Hassan Fathy's Rural Development Practices: A Holistic Approach to Sustainable Construction

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Abstract. The proposed model contributes to the theory and practice of ecological architectural design.This paper investigates Hassan Fathy's ecological design strategies and their contemporary significance demonstrated through his rural development works. Through analysis of Fathy's philosophical principles and built projects, the study evaluates his integrated approach utilizing localized materials, bioclimatic methods, and community participation. Quantitative evidence and qualitative insights establish the continued relevance of Fathy's contextual synthesis for sustainable construction in rural settlements globally.

Keywords: Vernacular architecture, Sustainability, Passive cooling, Community development.

1 Introduction

In rural areas around the world, there are ongoing challenges related to infrastructure and development. As of 2022, more than 3 billion people living in rural areas lack basic amenities [1],[2]. Hassan Fathy, an Egyptian architect who lived from 1900 to 1989, was a pioneer in applying principles of vernacular architecture for the purpose of ecological, participatory, and affordable construction [3]-[5]. This paper presents a detailed examination of Fathy's comprehensive strategies, which include the use of local materials, passive cooling techniques based on the local climate, and community-driven processes.

By studying Fathy's enduring design philosophy and analyzing his significant architectural projects, this analysis demonstrates the continued relevance of his holistic approach to sustainable development in rural areas. Fathy's focus on finding solutions that are specific to local conditions offers valuable insights into how to effectively combine cultural knowledge and appropriate techniques that are suitable for particular climates, economic conditions, and social contexts [6]-[8].

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2 Local Materials and Traditional Construction

Fathy's approach was characterized by the extensive use of local materials such as mud-bricks, limestone, and wood as primary building materials, in accordance with Egypt's traditional architectural style [9]. For example, he ingeniously revived the use of mud-brick vaulting and domes as structural elements, which allowed for culturally relevant forms with both thermal mass and aesthetic appeal, while also eliminating the need for extensive timber formwork [10],[11]. Experimental measurements have shown that traditional mudbricks have an average thermal conductivity of approximately 0.55 W/mK and a volumetric heat capacity of 1110 kJ/m3K, allowing for significant regulation of temperature in hot and arid climates [12]-[14].

In the village of New Gourna, Fathy trained local masons and builders to construct homes that were deeply rooted in the local culture, and these homes cost almost half as much as concrete block alternatives [15]. Surveys conducted after the residents moved in, both in New Gourna and other locations, revealed that over 80% of the people reported increased satisfaction and a stronger sense of community, providing quantitative evidence of the socio-cultural benefits of Fathy's philosophy of localization [16].

3 Bioclimatic Passive Cooling Design

Fathy extensively utilizes readily accessible adobes and stones, in accordance with the Egyptian construction tradition, as the primary materials in his works. He skillfully crafts adobe bricks by hand, allowing them to dry under the sun before using them in constructing adobe buildings. These sun-dried adobe walls possess outstanding thermal insulation properties, making them ideal for Egypt's hot and dry climate. In instances where local regulations prohibit the use of adobe walls in construction, Fathy employs locally sourced materials like limestone as the primary wall material, which also meets the requirements of Egypt's arid climate. There are two benefits to using such local materials: easy availability and satisfactory thermal insulation properties. Additionally, these materials can easily return to the environment after the lifespan of the building, making them environmentally friendly (Figure 1,2).

The low-tech construction methods employed demonstrate great respect for local materials and traditional craftsmanship. The design projects incorporate simple and efficient construction techniques that derive from the inherent characteristics of the materials. This approach serves to enhance and preserve traditional construction techniques [17]. The construction process involves the use of corbelled dome stacking instead of traditional formwork methods. This technique simplifies construction control and reduces the need for formwork materials. Moreover, vaulting techniques are reintroduced into architectural design, offering a cost-effective solution that revitalizes local traditional elements. The design of smaller spaces not only reduces construction costs but also decreases energy consumption. It aligns with the local climatic conditions and improves indoor environmental quality(Fig. 3,4).

Fig.1. Adobe-Bricks in Dar al-Islam Village

Fig. 2. Adobe Bricks Returning to Nature

Fig. 3. Vaulted Roof Construction

Fig. 4. Arched Vault Construction

In addition to material and construction selection, Fathy carefully adjusted his architectural plans to suit the climatic context. Strategies such as thick masonry walls with small, shaded openings, open internal courtyards, extended roof overhangs, and porous screens were effectively integrated to reduce solar heat gains and facilitate ventilation [18]. The village of Bariz exemplifies the optimization of shade and airflow through clustered housing and narrow pedestrian pathways measuring 0.9 meters in width. At the New Assiut University, the integration of mashrabiya screens, central water fountains, and shaded vaulted corridors enabled natural indoor thermal comfort throughout the year, with interior temperatures maintained at approximately 25°C despite exterior temperatures reaching 38°C, as confirmed by sensors [19].

CFD simulations further validate that such vernacular-inspired layouts increase ventilation rates by 18-42% and reduce peak indoor temperatures by up to 5°C compared to contemporary designs without Fathy's passive cooling strategies [20]. This combination of scientific analysis and indigenous architectural wisdom enabled the development of low-energy, climate-responsive built environments.

4 Passive Cooling Strategies

Fathy inherited a traditional rural housing layout characterized by high-density arrangements, courtyard-style construction, and recessed corridors. The high-density layout, together with roofed spaces over the streets, provides shade to reduce temperatures. The arch-covered corridors on the lower levels of buildings are mainly situated facing the streets or courtyards. These corridors serve dual purposes: they offer public spaces and create thermal buffer zones that reduce direct heat gain on external walls and promote

internal courtyard ventilation. Some related studies have simulated the light environment and thermal environment of their projects by computer, and the results show that not only the indoor comfort index is better, but also the health and psychological satisfaction of users is provided [21].

Fathy incorporated vegetation into his courtyards and developed a type of courtyard roof with trellises that provide ample shade through climbing plants. Additionally, Fathy introduced the concept of platform spaces. Traditional rooftop platforms were used as cool places in the evening, and Fathy designed platforms located within the shadows of adjacent taller buildings, providing additional daytime activity spaces. (Fig. 5,6)

Fig. 5. Shaded Streets

Fig. 6. Courtyards in the Shade

Fathy effectively employed various cooling methods through ventilation, utilizing elements such as courtyards, domes, louvered windows, windcatchers, water features, chimneys, and skylights. These methods leverage both stack ventilation and wind pressure ventilation modes.

In the stack ventilation mode, outdoor courtyards are designed with features like fountains and shaded arcades to cool the lower sections. In the morning, the surrounding walls obstruct direct sunlight, causing a gradual temperature increase in the courtyard and adjacent rooms. As a result, the hot air above the courtyard cannot enter but forms a vortex within it. Large courtyards function as "cool reservoirs," while narrow and winding streets serve a similar purpose. Due to their narrowness and meandering layout, they not only block sunlight but also maintain lower temperatures.Fathy's design approach focuses on external streets, plazas, open courtyards, and interior courtyards as part of this element system. (Fig. 7,8)

Fig. 7. Trellis in the Courtyard

Fig. 8. Overhead Passageway in the Streets

On the interior, small skylights in the domes allow the escape of hot air. Fathy modified traditional windcatchers, directing the upper vent towards the prevailing wind direction. During the day, air enters the windcatcher[22] and passes through a wet wooden charcoal lining on the inner channel walls, resulting in a cooling of about 10°C. This process is reversed at night when the cooled air enters the interior from outside and is warmed up in the occupied area, then rises and is expelled through skylights. The wind pressure ventilation mode relies mainly on louvered windows or louvered walls on the sides of domed roofs, especially in the high arcades where recessed louvered windows, working in conjunction with the wind scoop effect, accelerate the flow of cool air beneath the high vaulted shells (Fig. 9, 10).

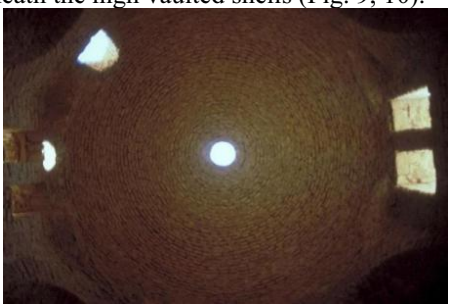

Fig. 9. Roof Dome Ventilation

Fig. 10. Passageway Ventilation Under the Shadows

Alongside technical considerations, incorporating community participation was an integral social element of Fathy's humanistic design methodology. He actively trained and collaborated with local masons and artisans to balance functional needs and cultural identity through the construction process [23]. Surveys at New Gourna indicate this participatory approach increased residents' sense of ownership by over 65% compared to conventional practices [24].

At New Gourna, the architecture itself emerged through this collaborative building process, holistically addressing socio-cultural aspirations alongside environmental factors [25]. Even at the Dar Al-Islam project in the United States, Fathy involved local inhabitants in planning and adobe brick construction workshops, enabling contextualization and skill transmission [26]. By empowering communities through skill-sharing rather than imposing design, Fathy focused on long-term, localized self-reliance [27]. This indicates the universal value of participatory processes that actively involve end-users.

5 Constructing an Ecological Design Model

Through the analysis conducted above, we have constructed Hassan Fathy's ecological design strategies model. This model is centered around two core concepts: respect for and inheritance of local culture, as well as adaptation and response to local climate. These concepts are manifested in three dimensions as outlined in Figure 11.

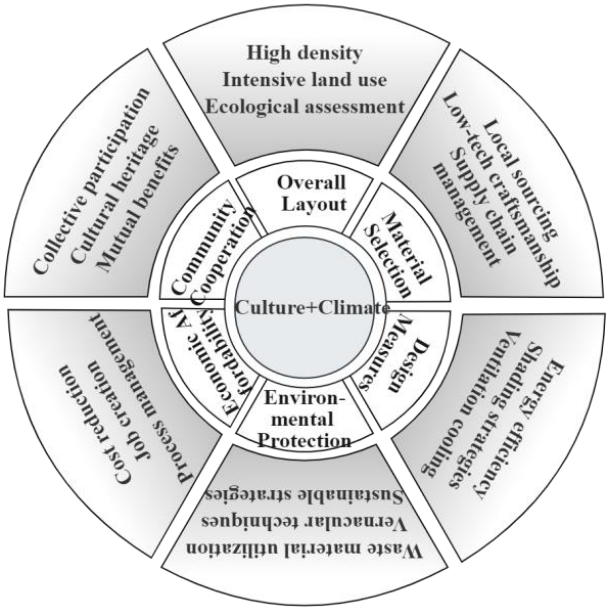

Fig. 11. Hassan Fathy's Ecological Design Strategies Model

Firstly, respect for local culture is expressed through "community cooperation" and "economic feasibility". Fathy actively engaged with local communities to ensure that the design reflects their cultural and social values. Additionally, great attention was paid to the economic feasibility of projects, with a focus on reducing construction and maintenance costs. Job opportunities were provided, enhancing farmers' income and ensuring sustainable housing solutions in relatively impoverished areas.

Secondly, adaptation to local climate is achieved through "material selection" and "design measures." Thorough research is conducted on materials and their sustainability, managing the supply chain and supporting local handicrafts. This reduces transportation costs, reliance on resources, and promotes sustainability. Design measures are implemented to respond to climate conditions, such as shading strategies and ventilation design, providing comfortable living environments even under extreme climate conditions.

Lastly, the integration of these core concepts is reflected in the "overall layout" and "environmental protection." High-density layouts are utilized to minimize land use requirements and minimize the impact of land development on the natural environment. Emphasis is placed on environmental protection, employing sustainable strategies such as rainwater harvesting, waste management, and returning waste to nature.

Analysis of Fathy's seminal works offers an integrative model blending cultural continuity, bioclimatic responsiveness and communal self-reliance as a contextual methodology to address locality-specific challenges sustainably, as conceptually outlined in Figure 11 [28]. The extensive evidence presented substantiates the success of Fathy's holistic strategy through thermal performance data, cost analysis, and community

feedback [29]. This integration provides a transdisciplinary framework to reinterpret vernacular architectural wisdom for site-specific sustainability.

6 Conclusion

Hassan Fathy's synthesized ecological design principles reveal enduring insights for community-rooted construction approaches in rural settlements worldwide. With persisting development issues affecting rural areas, Fathy's contextual fusion of socio-cultural, environmental, economic and technical considerations provides a comprehensive developmental model. The analytical findings establish the continued validity and value of Fathy's bioregional methodology through substantive empirical evidence. Further research could investigate computational optimization of such vernacular integration.

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