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INTEGRATION VALUE ENGINEERING WITH ENVIRONMENTAL SUSTAINABILITY- A CASE STUDY OF AL-AZHAR PARK, CAIRO

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ABSTRACT

Urban design and landscape architecture are increasingly challenged to reconcile cost-effectiveness with environmental sustainability. Value Engineering (VE), traditionally a cost-optimization tool, holds significant potential when aligned with ecosystem-based design principles. This study proposes a framework that integrates VE with sustainability strategies to enhance urban design and landscape practices. The research focuses on the transformation of Al-Azhar Park in Cairo from a neglected landfill into a vibrant green space, serving as a model of sustainable urban development. A mixed-methods approach was adopted to ensure comprehensive analysis. The methodology includes three main components: (1) an in-depth case study analysis of Al-Azhar Park, exploring environmental, social, and economic dimensions; (2) the development of a theoretical framework linking VE to sustainability metrics such as lifecycle cost analysis, resource efficiency, and ecological resilience; and (3) stakeholder surveys targeting urban planners, environmental experts, and community representatives. Both qualitative and quantitative data were collected and analyzed to assess the effectiveness and replicability of VE-driven sustainable practices. Findings highlight how strategic cost-saving decisions can coexist with ecological restoration, cultural heritage conservation, and community engagement. The proposed framework supports more resilient, inclusive, and environmentally responsible urban landscapes, offering a scalable model for cities facing similar sustainability challenges.

KEYWORDS: Urban Design, Value Engineering (VE), Environmental Sustainability, Urban Regeneration, Al-Azhar Park

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الملخص

يواجه التصميم الحضري وتنسيق المواقع ضغوطًا متزايدة لتحقيق التوازن بين الكفاءة الاقتصادية والاستدامة البيئية. وتُعد الهندسة القيمية (VE) أداة تقليدية لتحسين التكاليف، لكنها تكتسب إمكانات واعدة عند دمجها مع مبادئ التصميم البيئي والنظم الإيكولوجية. يقدّم هذا البحث إطارًا تكامليًا يوظف الهندسة القيمية مع استراتيجيات الاستدامة لتعزيز ممارسات التصميم الحضري وتنسيق المواقع، وذلك من خلال دراسة حالة مشروع تطوير حديقة الأزهر في القاهرة، والذي يُعد نموذجًا لتحول حضري مستدام. أُستخدمت منهجية متعددة الأدوات لتحقيق تحليل شامل، تضمنت ثلاث مراحل رئيسية: (١) دراسة حالة معمّقة لحديقة الأزهر تشمل الأبعاد البيئية والاجتماعية والاقتصادية، (٢) تطوير إطار نظري يربط الهندسة القيمية بمؤشرات الاستدامة مثل تحليل دورة الحياة، وكفاءة الموارد، والمرونة البيئية، (٣) تنفيذ استبيانات موجهة إلى المخططين الحضريين، والمتخصصين البيئيين، وممثلي المجتمع المحلي. تم تحليل البيانات النوعية والكمية لفهم فعالية هذه المنهجية وإمكانية تطبيقها في مشروعات أخرى. أظهرت النتائج أن قرارات توفير التكاليف يمكن أن تتوافق مع الاستعادة البيئية، والحفاظ على التراث الثقافي، وتعزيز إشراك المجتمع. الإطار المقترح يمثل نموذجًا قابلاً للتكرار يُعزز من مرونة المدن واستدامتها وشمولها البيئي والاجتماعي.

الكلمات المفتاحية : التصميم الحضري، الهندسة القيمية(VE) ، الاستدامة البيئية، التجديد الحضري ، حديقة الأزهر.

1. INTRODUCTION

The rapid urbanization of the 21st century has intensified challenges in achieving sustainable urban environments. Urban design and landscape architecture professionals are tasked with creating spaces that harmonize social, economic, and environmental needs. Traditional project delivery methods often prioritize cost over sustainability, which limits long-term value [1]. Integrating Value Engineering (VE) with environmental sustainability presents a promising avenue for addressing these challenges.

This paper aims to do the following, as shown in Fig.1:

- Explore the theoretical and practical intersections of VE and environmental sustainability.
- Investigate how ecosystem integration can enhance urban design and landscape practices.
- Highlight the revitalization of Al-Azhar Park as a local case study.
- Propose a methodological framework for embedding sustainability in VE processes.

Fig. 1: The Paper Aims

2. LITERATURE REVIEW

Integrating Value Engineering (VE) with environmental sustainability in urban design has gained increasing attention recently. As cities face mounting challenges regarding resource efficiency, cost-effectiveness, and ecological balance, applying VE principles to urban development and landscape architecture offers promising solutions. Developed initially as a cost-optimization tool, VE has evolved to incorporate sustainability principles, ensuring long-term environmental and economic benefits [2]. This section explores the foundational concepts of VE, the role of environmental sustainability in urban design, and the potential synergy between these two approaches to create resilient and efficient urban environments [3].

2.1. Value Engineering Principles

Value Engineering (VE) is a structured, systematic methodology aimed at optimizing the value of a product, process, or system by analyzing its essential functions while minimizing costs without compromising performance, safety, or quality. Developed by Lawrence D. Miles at General Electric during the mid-20th century, VE has since been widely adopted across various industries, including construction, manufacturing, and urban planning [4]. The key principle of VE is that

value is derived from the relationship between function and cost, where value can be increased by improving function or reducing costs [5].

The VE process follows a structured job plan, typically divided into five main phases [6], as shown in **Fig.2**:

- **Information Phase:** The project is analyzed to understand its objectives, constraints, and performance requirements. Critical cost drivers and inefficiencies are identified.
- **Creative Phase:** Brainstorming sessions generate alternative ideas to achieve the required functions at a reduced cost while maintaining or improving performance.
- **Evaluation Phase:** Proposed ideas are assessed based on feasibility, economic viability, and overall impact.
- **Development Phase:** Selected alternatives are further developed into detailed proposals, including implementation strategies and cost-benefit analyses.
- **Implementation Phase:** Approved solutions are integrated into the project with a focus on achieving maximum efficiency and effectiveness.

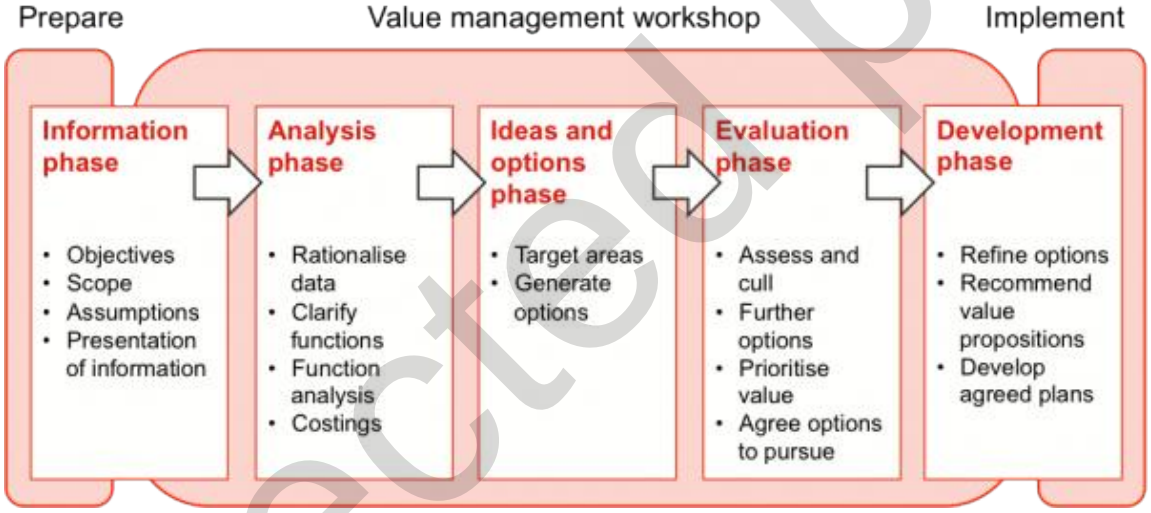


Fig. 2: VE Main Phases

When applied to urban design and landscape architecture, VE facilitates cost-effective decision-making that ensures economic viability without undermining sustainability and functionality [7]. Its structured approach encourages interdisciplinary collaboration, ensuring that urban development projects optimize resource utilization and achieve long-term resilience.

2.2. Environmental Sustainability in Urban Design

Environmental sustainability in urban design aims to reduce the negative environmental impact of human activities [8], while enhancing ecological resilience, promoting resource efficiency, and maintaining a balanced relationship between the built and natural environments [9]. As cities expand, sustainable urban development strategies become increasingly critical to mitigate climate change, conserve natural resources, and improve overall quality of life.

Key strategies for achieving environmental sustainability in urban design include the following, as shown in **Fig.3**:

- **Green Infrastructure:** Incorporating natural systems, such as green roofs, urban forests, and permeable pavements, to manage stormwater, improve air quality, and enhance urban biodiversity.
- **Low-Impact Development (LID):** A planning and design approach that minimizes land disturbance, reduces stormwater runoff and preserves natural water cycles through sustainable drainage systems, bioretention basins, and permeable surfaces.
- **Ecosystem Services Integration:** Utilizing natural processes, such as carbon sequestration [10], water purification, and temperature regulation, to enhance urban environments.
- **Energy Efficiency and Renewable Energy:** Promoting passive design strategies, energy-efficient building materials, and the integration of renewable energy sources such as solar panels and wind turbines.
- **Sustainable Transportation:** Encouraging public transit, cycling, and pedestrian-friendly infrastructure to reduce carbon emissions and traffic congestion.

Fig. 3: Key strategies for achieving environmental sustainability in urban design

Implementing these sustainable practices in urban design minimizes environmental degradation, improves human health, fosters social equity, and enhances economic stability by reducing long-term operational costs and increasing urban resilience to climate-related challenges [11].

2.3. Integration Between Value Engineering and Sustainability

Traditionally, Value Engineering has been primarily concerned with cost reduction, which, in some cases, has led to compromises in sustainability. However, a growing body of research and real-world applications suggest that VE can be reoriented to emphasize lifecycle benefits, ecological value, and long-term performance rather than solely focusing on immediate cost savings [12].

The Integration between VE and sustainability is built on several core principles, as shown in **Fig.4**:

- **Lifecycle Cost Analysis (LCA):** Shifting the focus from initial cost savings to long-term economic, environmental, and social benefits [13]. This approach considers energy efficiency, maintenance costs, and the environmental footprint of materials over the entire lifecycle of a project.
- **Multi-Disciplinary Collaboration:** VE encourages engagement among architects, engineers, environmental scientists, and urban planners to develop integrated solutions that balance cost-efficiency with ecological benefits.
- **Function-Oriented Sustainability:** Instead of cutting costs at the expense of sustainability, VE evaluates project functions holistically to ensure optimal performance with minimal environmental impact.
- **Waste Reduction and Resource Efficiency:** Sustainable VE practices emphasize using recycled materials, modular construction techniques, and waste reduction strategies that lower environmental impact while maintaining economic feasibility.

- **Resilience and Adaptability:** Designing urban projects with flexibility to adapt to environmental challenges, such as climate change and resource scarcity, without incurring excessive

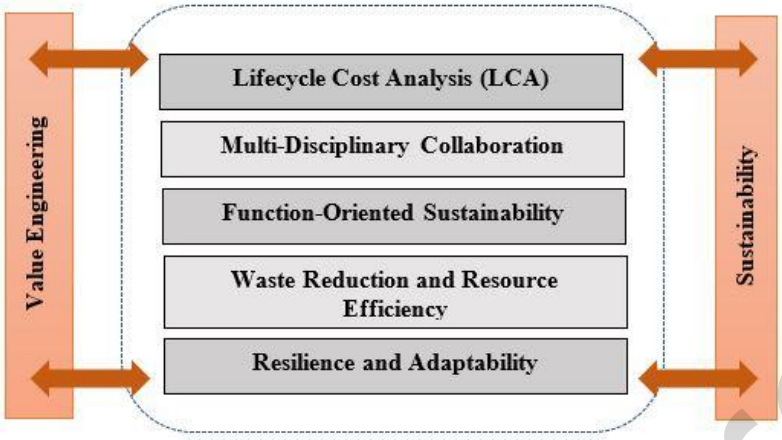


Fig. 4: The principles That Define the Integration between VE and sustainability

The application of VE in sustainable urban design has been demonstrated in several global projects where economic and ecological objectives align. By integrating sustainability within the VE process, urban planners and designers can create cost-effective, high-performance environments that benefit both people and the planet [14]. This innovative approach to VE guarantees that urban landscapes remain cost-effective, environmentally sustainable, socially inclusive, and adaptable to future challenges

In conclusion, integrating VE with sustainability principles presents a transformative opportunity to enhance urban design and landscape practices. By applying a function-based, cost-efficient, and sustainability-driven approach, urban planners can develop projects that achieve economic savings and environmental resilience, paving the way for more sustainable cities worldwide [15].

3. METHODOLOGY

This study employs a mixed-methods approach, combining qualitative and quantitative research techniques to comprehensively analyze the integration of Value Engineering (VE) and environmental sustainability in urban design. The methodology is structured into three primary components: case study analysis, theoretical framework development, and stakeholder surveys, as shown in **Fig.5**.

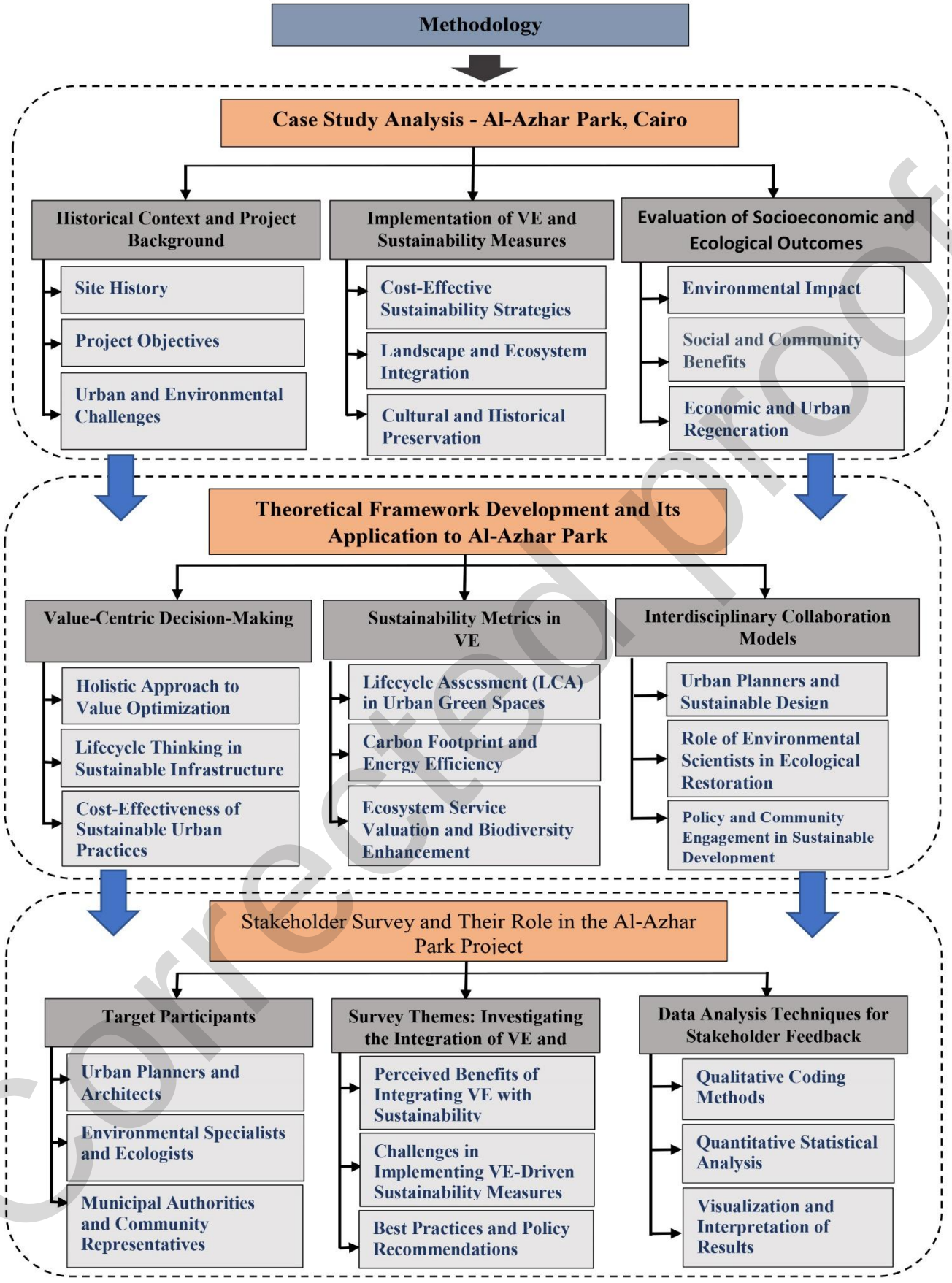


Fig. 5: Methodology

3.1. Case Study Analysis: Al-Azhar Park, Cairo

As shown in Fig.6, Al-Azhar Park in Cairo stands as a landmark example of sustainable urban transformation, demonstrating the successful integration of Value Engineering (VE) with environmental sustainability. This case study provides an in-depth analysis of how a neglected landfill site was converted into a vibrant green space that balances economic feasibility, social benefits, and ecological resilience. The project, initiated by the Aga Khan Trust for Culture (AKTC), highlights the potential of VE in optimizing resources while achieving long-term sus

Fig. 6: Map of Al-Azhar Park

3.1.1. Historical Context and Project Background

- **Site History:**

Before its development, the site of Al-Azhar Park was a centuries-old garbage dump adjacent to the historic district of Islamic Cairo, as shown in **Fig.7**. The area suffered from severe environmental degradation, poor air quality, and a lack of public green spaces [17]. The project aimed to revitalize this space while preserving the cultural and historical integrity of the sl

Fig. 7: Al-Azhar Park from Wasteland into A park

- **Project Objectives:**

The primary objectives of the Al-Azhar Park project were:

- To create a sustainable and accessible urban green space for the citizens of Cairo.
- To restore and integrate historic elements, including the adjacent Ayyubid Wall.
- To implement environmentally conscious design principles that promote biodiversity and resource efficiency [18].

- To drive economic and social regeneration in surrounding communities.

- **Urban and Environmental Challenges:**

Before its transformation, the site of Al-Azhar Park faced numerous urban and environmental challenges that significantly impacted the physical landscape and the quality of life of surrounding communities. These challenges necessitated a large-scale intervention that could restore environmental balance, address urban decay, and provide a sustainable green space for Cairo's residents.

- **Environmental Degradation and Pollution**
  The site was an uncontrolled landfill for centuries where waste accumulated, leading to severe environmental degradation [19]. The lack of waste management contributed to soil contamination, poor air quality, and hazardous conditions. Additionally, the area suffered from a lack of vegetation, exacerbating the urban heat island effect and reducing air purification. The accumulated debris and lack of green cover resulted in excessive dust and pollutants in the air, negatively impacting public health.

- **Lack of Public Green Spaces**
  Cairo, one of the most densely populated cities in the world, suffers from a critical shortage of green spaces. Before the park's development, residents of nearby neighborhoods had little to no access to recreational areas, limiting opportunities for relaxation, social interaction, and outdoor activities [20]. The absence of greenery also contributed to declining regional biodiversity and ecological balance.

- **Urban Decay and Neglected Heritage**
  The park's location adjacent to Islamic Cairo, a district rich in historical landmarks, posed another challenge. The surrounding area had deteriorated due to urban neglect, with limited investment in infrastructure and heritage preservation. The centuries-old Ayyubid Wall, a significant historical structure, had fallen into disrepair. The park project sought to incorporate the restoration of this wall into a comprehensive urban revitalization initiative, preserving both environmental and cultural heritage elements.

- **Socioeconomic Disparities**
  The surrounding communities, particularly Al-Darb Al-Ahmar, experienced high levels of poverty, unemployment, and limited economic opportunities. The project needed to provide environmental and recreational benefits and contribute to economic upliftment by creating jobs, fostering tourism, and generating sustainable development in the area.

3.1.2. Implementation of VE and Sustainability Measures

The success of the Al-Azhar Park project can be attributed to the strategic application of VE and sustainability measures. These included [21]:

- **Cost-Effective Sustainability Strategies**

  - **Water Conservation:** A cost-efficient irrigation system was implemented using treated wastewater, reducing reliance on freshwater resources.

- **Green Infrastructure:** Landscapes were designed with drought-tolerant native plants to minimize water consumption while enhancing biodiversity.
- **Adaptive Reuse of Materials:** Locally sourced materials and recycled construction debris were used to lower costs and reduce the project's carbon footprint.

- **Landscape and Ecosystem Integration**
  - The park was designed with ecological corridors and native vegetation to support local wildlife.
  - Stormwater management techniques were integrated to prevent soil erosion and improve groundwater recharge [22].
- **Cultural and Historical Preservation**
  - The rehabilitation of the Ayyubid Wall was incorporated into the project to link the park with Cairo's historic urban fabric.
  - Traditional architectural elements were preserved and adapted to modern functions within the park.

3.1.3. Evaluation of Socioeconomic and Ecological Outcomes

The transformation of Al-Azhar Park has resulted in significant positive impacts across multiple domains:

- **Environmental Impact**
  - The park has improved air quality and reduced urban heat island effects in Cairo.
  - Increased vegetation and water management systems have enhanced local biodiversity and ecological stability.
- **Social and Community Benefits**
  - Al-Azhar Park provides annual recreational, cultural, and educational opportunities for millions of visitors.
  - The park catalyzes community engagement, hosting events and activities that promote social cohesion.
  - Public access to green space has improved local residents' overall well-being and mental health.
- **Economic and Urban Regeneration**
  - The park has generated employment opportunities in landscaping, maintenance, and tourism.
  - Increased foot traffic has stimulated economic activity in adjacent neighborhoods, benefiting local businesses and artisans.
  - Property values in the surrounding areas have increased, reflecting the long-term economic benefits of urban greening projects.

3.2. Theoretical Framework Development and Its Application to Al-Azhar Park

Developing a theoretical framework for integrating Value Engineering (VE) and environmental sustainability is crucial to understanding how these two disciplines can enhance urban design. In Al-Azhar Park's case, the project is a practical example of how sustainability-oriented VE principles can be implemented to optimize costs, environmental benefits, and social value. This section elaborates on three major components: value-centric decision-making, sustainability

metrics in VE, and interdisciplinary collaboration models—each examined within the context of Al-Azhar Park.

3.2.1. Value-Centric Decision-Making

Traditionally, VE has been associated with reducing costs while maintaining performance. However, when integrated with sustainability, the approach shifts towards maximizing long-term value, considering environmental and social aspects. Al-Azhar Park exemplifies how value-centric decision-making can result in a balanced approach to cost-efficiency and sustainability.

- **Holistic Approach to Value Optimization**

The development of Al-Azhar Park required a shift from merely focusing on cost-saving measures to embracing a holistic approach that optimized social, environmental, and economic benefits. The project went beyond financial efficiency to ensure cultural preservation, environmental restoration, and long-term urban sustainability. Instead of creating a green space, the project incorporated historical conservation elements, sustainable landscape practices, and social development programs.

- **Lifecycle Thinking in Sustainable Infrastructure**

A key component of VE is lifecycle thinking, which evaluates the long-term benefits and costs of materials and infrastructure. In Al-Azhar Park, this meant choosing durable materials, implementing energy-efficient lighting, and designing irrigation systems that minimized water consumption. Considering each component's lifecycle, the project reduced maintenance costs and improved environmental efficiency.

- **Cost-Effectiveness of Sustainable Urban Practices**

Despite its large-scale and sustainability-driven approach, the Al-Azhar Park project remained cost-effective through innovative design choices [23]. For example, local and recycled materials were used for construction, and historical structures, such as the Ayyubid Wall, were restored rather than replaced. Additionally, VE methodologies ensured that ecological restoration efforts—such as soil remediation and tree planting—were implemented financially efficiently.

3.2.2. Sustainability Metrics in VE at Al-Azhar Park

Measuring sustainability within a VE framework requires specific metrics that assess a project's environmental impact, efficiency, and benefits. Al-Azhar Park provides a valuable case study to explore these metrics and how they were implemented effectively.

- **Lifecycle Assessment (LCA) in Urban Green Spaces**

Lifecycle assessment (LCA) is an essential tool in sustainable urban development, allowing planners to evaluate the environmental impacts of materials, water systems, and energy use throughout a project’s lifespan. In Al-Azhar Park, LCA was used to select sustainable landscaping materials, assess water conservation strategies, and determine the long-term environmental footprint of park maintenance.

- **Carbon Footprint and Energy Efficiency**

Reducing the park's carbon footprint was a primary sustainability objective. It was achieved through several key measures:

- The use of solar-powered lighting reduced reliance on nonrenewable energy.
- The park's green spaces function as carbon sinks, absorbing CO_2 emissions from the surrounding urban environment.
- Integrating shaded walkways and water-efficient fountains helped regulate microclimate temperatures, reducing the need for artificial cooling.

- **Ecosystem Service Valuation and Biodiversity Enhancement**

Al-Azhar Park was designed to provide ecosystem services such as air purification, habitat restoration, and water management. These benefits were quantified by assessing the following:

- The number of plant species introduced to enhance biodiversity.
- Improvements in local air quality due to increased green coverage.
- The park's contribution to stormwater management and groundwater recharge.

3.2.3. Interdisciplinary Collaboration Models

The successful implementation of VE and sustainability principles at Al-Azhar Park was made possible through collaboration between urban planners, environmental scientists, policymakers, and the local community. This interdisciplinary approach ensured that the project addressed multiple dimensions of urban sustainability.

- **Urban Planners and Sustainable Design Strategies**

Urban planners were key in integrating green infrastructure into the park's layout. Their contributions included:

- Designing pedestrian pathways that followed natural contours, reducing soil erosion.
- Incorporating shaded seating areas to enhance visitor comfort while reducing heat stress.
- Ensuring connectivity between the park and surrounding historical sites to maintain cultural integration.

These strategies helped maximize the social and environmental impact of the park while maintaining its historical integrity.

- **Role of Environmental Scientists in Ecological Restoration**

Environmental scientists contributed significantly to the park's sustainability goals by implementing ecological restoration techniques, such as:

- **Soil remediation:** Since the site was previously a landfill, extensive efforts were made to detoxify and restore soil quality before planting vegetation.
- **Water conservation strategies:** Using drought-resistant plants, rainwater harvesting, and efficient irrigation systems reduced water consumption.
- **Wildlife habitat creation:** Green spaces were designed to attract birds, pollinators, and other urban wildlife, enhancing biodiversity.

These interventions ensured that the park functioned as a recreational space and a model for urban ecological restoration.

- **Policy and Community Engagement in Sustainable Development**

The park's success was also a result of effective policymaking and strong community engagement. Governmental and non-governmental organizations collaborated to secure funding and ensure regulatory compliance. Meanwhile, local communities were actively involved through:

- Job opportunities in park maintenance and tourism-related sectors.
- Educational programs promoting environmental awareness.
- Cultural and artistic events are hosted within the park to foster social inclusion.

3.3. Stakeholder Surveys and their Role in the Al-Azhar Park Project

Understanding the integration of Value Engineering (VE) and sustainability in urban design requires key stakeholders' input in planning, implementation, and management. The Al-Azhar Park project serves as a model case study where stakeholders played a crucial role in decision-making, ensuring sustainability goals aligned with economic and social priorities. This study incorporates structured surveys targeting professionals and community representatives to capture diverse perspectives. The survey process comprises three main components: target participants, survey themes, and data analysis techniques [24].

3.3.1. Target Participants in the Al-Azhar Park Project

Identifying the right participants is essential for obtaining meaningful insights into how VE and sustainability were implemented in the Al-Azhar Park project. The survey targets individuals directly or indirectly involved in the park's planning, execution, and maintenance.

- **Urban Planners and Architects**

These professionals were instrumental in designing the park's layout and integrating sustainable urban infrastructure. Their survey responses provide insights into the following:

- How VE methodologies influenced design decisions.
- Challenges encountered in balancing cost efficiency with environmental objectives.
- The effectiveness of green infrastructure solutions such as rainwater harvesting and energy-efficient lighting.

- **Environmental Specialists and Ecologists**

The park's ecological restoration and sustainability measures required input from environmental experts. Surveying this group reveals:

- The extent to which VE contributed to resource efficiency and ecological restoration.
- Sustainability assessments, including lifecycle analysis, are significant in project decisions.

- **Municipal Authorities and Community Representatives**

Local authorities and residents were key stakeholders in the project's implementation and ongoing management [25]. Their perspectives help assess:

- The economic and social impact of Al-Azhar Park on surrounding neighborhoods.
- Encouraging community involvement in park maintenance and cultural programs.
- Developing policy recommendations to enhance future urban sustainability initiatives.

3.3.2. Survey Themes: Investigating the Integration of VE and Sustainability

The survey questions are structured to explore critical themes surrounding the role of VE in sustainable urban projects like Al-Azhar Park. These themes help identify successes, challenges, and areas for improvement.

- **Perceived Benefits of Integrating VE with Sustainability**

Participants provide insights into how VE contributed to sustainability outcomes at Al-Azhar Park. Key areas of focus include:

- Cost savings are achieved through material efficiency and lifecycle planning.
- Environmental benefits include improved air quality, reduced heat island effects, and enhanced biodiversity.
- Social benefits include increased community engagement and improved public health.

- **Challenges in Implementing VE-Driven Sustainability Measures**

While VE aims to optimize resources, specific challenges can arise when integrating sustainability objectives. Participants discuss:

- Financial and logistical barriers in implementing green infrastructure.
- Technical constraints in applying VE methodologies to ecological restoration.
- The role of regulatory frameworks in shaping sustainability outcomes.

- **Best Practices and Policy Recommendations**

Stakeholders are asked to suggest best practices and policy improvements to improve VE in sustainable urban projects. Their responses highlight:

- Approaches to fostering interdisciplinary collaboration among planners, engineers, and environmental specialists.
- Policy incentives to promote and support sustainable practices in urban development
- Lessons learned from the Al-Azhar Park project that can inform future green urban initiatives.

3.3.3. Data Analysis Techniques for Stakeholder Feedback

To ensure comprehensive insights into stakeholder perspectives on the integration of Value Engineering (VE) and sustainability at Al-Azhar Park, this study employed a combination of **qualitative and quantitative data analysis techniques**. These methods allowed for both thematic interpretation and statistical evaluation of survey responses.

Sample Description

The survey targeted a **purposive sample** of 30 stakeholders who were either directly involved in the Al-Azhar Park project or possess relevant expertise in urban planning, environmental sustainability, or heritage preservation. The sample included the following, as shown in Table 1:

Table 1: Sample Description

Sample classification	No. of Response
Urban planners and architects	10
Environmental specialists and ecologists	8
Municipal officials and policymakers	6
Community representatives and NGO members	6

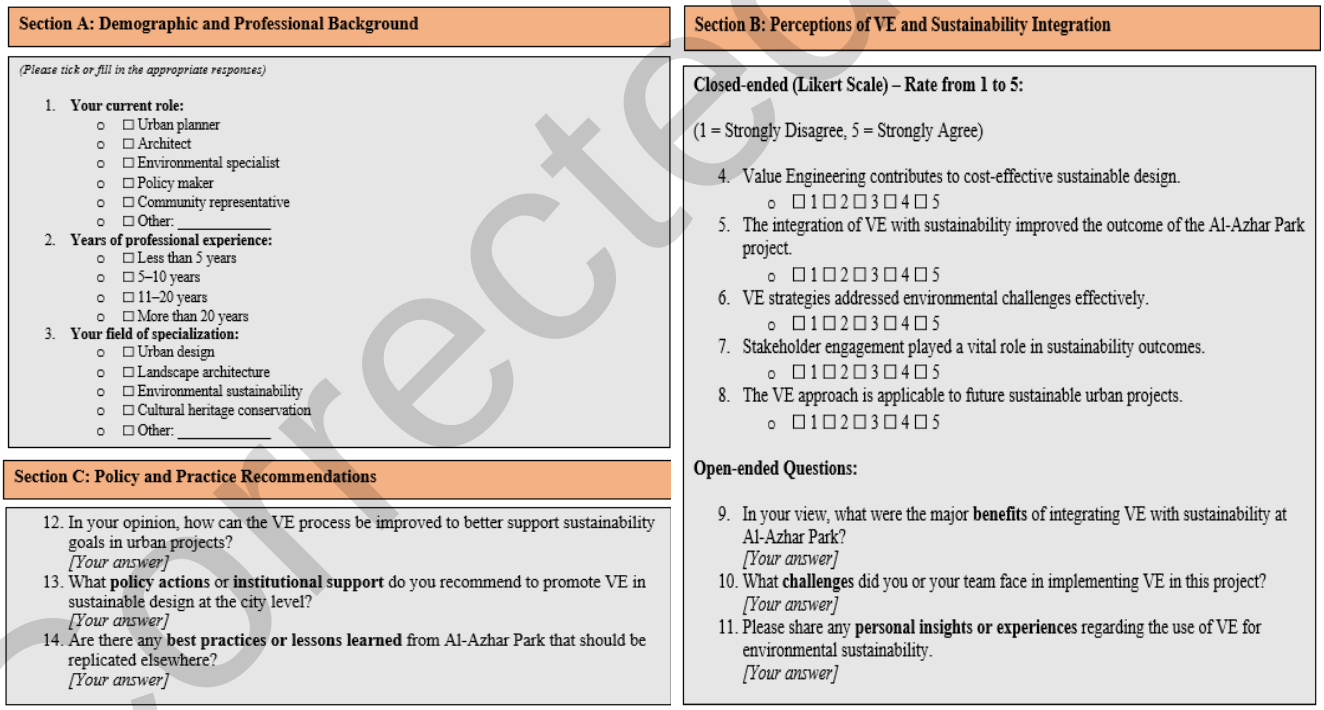
This sample was chosen to reflect the diverse spectrum of actors involved in or affected by sustainable urban development in Cairo.

Survey Instrument and Structure

A semi-structured questionnaire was developed and distributed online via email and in-person during stakeholder meetings. The survey included:

- **Section A: Demographic and Professional Background** (e.g., role, years of experience, field of specialization)
- **Section B: Perceptions of VE and Sustainability Integration**
  - **Closed-ended questions** (using Likert scales) to assess perceived benefits, challenges, and effectiveness
  - **Open-ended questions** to gather qualitative feedback and personal insights
- **Section C: Policy and Practice Recommendations**
  - Questions aimed at eliciting suggestions for enhancing VE-driven sustainability frameworks in future urban projects

The following Fig. (8) illustrates the structure of the stakeholder questionnaire, which is organized into three main sections. Each section is designed to capture specific aspects of stakeholder perspectives on Value Engineering (VE) and sustainability integration in the Al-Azhar Park project. The questionnaire consists of both closed-ended (Likert scale) and open-ended questions, as



Section A: Demographic and Professional Background

(Please tick or fill in the appropriate responses)

1. **Your current role:**
   - ☐ Urban planner
   - ☐ Architect
   - ☐ Environmental specialist
   - ☐ Policy maker
   - ☐ Community representative
   - ☐ Other: _____
2. **Years of professional experience:**
   - ☐ Less than 5 years
   - ☐ 5–10 years
   - ☐ 11–20 years
   - ☐ More than 20 years
3. **Your field of specialization:**
   - ☐ Urban design
   - ☐ Landscape architecture
   - ☐ Environmental sustainability
   - ☐ Cultural heritage conservation
   - ☐ Other: _____

Section B: Perceptions of VE and Sustainability Integration

Closed-ended (Likert Scale) – Rate from 1 to 5:

(1 = Strongly Disagree, 5 = Strongly Agree)

4. Value Engineering contributes to cost-effective sustainable design.
   - ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
5. The integration of VE with sustainability improved the outcome of the Al-Azhar Park project.
   - ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
6. VE strategies addressed environmental challenges effectively.
   - ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
7. Stakeholder engagement played a vital role in sustainability outcomes.
   - ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
8. The VE approach is applicable to future sustainable urban projects.
   - ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Open-ended Questions:

9. In your view, what were the major **benefits** of integrating VE with sustainability at Al-Azhar Park?
   [Your answer]
10. What **challenges** did you or your team face in implementing VE in this project?
    [Your answer]
11. Please share any **personal insights or experiences** regarding the use of VE for environmental sustainability.
    [Your answer]

Section C: Policy and Practice Recommendations

12. In your opinion, how can the VE process be improved to better support sustainability goals in urban projects?
    [Your answer]
13. What **policy actions** or **institutional support** do you recommend to promote VE in sustainable design at the city level?
    [Your answer]
14. Are there any **best practices or lessons learned** from Al-Azhar Park that should be replicated elsewhere?
    [Your answer]

Fig. 8: Example for semi-structured questionnaire

- **Qualitative Coding Methods**

Responses to open-ended questions were analyzed using **manual thematic coding**. The process involved:

- Identifying recurring **themes and patterns** across stakeholder narratives
- Categorizing feedback into three main areas: **benefits**, **challenges**, and **recommendations**

- Highlighting **unique insights** that offer context-specific understanding of VE–sustainability interactions, for instance, if multiple architects mentioned difficulty accessing eco-friendly materials, this was coded under "Resource Constraints in VE Implementation."

- **Quantitative Statistical Analysis**

Responses to closed-ended questions were subjected to basic statistical analysis using Excel and SPSS. The following techniques were applied:

- **Descriptive statistics**: To calculate response frequencies and mean ratings on topics such as cost savings, sustainability outcomes, and interdisciplinary collaboration
- **Comparative analysis**: To examine differences in opinion among stakeholder groups (e.g., comparing responses of urban planners vs. environmental experts)
- **Correlation analysis**: To explore relationships between the perceived success of VE measures and factors like community engagement or use of lifecycle assessments

- **Visualization and Interpretation of Results**

The integrated findings were presented using visual tools, including:

- **Bar charts and pie charts** for quantitative trends
- **Thematic maps** and **word clouds** for qualitative insights

This multimodal approach enabled the research to:

- Clearly illustrate stakeholder opinions on VE and sustainability at Al-Azhar Park
- Generate **data-driven recommendations** for future urban projects in similar socio-environmental contexts
- Effectively communicate findings to **policymakers, urban designers, and sustainability advocates**, supporting informed decision-making in sustainable urban planning.

SUMMARY AND CONCLUSIONS

Summary of Key Findings

This research explored the integration of Value Engineering (VE) with environmental sustainability in the context of urban design and landscape practices. By examining the theoretical foundations, analyzing relevant literature, and applying a detailed case study of Al-Azhar Park in Cairo, the study demonstrates how VE can evolve from a cost-cutting mechanism into a sustainability-enabling methodology.

1. **Redefining the Role of VE:**
   VE, originally developed as a cost optimization tool, can be reframed to enhance long-term environmental and economic value. When integrated with lifecycle thinking and sustainability metrics, VE contributes to resource efficiency, ecological resilience, and holistic value creation.

2. **Environmental Sustainability in Urban Design:**
   Key strategies such as green infrastructure, low-impact development, and renewable energy integration are central to achieving sustainable urban outcomes. The Al-Azhar Park case exemplifies how these principles can be realized in practice through interdisciplinary planning and ecosystem integration.

3. **Case Study Evidence – Al-Azhar Park:**

   The transformation of a centuries-old landfill into a thriving public park demonstrates the practical application of VE and sustainability. The project successfully integrated cost-effective materials, ecological restoration strategies, cultural heritage preservation, and stakeholder engagement.

4. **Survey Findings: Stakeholder Perspectives on VE and Sustainability Integration**

   As part of this research, a structured survey was conducted targeting 30 stakeholders, including urban planners, architects, environmental specialists, policymakers, and community representatives. The goal was to assess their perspectives on the effectiveness, challenges, and potential of integrating Value Engineering (VE) with sustainability principles, particularly in the Al-Azhar Park project.
   Key findings include:

   - **Perceived Benefits of VE Integration:**
     - 87% of respondents agreed that VE contributed positively to cost savings in the park project.
     - 80% believed that VE facilitated better resource efficiency and reduced environmental impact.
     - 76% acknowledged that VE, when aligned with sustainability goals, improved long-term project performance.
   - **Challenges Identified:**
     - 65% cited difficulties in sourcing sustainable materials within budget constraints.
     - 58% noted a lack of awareness or training in applying VE from a sustainability perspective.
     - 52% pointed to the absence of clear regulatory frameworks that support sustainability-driven VE.
   - **Best Practices and Recommendations:**
     - Most respondents emphasized the importance of early stakeholder involvement during the planning phase.
     - 70% recommended mandatory environmental impact assessments within VE studies.
     - Many advocated for interdisciplinary collaboration and government-supported incentives to adopt green technologies.

   The fig (9) below summarizes key findings from the stakeholder survey, focusing on the perceived benefits of integrating Value Engineering (VE) with sustainability, challenges

faced during the implementation process, and recommendations for enhancing VE-driven sustainability in future urban projects.

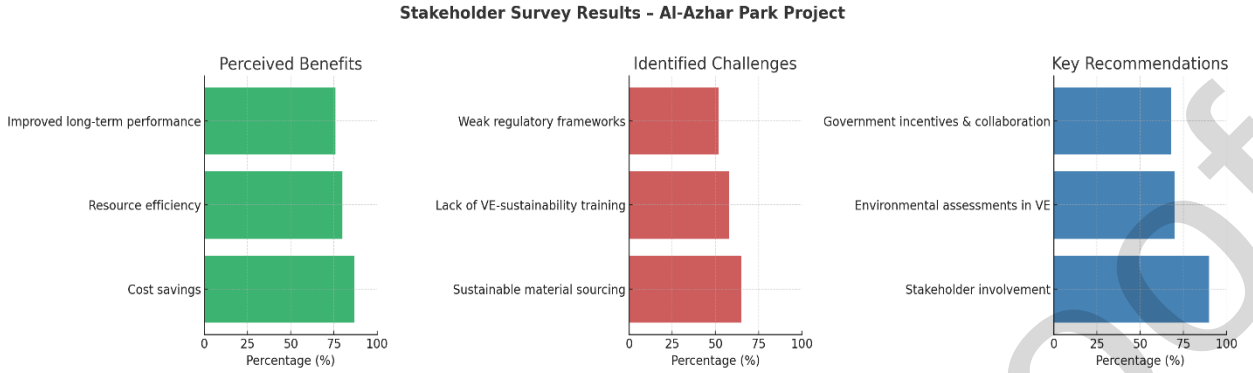


Fig. 9: Survey results including benefits, challenges, and recommendations as reported by 30 stakeholders.

These findings support the conclusion that VE can serve as an effective tool for sustainable urban development—**provided it is reframed to consider long-term ecological and social value** rather than short-term cost reductions. The survey results directly informed the design of the proposed framework and validate its applicability across similar urban contexts.

Conclusion and Future Recommendations

This study, grounded in theoretical review, analytical investigation, and the case study of Al-Azhar Park, proposes a strategic framework for integrating Value Engineering (VE) with environmental sustainability in urban design. The findings demonstrate that VE—when reframed beyond its traditional cost-cutting function—can serve as a powerful, holistic methodology that maximizes long-term environmental, economic, and social value.

The proposed framework is both evidence-based and practice-oriented, offering a replicable model for sustainable urban transformation. It consists of four integrated pillars:

1. Redefining VE for Sustainable Urban Development

VE should evolve into a long-term value optimization strategy rather than a short-term cost-reduction tool. This involves:

- Integrating Lifecycle Assessments (LCA) and sustainability performance indicators to ensure comprehensive evaluation across the project's lifespan.
- Prioritizing ecological, cultural, and community benefits alongside financial considerations.

2. Policy and Regulatory Support

Sustainability-driven policies are essential to institutionalize the VE approach. This includes:

- Establishing clear regulatory frameworks that require VE to address environmental impacts explicitly.

- Offering financial incentives, fast-track approvals, or certification credits for projects that meet sustainable VE benchmarks.

3. Enhancing Interdisciplinary Collaboration and Stakeholder Awareness

Cross-sector collaboration is crucial for innovative and balanced solutions. Recommendations include:

- Involving urban planners, environmental specialists, economists, and community actors early in the planning phase.
- Implementing capacity-building programs, training workshops, and public forums to raise awareness and share knowledge on VE-sustainability integration.

4. Investing in Sustainable Technologies and Practices

Technological advancement and material innovation are vital for achieving sustainability goals. Suggested actions:

- Prioritize energy-efficient materials, passive design systems, and renewable energy integration.
- Encourage modular construction, circular economy principles, and the reuse of local materials to reduce carbon footprints and construction waste.

This framework directly supports the research objective: to provide an actionable, scalable model derived from theory, analysis, and real-world application—exemplified by the Al-Azhar Park project. It offers urban designers, policymakers, and sustainability advocates a roadmap for transforming cities into resilient, cost-effective, and ecologically responsible environments.

Future Research Direction:

Further studies are encouraged to test and refine the proposed framework in different urban contexts. Comparative evaluations across geographical, climatic, and socio-economic conditions would help validate its adaptability, improve policy alignment, and enhance global knowledge on sustainable VE applications.

CONFLICT OF INTEREST

The authors have no financial interest to declare about the content of this article.

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