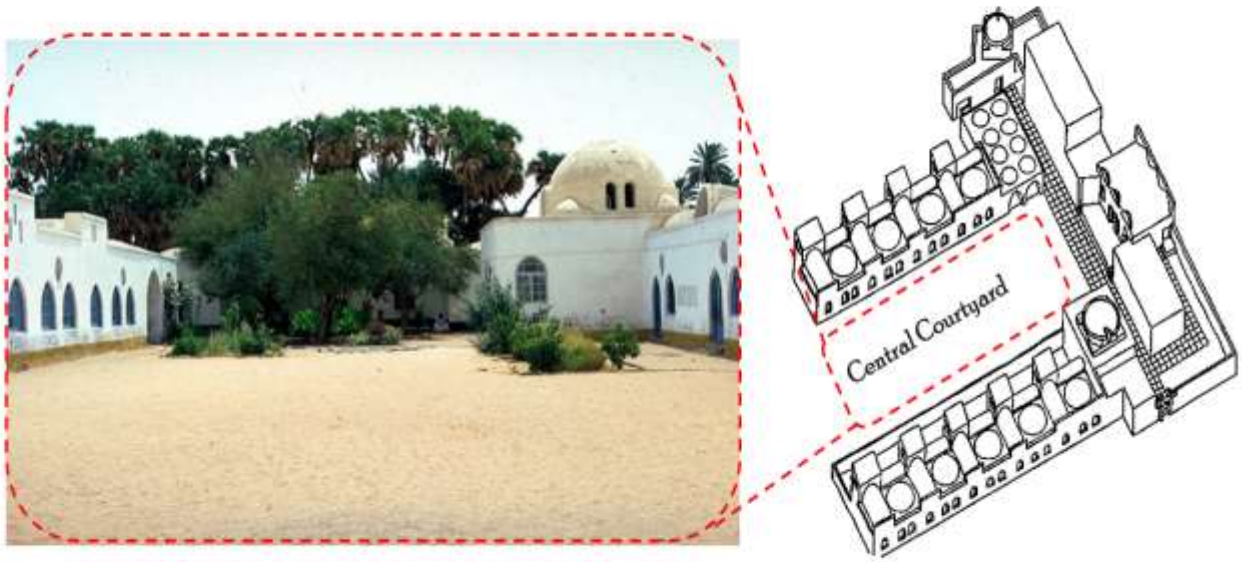

Figure (11) The open Central courtyard at the heart of the school acts as a buffer zone in Hassan Fathy's Fares Village School

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7- Using Local Materials

Fathi relied on locally available materials (mud bricks, local timber, lime) to reduce the energy content of building materials and transportation costs. He combined his knowledge of the Egyptian rural economy with extensive knowledge of traditional architectural and civil design techniques. He trained local people to make their own building materials and construct their own buildings.

Figure (12) Using Local Materials

8- Integration with Nature:

Fathi advocated for integrating nature into architectural design by planting trees and plants around the school and in its courtyard to provide shade and modify the local climate. He also designed beautiful architectural openings to capture cool breezes and direct airflows through the interior to expel warm air.

Figure (13) illustrates integration with nature through the incorporation of nature into the architectural design by planting trees and plants around the school and in its courtyard to provide shade and modify the local climate. https://www.archnet.org/sites/2608 3-12-2025

11. Proposed Methodology for Assessing Sustainable Schools – Performance Indicators, Weights, and Reference Criteria

Table (1): Proposed Methodology for Assessing Sustainable Schools – Performance Indicators, Weights, and Reference Criteria

Category	**Key Performance Indicators**	**Proposed Relative Weight (%)**	**Reference Criteria**	**Supporting References**
1. Energy Efficiency and Thermal Performance	• Energy Use Intensity (EUI) (kWh/m²/year) • Cooling and heating energy consumption • Number of thermal comfort hours (ASHRAE 55) • Building envelope performance (U-values for walls and windows) • Use of natural ventilation systems	29-30%	• Achieve ≥ 30% reduction in energy consumption compared to traditional schools • Achieve thermal comfort for ≥ 70% of school day hours • Compliance with ASHRAE 55 thermal comfort standards	Hernández-Cruz, S., et al. (2025). Mohammed, H. A., Aswed, G. K., & Ahmed, M. N. (2024). Bernardo, H., Quintal, E., & Oliveira, F. (2017).
2. Indoor Environmental Quality (IEQ)	• Indoor air quality (CO_2 levels, ventilation rates) • Natural lighting (illuminance levels, light distribution) • Visual comfort and glare control	10-15%	• Compliance with ASHRAE 62.1 ventilation standards • Provide natural lighting at 300-500 lux in classrooms	Hernández-Cruz, S., et al. (2025). DesignBuilder Software Ltd. (2025). designbuilder.co.uk.

	• Noise levels and acoustic comfort • Local thermal comfort		• Provide cross-ventilation in most classrooms	Azmy, N. Y. (2024).
3. Passive Design Strategies	• Use of thermal mass (thick walls) • Natural ventilation system (wind catchers, cross-ventilation) • Shading and solar treatments • Use of local low-embodied energy materials • Central courtyard as thermal regulator	15-20%	• Employ ≥ 3 main passive strategies • Measure impact on cooling load reduction ≥ 25% • Use local materials ≥ 30%	Archnet. (2014). Retrieved from https://www.archnet.org. -Abdelsalam, T. (2014). Hernández-Cruz, S., et al. (2025).
4. Environmental Sustainability and Materials	• Use of environmentally friendly materials (local, recyclable) • Embodied carbon in building materials ($kgCO_2/m^2$) • Waste management and recycling • Water use efficiency • Use of renewable energy sources	15-20%	• Reduce embodied carbon by ≥ 20% • Recycle waste by ≥ 50% • Achieve water use efficiency ≥ 20%	Adas, A. O., Saleh, Y. A., & Ramahi, A. A. (2024). -UNESCO. (2026).
5. Social Sustainability and Community Participation	• Universal accessibility (for people with special needs) • Local community participation in design and operation • Provision of public and open spaces for the community • Safety and security • Climate justice and social equity	15-18%	• Achieve universal accessibility standards • Have annual community participation programs • Provide open spaces ≥ 20% of site area	Hernández-Cruz, S., et al. (2025). -UNESCO. (2026).
6. Educational Value and Curriculum	• Integration of sustainability in the curriculum • Use of building as a teaching tool (3D Textbook) • Environmental awareness programs for students • Student participation in sustainability initiatives • Extent of sustainability consideration in school design	10-12%	• Have an integrated sustainability curriculum • Implement annual environmental programs • Integrate sustainability in extracurricular activities	UNESCO. (2026). Retrieved from www.unesco.org.
7. Operational Management and Long-Term Performance	• Building Energy Management System (BEMS) • Regular maintenance of thermal performance • Monitoring of energy and water consumption • Continuous improvement plans • Green building management	7-10%	• Have an energy monitoring and management system • Documented regular maintenance plans • Achieve annual improvement in performance indicators	Mohammed, H. A., Aswed, G. K., & Ahmed, M. N. (2024). UNESCO. (2026). Retrieved from www.unesco.org.

Table (2): Stages of Applying the Proposed Methodology

Stage	**Main Objective**	**Activities and Procedures**	**Tools and Techniques**	**Expected Outcomes**	**Supporting References**
Stage 1: Self-Assessment and	Form the assessment team and determine	• Form an assessment committee including stakeholders (school administration,	• Questionnaires and interviews • Environmental audit forms	• Self-assessment report • Identification	UNESCO.(2026)- . Hekimoğlu, İ., Özgen,

Preliminary Analysis	the current status	teachers, students, parents, local community) • Conduct an initial sustainability audit • Identify strengths, weaknesses, opportunities, and threats (SWOT analysis)	• SWOT analysis	of gaps and priorities	D., & Şen, C. (2025).
Stage 2: Field Data Collection	Document architectural and environmental characteristics and collect performance data	• Field measurements (temperature, humidity, lighting levels, air quality) • Document architectural and structural characteristics (plans, building materials, systems) • Collect energy and water consumption data (bills, operation records)	• Microclimate measurement devices • Architectural drawing software (AutoCAD, Revit) • Energy and water consumption records	• Comprehensive school database • Field measurement report	Archnet. (2014). https://www.archnet.org. - Bernardo, H., Quintal, E., & Oliveira, F. (2017).
Stage 3: Modeling and Computer Simulation	Evaluate thermal performance and energy efficiency using simulation	• Build a digital model of the building using Design Builder V 7.0 • Input climate data (EPW file for the location) • Input building material properties and ventilation and lighting systems • Run simulation to calculate performance indicators	• Design Builder V 7.0 / EnergyPlus software • Climate data files (EPW) • Material properties data sheets	• Simulation results: operating temperatures, energy consumption, cooling and heating loads • Number of thermal comfort hours (ASHRAE 55)	DesignBuilder Software Ltd. (2025). designbuilder.co.uk. - Bernardo, H., Quintal, E., & Oliveira, F. (2017). - Pashaki, E. K. (2026).
Stage 4: Assessment According to Adopted Indicators	Measure performance according to the seven sustainability indicators	• Apply assessment indicators (Table 1) • Calculate scores for each indicator according to specific reference criteria • Use the Balanced Scorecard model	• Balanced Scorecard (BSC) model • SSA-tool (Excel) based on AHP • Assessment matrices	• Comprehensive performance assessment report • Determine sustainability level (Distinguished Green, Advanced Green, Green, Eligible for Improvement, Unsustainable)	Adas, A. O., Saleh, Y. A., & Ramahi, A. A. (2024). - Hernández-Cruz, S., et al. (2025)..
Stage 5: Comparative Analysis	Compare performance with local and international standards	• Compare school performance with traditional schools in the same climate zone • Compare with	• International assessment systems (LEED, BREEAM) • UNESCO Green Schools	• Comparative analysis report • Identify gaps and improvement areas	LEED for Schools Rating System. (2025). *USGBC*. -

		national standards (if available) • Compare with international standards (LEED, BREEAM, UNESCO standard)	Standard • Comparison tables	• Determine the school's relative ranking	BREEAM Education Assessment. (2025). *BRE Global*. - UNESCO. (2026).
Stage 6: Develop Improvement Plan	Prioritize interventions and develop an action plan	• Prioritize interventions based on cost-effectiveness • Propose short, medium, and long-term improvement measures • Develop an action plan and implementation timeline	• Cost-effectiveness analysis • Priority matrix • Timelines	• Comprehensive improvement action plan • Cost and benefit estimates	Rashed, E., & Elmansoury, A. (2023). - UNESCO. (2026). www.unesco.org.
Stage 7: Monitoring and Continuous Evaluation	Measure impact and ensure continuous improvement	• Measure impact after implementing improvements • Monitor performance periodically • Continuously update the improvement plan • Certify the school as an accredited "Green School"	• Building Energy Management System (BEMS) • Key Performance Indicators (KPIs) • Periodic reports	• Periodic monitoring reports • Documentation of achieved improvements • Green School certification	UNESCO. (2026). - Hekimoğlu, İ., Özgen, D., & Şen, C. (2025). -

Table (3): Proposed Classification System for Sustainable Schools

Category	**Percentage Range (%)**	**Description**	**Basic Requirements**	**Supporting References**
Distinguished Green School	85-100	Advanced sustainability performance, leadership in all categories	• Achieve ≥ 90% in Energy Efficiency category • Employ ≥ 5 passive design strategies • Obtain LEED Gold certification or equivalent	Hernández-Cruz, S., et al. (2025).
Advanced Green School	70-84	Good sustainability performance with some areas for improvement	• Achieve ≥ 75% in Energy Efficiency category • Employ ≥ 4 passive design strategies • Obtain LEED Silver certification or equivalent	Adas, A. O., Saleh, Y. A., & Ramahi, A. A. (2024).
Green School	55-69	Achieves minimum sustainability standards	• Achieve ≥ 60% in Energy Efficiency category • Employ ≥ 3 passive design strategies • Compliance with UNESCO basic standards	UNESCO. (2026).
School Eligible for Improvement	40-54	Limited sustainability performance, needs substantial improvements	• Achieve ≥ 45% in Energy Efficiency category • Employ ≥ 2 passive design strategies • Approved improvement plan	Rashed, E., & Elmansoury, A. (2023).
Unsustainable School	Less than 40	Does not meet basic sustainability standards	• Achieve < 40% in most categories • No passive design strategies	Saleem, A. A., Abel-Rahman, A. K., Ali, A.

			employed • High energy consumption (> 200 kWh/m²/year)	H. H., & Ookawara, S. (2016).

12. Study Results and Discussion

12.1 Results of the Architectural Characteristics Analysis of Fares School

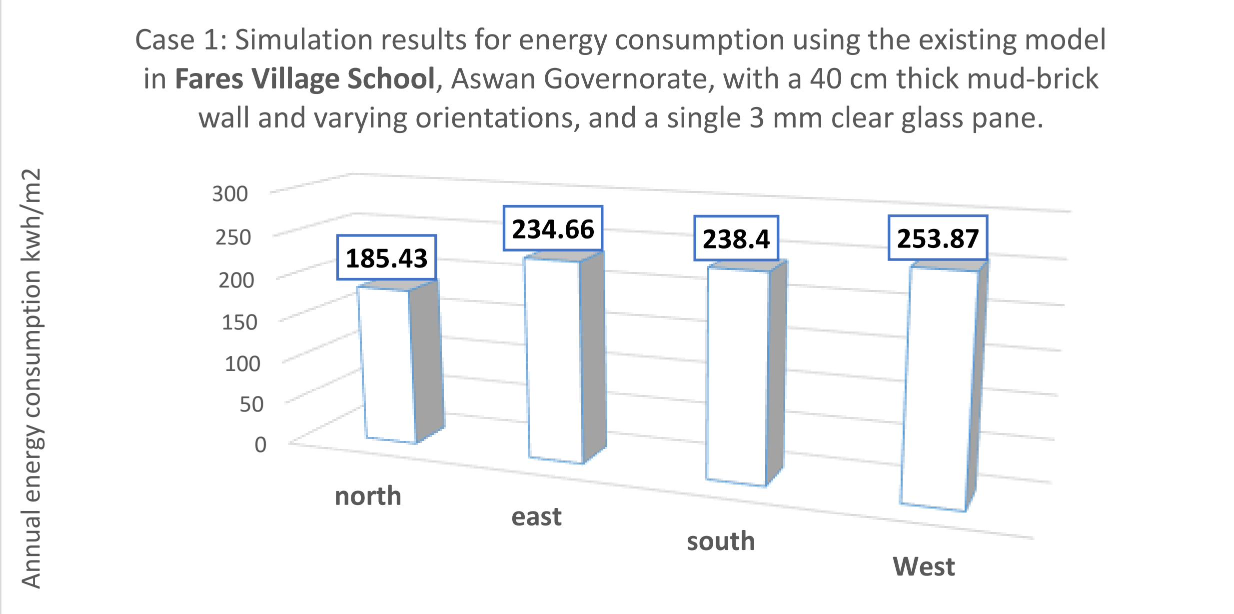
The analysis of the architectural characteristics of Fares School revealed that Hassan Fathy implemented a comprehensive set of sustainable environmental design strategies characterized by the following:

1. Use of Local Climate: The school's design leverages the region's weather conditions effectively to achieve comfortable temperatures within the building without the use of mechanical systems.
2. Use of Local Materials: By using mud bricks made in the vicinity, the building's materials had low energy and also strengthened the local economy and minimized transport expenses.
3. Function and Environmental Considerations Combined: The design takes into account the functional aspect (distribution of activities, setting up spaces for education and recreation) and environmental aspect (natural ventilation).
4. Social sustainability: The entire project is socially sustainable because locals were included in the process of construction, creating jobs for local people and allowing them to be part of the project as a community initiative.
5. Value of Education: The building was created as an educational institution, which will allow students to study sustainable architecture and environmental compatibility thanks to its construction.

12.2 Computer Simulation Results

Based on applying the proposed methodology using Design Builder V 7.0, the following results can be drawn:

Case 1: Simulation results for energy consumption using the existing model in **Fares Village School**, Aswan Governorate, with a 40 cm thick mud-brick wall and varying orientations, and a single 3 mm clear glass pane.



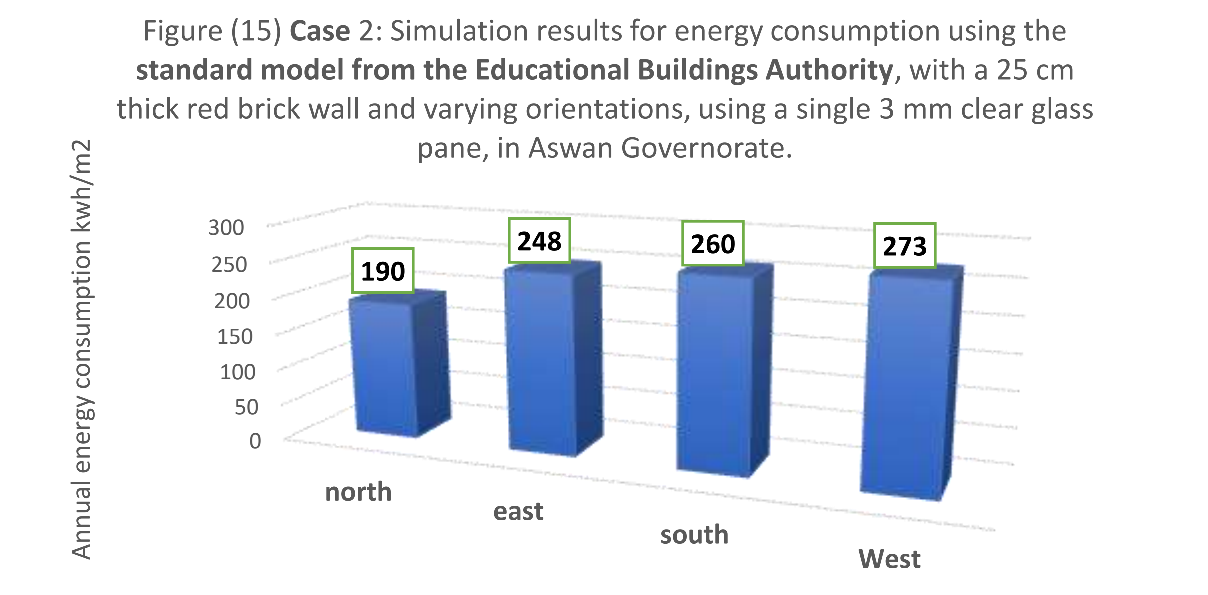
	north	east	south	West
cooling	185.43	234.66	238.4	253.87

Figure (14) shows the simulation results for energy consumption in the first scenario using the existing model at Fares Village School in Aswan Governorate. The walls are 40 cm thick mud bricks, with varying orientations, and feature 3 mm single clear glass.

The simulation results showed that the highest energy consumption was observed when using the existing model at Fares Village School in Aswan Governorate, with 40 cm thick mud brick walls and varying orientations, specifically when using 3 mm single clear glass (west-facing) and 40 cm thick mud brick walls with 3 mm single clear glass. The values for these two scenarios are (SHGC = 0.861, LT = 0.898, UV = 5.894), resulting in an annual cooling energy consumption rate of 253.87 kWh per m², the highest energy consumption rate for classrooms. Conversely, the annual cooling energy consumption decreases when facing north, resulting in the lowest energy consumption rate of 185.43

kWh per m², representing a significant improvement in energy efficiency. 27% of the baseline, followed by the (south) direction with an annual cooling energy consumption rate of 238.4 kWh per m2. This is followed by the (east) direction with an annual cooling energy consumption rate of 234.66 kWh per m2.

Case2: Simulation results for energy consumption using the standard model from the Educational Buildings Authority, 25 cm thick red brick walls, varying orientations, with 3 mm single transparent glass panes, in Aswan **Governorate**



	north	east	south	West
cooling	190	248	260	273

Figure (15) Second Case: Simulation results for energy consumption using the standard model from the Educational Buildings Authority, 25 cm thick red brick walls, varying orientations, with 3 mm single transparent glass panes, in Aswan Governorate.

The simulation results showed that the highest cooling energy consumption for classrooms in Aswan Governorate, when using the standard model from the Educational Buildings Authority, was for the (west) orientation, with 25 cm thick red brick walls and 3 mm thick single transparent glass panes (0.861 SHGC = 0.898 LT = 0.894 UV = 5.894), resulting in an annual cooling energy consumption rate of 273 kWh per m², the highest energy consumption rate for classrooms. The lowest annual cooling energy consumption was for the (north) orientation, at 190 kWh per m², representing a 30% improvement in energy consumption compared to the baseline scenario. The (south) orientation followed with a lower annual cooling energy consumption rate. 260 kWh per m2, then directing (east) with an annual cooling energy consumption rate of 248 kWh per m2.

- **Comparison of energy consumption simulation results**

for the first case using the existing model in Fares Village School, Aswan Governorate, with a 40 cm thick mud-brick wall and varying orientations, using 3 mm single-pane clear glass; and the second case using the standard model from the Educational Buildings Authority, with a 25 cm thick red brick wall and varying orientations, using 3 mm single-pane clear glass, also in Aswan Governorate.

Figure (16) Comparison of energy consumption simulation results for the first case using the existing model in Fares Village School, Aswan Governorate, with a 40 cm thick mud-brick wall and varying orientations, using 3 mm single-pane clear glass; and the

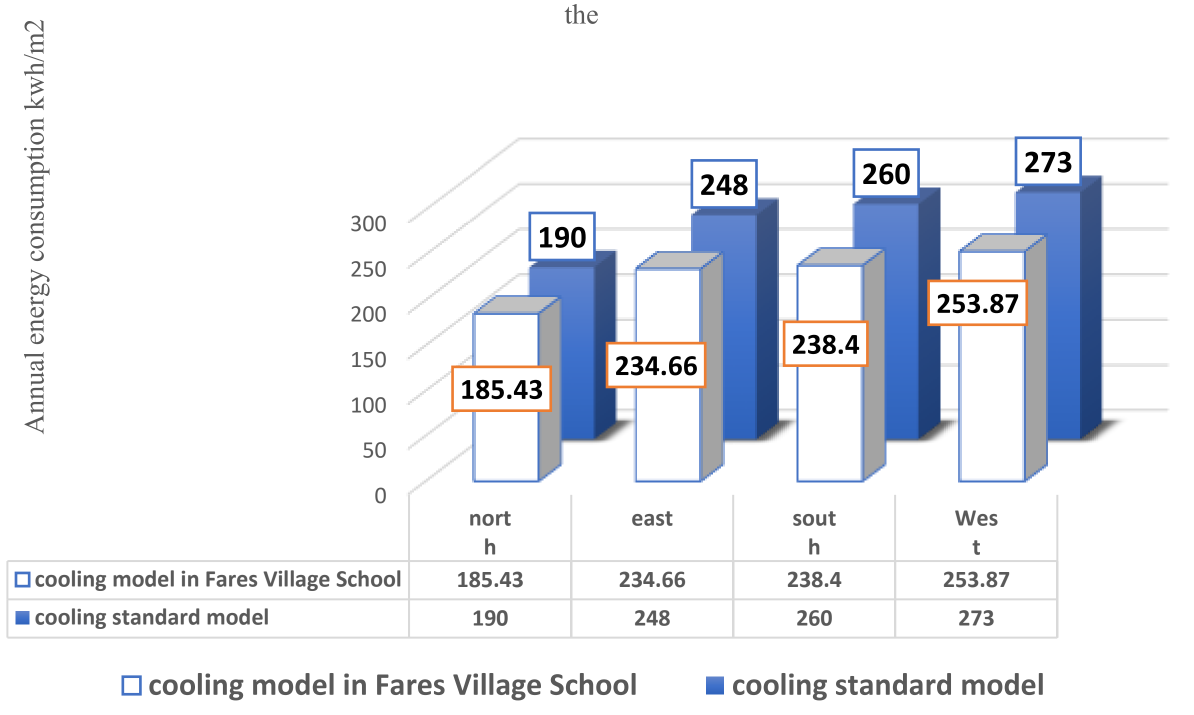


Figure (16) illustrates a comparison of the simulation results for energy consumption in the first case using the existing model in the Fares Village School in Aswan Governorate, with a 40 cm thick mud-brick wall and varying orientations, and with 3 mm single-pane clear glass. The second case uses the standard model from the Educational Buildings Authority, with a 25 cm thick red brick wall and varying orientations, and with 3 mm single-pane clear glass, also in Aswan Governorate.

A comparison of simulation results showed that the highest energy consumption was observed in the existing model at the Fares Village School in Aswan Governorate. The model features 40 cm thick mud-brick walls with varying orientations: one with 3 mm single clear glass panes (west-facing) and the other with 40 cm thick mud-brick walls and 3 mm single clear glass panes (0.861 SHGC, 0.898 LT, 5.894 UV). This resulted in an annual cooling energy consumption rate of 253.87 kWh per square meter, the highest energy consumption rate for school classrooms. In contrast, the second case, the standard model from the Educational Buildings Authority under study, showed energy consumption simulation results for a west-facing configuration with 25 cm thick red brick walls and 3 mm single clear glass panes (0.861 SHGC, 0.898 LT, 5.894 UV). This resulted in an annual cooling energy consumption rate of 273 kWh per square meter. The energy consumption rate in Fares School is 1 watt-hour per square meter, the highest rate for school classrooms, with a 7% energy saving compared to the standard model of the Educational Buildings Authority, assuming air-conditioned classrooms. According to the simulation results, it has become evident that Fares School performs better thermally when compared to conventional schools located in the same climate zone due to the following reasons:

1. Reduced temperature fluctuations: The thick mud-brick walls (40 cm thick) act as a thermal mass, mitigating daily temperature fluctuations.
2. Lower internal temperatures.
3. Effective natural ventilation: Windcatchers and skylights contribute to effective natural ventilation, with air renewal rates reaching 6-8 changes per hour during daylight hours.
4. Thermal comfort: Operating temperatures in the classrooms are within the thermal comfort range.

The simulation results also showed that Fares School's energy consumption is significantly lower than that of conventional schools:

1. Zero cooling energy consumption: Due to the school's reliance on natural cooling, energy consumption for cooling is zero, compared to conventional schools that consume large amounts of energy for cooling.
2. Reduced energy consumption Lighting: Windows and skylights contribute to providing good natural lighting, reducing the need for artificial lighting by a certain percentage.

13. Recommendations

Following are the recommendations derived from the conclusions of this research:

Recommendations concerning Design.

1. Implementation of Passive Design Techniques: The researchers recommend that, in designing educational buildings in arid climates, passive design techniques of thick walls with high thermal mass, ventilation, shadows, and locally available materials are used.

2. Adaptation of Design Techniques by Hassan Fathy: The idea proposed is to adapt Hassan Fathy's design techniques for contemporary use and process improvement in the design practice of educational buildings in Upper Egypt.

3. Integration of Architecture with Nature: The study is of the opinion that the integration of architectural design and natural aspects that can positively affect the microclimate in terms of less need for mechanical solutions should be performed.

4. Flexibility and Adaptability: It is suggested that educational buildings can be designed with the possibility of future change in climate conditions and to meet the needs of future users. Technical recommendations

5. Application of Computer Simulation: It is recommended that the application of computer simulation techniques (e.g. Design Builder) should be adopted at the earliest stages of projects in order to understand the thermal performance and energy efficiency of the buildings.

6. Creation of Local Database: It is advisable to create a database of available building materials in Egypt and their heat transfer coefficients to allow for the use of computer modeling in local projects.

7. Introduction of National Energy Efficiency Regulations: It is advisable to introduce compulsory national energy efficiency regulations for educational buildings, including maximum energy requirements and specific thermal performance qualities.

Institutional and Policy Recommendations

8. Modification of the General Authority of Educational Buildings Regulations: It is advised to modify the regulations of the General Authority of Educational Buildings by integrating mandatory environmental requirements related to energy efficiency and thermal performance into the regulations.

9. Preparation of Training Programs for Designers: It is recommended to prepare training programs for the specialists dealing with building design related to the principles of sustainable design.

10. Incentives for Sustainable Buildings: It is recommended to provide incentives for those building schools using sustainable design solutions and getting high energy efficiency.

11. Writing about Sustainable Architectural Heritage: The statement above emphasizes the importance of documenting and analyzing sustainable architectural heritage models in Egypt, such as that of the architect Hassan Fathy, which should also be published so that the current designers can benefit from the lessons learned.

Recommendations for Fares School

12. Restoring the School in Accordance with Original Principles: The statement above points out the need to restore Fares School according to the original design principles implemented by Hassan Fathy with the use of local materials and technology.

13. Converting the School into an Environmental Education Center: Another suggestion from the statement is to convert Fares School into an environmental education center and a practical example of sustainable architecture.

14. Reopening of the School as an Educational Institution: The above statement includes the need for re-opening Fares School as an educational institution to give back its original function as a sustainable learning atmosphere in Fares village.

14. References

1. UNEP (United Nations Environment Programme). (2020). 2020 Global Status Report for Buildings and Construction. Nairobi: UNEP.
2. Mahmoud, A. R. A., Aly, A. M., & Hassan, M. H. (2015). Evaluating the thermal performance of urban spaces in aswan city “a case study of saad zaghloul street. JES. Journal of Engineering Sciences, 43(5), 766-782.
3. Saleem, A. A., Abel-Rahman, A. K., Ali, A. H. H., & Ookawara, S. (2016). An analysis of thermal comfort and energy consumption within public primary schools in Egypt. *IAFOR Journal of Sustainability, Energy & the Environment*, *3*(1), 51-64.
4. Mohamed, M. (2009). *Investigating the environmental performance of Government primary schools in Egypt: With particular concern to thermal comfort* [Doctoral dissertation, University of Dundee].
5. Azmy, N. Y. (2024). Evaluating the impact of classroom design and orientation on the indoor environment quality in Egyptian schools. *JES: Journal of Engineering Sciences*, *52*(6), 704-727.
6. -William, M. A., Suárez-López, M. J., Soutullo, S., & Hanafy, A. A. (2021). Building envelopes toward energy-efficient buildings: A balanced multi-approach decision making. *International Journal of Energy Research*, *45*(15), 21096-21113.
7. Rashed, E., & Elmansoury, A. (2023). Energy retrofitting strategies for school buildings in hot arid climate. *Journal of University Studies and Inclusive Research*, *1*(13), 8188-8818.

8. Bernardo, H., Quintal, E., & Oliveira, F. (2017). Using a calibrated building energy simulation model to study the effects of improving the ventilation in a school. *INESC TEC*.
9. Mohamed, M. A., & Mansour, S. S. (2021). Using the Nanotechnology Treated Glass for Improving Energy Performance of School Classrooms in Qena, Egypt. Journal of Urban Research, 40(1), 25-35.
10. -Archnet. (2025). *Hassan Fathy Collection*. Retrieved from https://www.archnet.org 10-12-2025
11. Al-Ahram Gate. (2020). Fares School: Hassan Fathy's Architectural Masterpiece Awaits Restoration. Retrieved from https://www.ahram.org.eg 10-12-2025
12. Youm7. (2020). Details of the Restoration of the Historic Fares School in Aswan. Retrieved from https://www.youm7.com 10-12-2025
13. Abdelsalam, T. (2014). A vision for future: Analysis of the prominent synthesis of culture and sustainability in Hassan Fathy architecture. *Repository MSA*.
14. Abd El-Hamid, G. A., & Hussein, D. A. (2014). Developing Egyptian design criteria for educational buildings according to the American collaborative standard for high-performance schools. *Journal of Urban Research*, *13*(1), 82-94.
15. Adas, A. O., Saleh, Y. A., & Ramahi, A. A. (2024). Developing an analytic hierarchical process-based tool for assessing sustainability in public schools: a developing country context. *Advances in Building Energy Research*, *18*(6), 641-667.
16. BREEAM Education Assessment. (2025). *BRE Global*.
17. DesignBuilder Software Ltd. (2025). *DesignBuilder User Manual*. Retrieved from designbuilder.co.uk.
18. Hekimoğlu, İ., Özgen, D., & Şen, C. (2025). A Methodology for Identifying Critical Success Factors and Performance Measurement for Sustainable Schools. *Sustainability*, *17*(10), 4497.
19. Hernández-Cruz, S., et al. (2025). Towards Climate-Just and Sustainable Schools: Developing the Level(s)+37 Passive Design Framework. *MDPI Applied Sciences*, *15*(21), 11617.
20. LEED for Schools Rating System. (2025). *USGBC*.
21. Mohammed, H. A., Aswed, G. K., & Ahmed, M. N. (2024). Developing a Sustainability Assessment System for an Educational Building in the Iraqi Environment. *Tikrit Journal of Engineering Sciences*, *31*(4), 25-33.
22. Pashaki, E. K. (2026). Energy Performance Assessment in Educational Buildings Using Ventilation Systems: A Case Study and an Energy Optimization Approach. *Journal of Computational Analysis & Applications*, *35*(5), 257.
23. Steele, J. (1989). *The Hassan Fathy Collection: A Catalogue of Visual Documents at the Aga Khan Award for Architecture*. Bern, Switzerland: The Aga Khan Trust for Culture.
24. UNESCO. (2026). *Green school quality standard: Greening every learning environment*. Paris: UNESCO.