



Adaptive Reuse of Ministerial Buildings in Egypt to Achieve Sustainable Urban Development

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Abstract: Adaptive reuse is a sustainable strategy that repurposes existing buildings to minimize environmental impact, preserve cultural heritage, and support urban regeneration. This study evaluates the adaptive reuse potential of key ministerial buildings in Cairo following the relocation of government offices to the New Administrative Capital. A multi-criteria decision-making (MCDM) approach integrated with Geographic Information Systems (GIS) was employed to assess the suitability of reuse strategies based on five dimensions: architectural integrity, economic feasibility, environmental sustainability, legislative considerations, and social impact. The methodology involved spatial analysis, and site visits, utilizing overlay analysis and heat mapping to identify optimal reuse opportunities. Findings reveal that these buildings can be repurposed into innovation hubs, cultural centers, research facilities, hotels, and mixed-use developments, contributing to Cairo's sustainable urban development. The Ministry of Education building is well-suited for scientific and medical research centers, the General Organization for Physical Planning building for urban heritage and planning initiatives, and the Ministry of Housing building for commercial, entrepreneurial, and hospitality functions due to its high economic viability. By leveraging data-driven spatial analysis and sustainability assessments, adaptive reuse can transform underutilized government assets into economically viable, environmentally sustainable, and culturally significant spaces, supporting Egypt's urban development agenda.

1. Introduction

Adaptive reuse has emerged as a pivotal strategy in sustainable architecture, repurposing existing structures to accommodate contemporary needs while preserving their historical, cultural, and architectural significance [40]. This approach mitigates the environmental impact of new construction by conserving embodied energy, minimizing waste, and

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reducing carbon emissions, aligning with global sustainability goals [6]. Additionally, adaptive reuse fosters urban regeneration by revitalizing underutilized spaces, curbing urban sprawl, and optimizing land use efficiency [27]. Beyond environmental benefits, it contributes to economic and social sustainability by generating employment opportunities, enhancing social inclusion, and reinforcing cultural identity. Aligned with the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action), adaptive reuse promotes responsible resource management and energy efficiency [10]. However, its implementation is often hindered by regulatory challenges, structural limitations, and the complexities of integrating modern functionalities into heritage structures. These obstacles necessitate innovative design solutions and strategic planning to balance historical preservation with contemporary urban demands [26].

Egypt, with its rich architectural heritage, possesses significant potential for adaptive reuse in fostering sustainable urban development [31]. Historic buildings, including palaces, governmental structures, and monuments, provide opportunities for functional transformation while safeguarding cultural heritage. Since the 1952 revolution, several heritage structures have been repurposed into museums, schools, and hotels, yet many, particularly former schools, have suffered neglect and deterioration [12]. Governed by Law No. 117 of 1983, Egypt's legal framework seeks to protect historical structures while allowing for adaptive reuse [33], though challenges such as regulatory barriers, conflicting heritage values, and integration difficulties persist [45]. The recent relocation of government ministries to the New Administrative Capital has left numerous historic ministerial buildings in Cairo vacant [14, 17]. Their repurposing presents a unique opportunity to address urban congestion, introduce green spaces, and enhance economic and cultural landscapes [20]. Potential uses include cultural institutions, commercial hubs, research centers, or hospitality venues, each contributing to urban revitalization while preserving Egypt's architectural identity [29]. This study proposes a structured framework for evaluating the feasibility of adaptive reuse for selected ministerial buildings in Cairo [17]. The methodology incorporates geospatial analysis and multi-criteria decision-making models to assess factors such as structural integrity, surrounding infrastructure, and socio-economic impact. By integrating these tools, the study aims to provide a comprehensive perspective on adaptive reuse as a sustainable urban development strategy in Egypt.

1.1 Adaptive Reuse and Sustainable Urban Development

Adaptive reuse extends the life cycle of buildings by transforming their function rather than resorting to demolition. Traditionally focused on preservation, this approach has evolved into a key component of sustainability and urban regeneration. By retaining embodied energy and reducing construction waste, adaptive reuse minimizes environmental degradation while offering economic and social advantages. It enhances urban livability, fosters community engagement, and contributes to long-term economic stability through job creation and investment. Preserving the embodied energy of historic buildings is a critical

sustainability measure, as renovation generally requires fewer resources than new construction. Additionally, adaptive reuse mitigates urban decline, supporting economic revitalization by attracting businesses and cultural activities. The concept of reuse encompasses three primary approaches—original reuse, adaptive reuse, and integral reuse—all of which contribute to extending the building life cycle and preventing deterioration. Reusing historic buildings plays a vital role in regeneration strategies, requiring careful analysis of the existing fabric to ensure authenticity [28]:

- ❖ **Original Reuse (Maintaining the Original Function):** This approach involves preserving the original function of a building while implementing necessary renovations to enhance its usability and extend its lifespan. An example is the **Bibliotheca Alexandrina** in Egypt, where a modern structure was constructed to continue serving as a library and cultural center, aligning with its historical predecessor, the ancient Library of Alexandria.
- ❖ **Adaptive Reuse (Modifying the Function While Preserving Key Features):** This method transforms a building's function while maintaining its essential architectural elements. A notable example is the **Tate Modern in London**, where a former power station was converted into a contemporary art museum while preserving its industrial aesthetic and structural integrity.
- ❖ **Integral Reuse (Incorporating New Elements While Retaining Historical Integrity):** In this approach, buildings retain their historical character while integrating new architectural components or functions. The **Fondazione Prada in Milan**, for instance, transformed a former gin distillery into a mixed-use cultural complex, incorporating modern architectural additions alongside preserved industrial structures.

These examples illustrate the distinct characteristics of each reuse approach, demonstrating how adaptive reuse strategies vary based on the extent of functional and structural modifications while balancing preservation and modernization. When integrated into urban planning, adaptive reuse becomes a catalyst for sustainability, balancing heritage conservation with environmental, economic, and social well-being. Table 1 outlines the core sustainability principles and associated benefits of adaptive reuse:

Adaptive reuse directly supports several United Nations Sustainable Development Goals (SDGs 2030) [11]:

- **SDG 8: Decent Work and Economic Growth:** Stimulates economic growth by creating jobs through construction, renovation, and new business opportunities in repurposed spaces.
- **SDG 11: Sustainable Cities and Communities:** Promotes inclusive, safe, resilient, and sustainable urbanization by revitalizing existing structures and preventing urban sprawl.
- **SDG 12: Responsible Consumption and Production:** Encourages sustainable practices in resource management and waste reduction, promoting responsible consumption patterns.
- **SDG 13: Climate Action:** Contributes to climate change mitigation through energy conservation and reducing emissions associated with construction activities.

Despite its advantages, adaptive reuse faces significant challenges. Regulatory constraints, such as zoning laws and heritage preservation regulations, can complicate the process [42]. Structural deficiencies in older buildings often require extensive retrofitting, increasing costs and project timelines [5]. Furthermore, maintaining a building's historical authenticity while adapting it for modern use demands careful planning and innovative design strategies [11]. These complexities highlight the need for comprehensive policy frameworks and financial incentives to facilitate adaptive reuse projects [19].

Table 1: Adaptive reuse and Sustainable principles: Source: [22], [3] and by authors

Sustainable principles	Benefits
Environmental Benefits	Waste Reduction: Adaptive reuse repurposes old buildings, reducing demolition waste and environmental impact by conserving materials.
	Resource Conservation: Repurposing buildings saves resources by reusing materials, reducing demand for new materials, and lowering environmental costs.
	Energy Efficiency: Renovating buildings uses less energy than new construction, and retrofitting improves energy efficiency and reduces emissions.
	Urban Sprawl Mitigation: Adaptive reuse promotes urban infill, repurposing buildings to combat sprawl and protect natural landscapes.
Economic Benefits	Cost-Effectiveness: Adaptive reuse is cost-effective, reducing demolition expenses and utilizing existing infrastructure to lower overall costs.
	Revitalization of Local Economies: Repurposed buildings create vibrant mixed-use developments, attracting businesses and investments that drive job creation and growth.
	Long-Term Value: Adaptive reuse extends the life of buildings, creating lasting assets that generate revenue and economic stability.
Social and Cultural Benefits	Cultural Heritage Preservation: Adaptive reuse preserves historically significant buildings, helping communities maintain cultural identity and fostering pride among residents.
	Community Engagement: Community consultation in adaptive reuse projects strengthens ties and promotes inclusivity, ensuring spaces meet local needs.
	Improved Urban Livability: Repurposed buildings become community hubs, enhancing urban livability with amenities and social spaces for residents.

1.2 Adaptive Reuse in Egypt

Egypt's architectural heritage is characterized by a vast collection of historic buildings, including palaces and government structures, which reflect diverse historical and stylistic influences. Since the 1952 revolution, some of these buildings have been repurposed as museums, hotels, and schools [38]. However, while museum conversions have preserved architectural integrity, buildings reused as schools have suffered from neglect and partial demolition [12]. Under Egyptian Law No. 117 of 1983, heritage buildings are not assigned

specific functions, but any proposed reuse requires approval from the Permanent Committee for Antiquities [39]. The decision-making process involves balancing conflicting heritage values, structural considerations, and regulatory requirements. Additionally, the fragmented implementation of sustainable preservation strategies underscores the need for a systematic approach to adaptive reuse [13]. The relocation of Egypt's government ministries to the New Administrative Capital has left many ministerial buildings in Cairo underutilized [31]. Repurposing these structures presents an opportunity to enhance urban sustainability by addressing challenges such as congestion, inadequate green spaces, and outdated infrastructure [36]. Table 2 outlines potential strategies for reusing ministerial buildings:

Table 2: Proposed strategies for the reuse of ministerial buildings

Cultural and Artistic Hubs	Art galleries and museums: Cairo has a rich cultural history, and these buildings can showcase Egypt's heritage.
	Cultural centers: These buildings could host events, exhibitions, concerts, and workshops, promoting cultural exchange and artistic expression
Business and Innovation Centers	Business incubators and accelerators: Transforming former government offices into collaborative workspaces for startups and entrepreneurs.
	Tech hubs: These buildings could be converted into innovation spaces where tech companies and research institutions collaborate on projects.
Affordable Housing and Mixed-use Development	Affordable housing: Convert some of these buildings into residential units, targeting young professionals, students, or lower-income residents.
	Mixed-use projects: Combine residential, commercial, and office spaces in one building, bringing economic life back to urban neighborhoods.
Educational Institutions	Universities or technical schools: These buildings can provide new educational facilities in city centers, easing the pressure on existing institutions.
	Research centers: Academic research centers for disciplines such as urban planning, history, and social sciences could be housed in these spaces.
Public Services and Green Spaces	Community centers: Offering public services like libraries, healthcare, or youth centers.
	Green spaces: The area around ministerial buildings could be developed into public parks and green spaces, providing much-needed recreation areas for residents.
Tourism and Hospitality	Boutique hotels: Many of the older government buildings have unique architectural styles that could be converted into upscale hotels for tourists.
	Event venues: Some of the buildings could be converted into venues for weddings, conferences, or other large gatherings.
Social and Affordable Services	Non-profit headquarters: Re-use these buildings as offices for NGOs and charitable organizations.
	Social enterprises: Turn some of the space into centers for social entrepreneurship, offering services and training to underserved communities.
Green and Sustainable Development	Energy-efficient retrofits: Renovate the buildings to be more energy-efficient by installing solar panels, using sustainable materials, and improving insulation.
	Urban agriculture: Some rooftops or open areas around these buildings could be converted into urban farms or greenhouses, contributing to local food security and sustainability efforts.
Foreign Embassies or	Diplomatic centers: Former ministerial buildings can be transformed into embassy complexes, given their size and strategic location.

International Organizations	International NGO headquarters: These buildings could also host international non-governmental organizations (INGOs), which often seek prestigious locations for their regional headquarters.
Historical Preservation and Tourism	Heritage sites: Preserve the buildings in their original form as cultural heritage sites, where tourists can learn about Egypt's administrative history.
	Guided tours: The history of these buildings could be showcased through guided tours, providing visitors with a deeper understanding of their significance.
Source: [8], [18], [13], [32], and by authors.	

The reuse strategies for ministerial buildings were proposed based on a multi-faceted evaluation process that integrates urban context analysis, sustainability principles, economic feasibility, stakeholder needs, and global best practices in adaptive reuse. The selection criteria for these strategies align with the following key factors:

1. Urban Context and Surrounding Land Use Compatibility:

- The reuse proposals consider the existing urban fabric, surrounding functions, and land use patterns. For example, the recommendation to develop business incubators and tech hubs stems from the presence of administrative and governmental institutions that could benefit from innovation-driven initiatives.
- Similarly, educational institutions are proposed due to their proximity to existing research centers and universities, ensuring synergy between academic and professional sectors.

2. Cultural and Heritage Significance:

- Strategies such as cultural centers, art galleries, and museums were proposed based on Egypt's rich artistic and historical heritage. Repurposing buildings into cultural hubs aligns with global precedents where historic structures have been successfully transformed into spaces that celebrate national identity and artistic expression.

3. Economic Revitalization and Sustainable Development Goals:

- The recommendations emphasize economic regeneration by introducing mixed-use development, tourism facilities, and commercial spaces, which can attract investment, create jobs, and foster entrepreneurship.
- Boutique hotels and event venues were suggested in response to Egypt's growing tourism sector, leveraging the architectural and historical value of these buildings to enhance cultural tourism.
- The proposal for social enterprises and non-profit headquarters aligns with urban revitalization efforts that aim to integrate marginalized communities and promote inclusive economic growth.

4. Social and Environmental Sustainability Considerations:

- The emphasis on affordable housing and mixed-use projects directly addresses Egypt's housing demands, particularly in urban centers where residential options are limited.

- Energy-efficient retrofits, green spaces, and urban agriculture align with international sustainability frameworks such as LEED and Egypt Vision 2030, ensuring that the reuse strategies contribute to climate resilience and ecological well-being.

5. Policy and Institutional Factors:

- The inclusion of foreign embassies and international organizations as a potential reuse option is based on the strategic location and diplomatic importance of downtown Cairo, making it a suitable site for regional and international institutions.
- Historical preservation efforts, such as guided tours and heritage conservation projects, align with Egypt's national heritage protection policies, ensuring that architectural legacies are maintained while adapting buildings to contemporary needs.

The proposed reuse strategies outlined in Table 2 emphasize a diverse and holistic approach to adaptive reuse, ensuring that former ministerial buildings contribute to Cairo's sustainable urban development. These strategies address key sustainability dimensions, including cultural preservation, economic revitalization, environmental sustainability, and social inclusion. By repurposing buildings as cultural hubs, innovation centers, mixed-use developments, and public services, the study aligns with global best practices in adaptive reuse while considering Cairo's unique historical and urban context. Additionally, the strategies proposed in Table 2 demonstrate a balance between conservation and modernization, ensuring that heritage buildings retain their architectural integrity while being adapted for contemporary needs. The integration of green infrastructure, energy-efficient retrofits, and urban agriculture further enhances the environmental sustainability of these reuse projects. These findings highlight the potential of adaptive reuse to transform underutilized government assets into vibrant, multifunctional spaces that promote economic growth, cultural engagement, and community well-being. Adaptive reuse in Egypt presents a strategic opportunity to integrate historical preservation with contemporary urban needs. By adopting innovative approaches and policy support, these projects can enhance Cairo's cultural and economic landscape, contributing to a more sustainable and resilient urban future.

2. Material and methods

2.1. Case study

The Ministry Square in downtown Cairo is an important administrative center known for its architectural density and functional diversity, featuring government housing and ministerial buildings that reflect the historical and urban development of the city. The square was designed to blend modern and traditional architecture, highlighting cultural diversity while playing a pivotal role in political and economic activities and serving as a social gathering point [2]. Established in the early 20th century, it embodies the strength and prestige of neoclassical architecture but now faces challenges related to maintenance and heritage preservation, requiring investments for sustainability [34].

The study area includes several ministries, such as the Ministry of Interior, the Ministry of Education and Technical Education, the Ministry of Higher Education, the Ministry of Justice, and the Ministry of Social Solidarity, among others. The administrative boundaries of the study area encompass ten neighborhoods (al-Dawâwîn, Khayrat, Sibâ'în, al-Sayyida, Qasr al-Dûbâra, Garden City, al-'Aynî, al-Insha wa al-Munîra, al-Shaykh 'Abdallah, al-Gazîra al-Gadîda), as illustrated in Figure 2. These neighborhoods fall within the jurisdictions of Qasr al-Nîl, Sayyida Zeinab, and Abdeen police divisions [14]. The total area of the study zone is approximately 2,307,345.885 square meters, with a population of 69,792 individuals, according to the Central Agency for Public Mobilization and Statistics (CAPMAS) in 2024 [1].

Since the relocation of ministries and government agencies from central Cairo to the New Administrative Capital, the fate of many facilities being vacated remains uncertain. There is ongoing debate regarding how to capitalize on these sites both economically and culturally, advocating for their transformation into museums, tourist attractions, hotels, or other suitable activities instead of demolishing them [37]. Given that most of the buildings of significance in central Cairo scheduled for transfer to the New Administrative Capital are listed as heritage sites or possess architectural and cultural value, there is a pressing need to develop a flexible and clear plan for their redevelopment and investment. This plan should aim to utilize these buildings in a positive manner, ensuring that their historical and architectural integrity is preserved [36]. The selection of the Ministry of Education and Technical Education Building, the General Organization for Physical Planning Building, and the Ministry of Housing, Utilities, and Urban Communities Building for this study as shown as Figure 3, was based on several key factors that align with the study's objectives and the principles of sustainable development. The justification for focusing on these three cases includes:

- ❖ **Strategic Urban Context:** These buildings are in a historically and administratively significant area of downtown Cairo, where urban revitalization efforts and sustainable development initiatives are highly relevant. Their central location enhances their potential impact on surrounding urban functions and accessibility.
- ❖ **Diverse Functional and Architectural Characteristics:** Each selected building represents different typologies and functional roles within the urban fabric. The Ministry of Education building has historical and institutional significance, the General Organization for Physical Planning building is linked to urban planning policies, and the Ministry of Housing building has a mixed-use potential that can accommodate commercial, entrepreneurial, and hospitality functions. This diversity allows for a comprehensive exploration of adaptive reuse models.
- ❖ **Policy and Institutional Significance:** These buildings are affiliated with ministries that directly influence urban planning, heritage conservation, and development policies. Their reuse could serve as a precedent for broader government-led initiatives in adaptive reuse, making them ideal for examining policy-driven decision-making frameworks.
- ❖ **Urgency of Intervention:** The selected buildings face challenges related to underutilization, aging infrastructure, and the need for functional upgrades. Addressing

their reuse aligns with the Egyptian government's sustainable development agenda, particularly in optimizing state-owned assets for economic and social benefit.

❖ **Availability of Data and Stakeholder Engagement:** Given their governmental affiliation, these buildings have well-documented architectural and land-use records, facilitating a data-driven analysis. Furthermore, their selection enables direct engagement with policymakers, urban planners, and conservation experts, strengthening the study's practical implications.

By selecting these three buildings, the study ensures a focused yet representative analysis of ministerial building reuse within a sustainable urban development framework. While generalizability may be limited, the findings can inform adaptive reuse strategies for similar government buildings across Egypt.

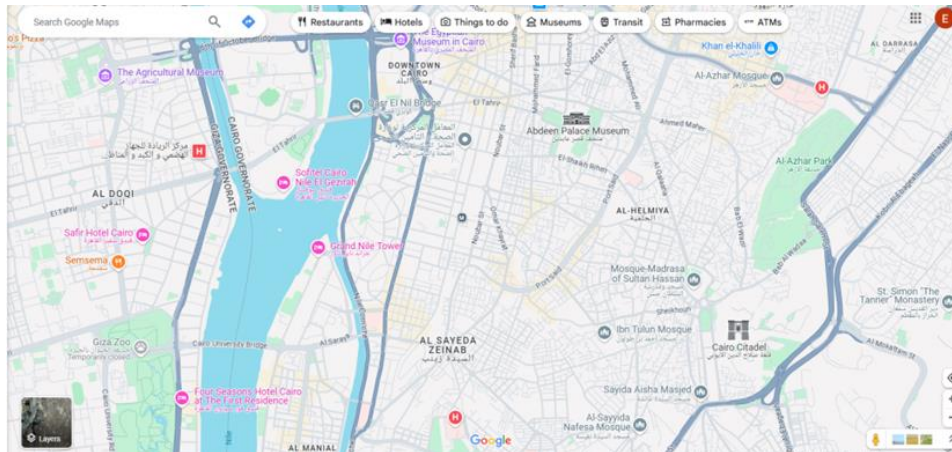


Fig. 1: Location of the Ministry Square in downtown Cairo (Google Maps—Egypt).

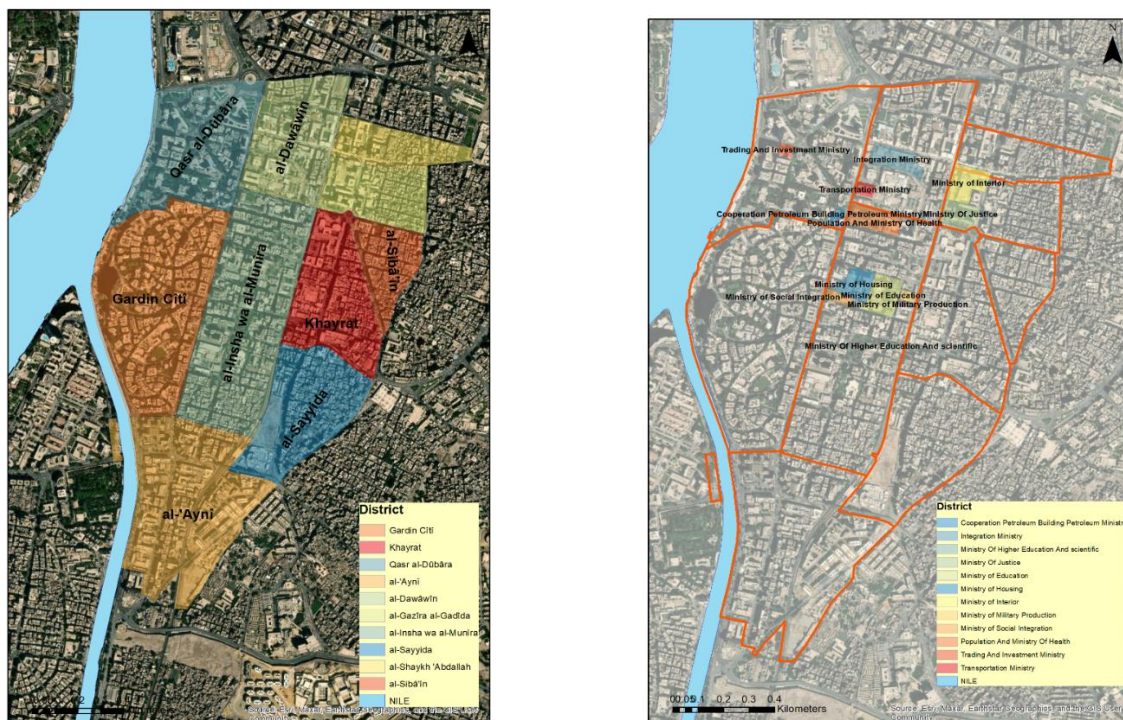


Fig. 2: The ten neighborhoods and the locations of ministries of the Ministry Square in downtown Cairo, by authors using Arc Map 10.5.



Fig. 3: The Ministry of Education and Technical Education and the Ministry of Housing Utility and Urban Communities in the Ministry Square in downtown Cairo, by authors.

2.2. Methodology for Evaluating Ministerial Building Reuse in Egypt for Sustainability

Adaptive reuse is increasingly recognized as a more sustainable alternative to new development; however, the decision-making process surrounding such projects is inherently complex [7]. This complexity arises from varying sustainability requirements and societal needs that differ significantly across contexts. To navigate these challenges effectively, it is essential to leverage the benefits of adaptive reuse [43]. Doing so not only enhances living conditions but also ensures the preservation of historical authenticity and alignment with sustainable development goals [16]. Recognizing the nuances of each project context allows stakeholders to implement strategies that balance modern demands with the preservation of cultural heritage [9]. This complexity necessitates a systematic approach that integrates geospatial analysis and Multi-Criteria Decision-Making (MCDM) techniques to evaluate reuse potential effectively. This study employs a structured methodology that incorporates GIS-based spatial analysis and multi-criteria evaluation to assess the feasibility of adaptive reuse for ministerial buildings in Cairo.

1. Geospatial Analysis Framework

A Geographic Information System (GIS) is employed to analyze the spatial characteristics of ministerial buildings and their surrounding urban environment. The process follows these steps:

- ❖ **Data Collection:** Spatial and non-spatial datasets were gathered from governmental sources such as the Ministry of Housing, the Ministry of Education and Technical Education, and other urban development authorities. Key datasets include:
 - Land use maps
 - Infrastructure networks (roads, public transport, utilities)
 - Historical and cultural significance
- ❖ **Spatial Mapping and Layer Integration:** Using ArcMap 10.5, thematic layers were created to visualize and analyze spatial relationships. The analysis includes:

- **Overlay Analysis:** Identifying optimal reuse opportunities by integrating land use compatibility, environmental factors, and urban policies.
- **Heat Mapping:** Highlighting underutilized or vacant spaces with high adaptive reuse potential.
- ❖ **Site Suitability Analysis:** A weighted overlay technique was applied to rank ministerial buildings based on their potential for adaptive reuse. Each factor was assigned a weight according to its significance in urban sustainability.

2. Multi-Criteria Decision-Making (MCDM) Model

To ensure an objective evaluation, a multi-criteria decision-making approach was used to prioritize reuse strategies. The methodology follows these steps:

- ❖ **Criteria Selection and Categorization:** An extensive literature review identified key evaluation criteria, categorized into five primary dimensions:
 - **Urban & Architectural:** Spatial efficiency, structural condition, and compliance with urban planning policies.
 - **Environmental:** Energy efficiency, material conservation, and integration of green infrastructure.
 - **Social & Cultural:** Historical significance, public accessibility, and community engagement.
 - **Economic:** Market viability, job creation, and revenue potential.
 - **Technological:** GIS-based spatial analysis, accessibility, and urban integration.
- ❖ **Weighting Criteria Using Analytical Hierarchy Process (AHP):**
 - AHP was employed to determine the relative importance of each criterion through a pairwise comparison matrix.
 - Experts in urban planning, architecture, and sustainability were consulted to assign weights based on their domain expertise.
- ❖ **Scoring and Ranking Alternatives:**
 - Each ministerial building was scored against the weighted criteria.
 - A composite score was computed for each site, indicating its overall suitability for adaptive reuse.
 - The top-ranking sites were further analyzed for specific reuse proposals.

This study proposes a structured methodology for evaluating the adaptive reuse potential of ministerial buildings in Cairo based on sustainable development principles. A multi-criteria approach integrating Geographic Information Systems (GIS) and Multi-Criteria Decision-Making (MCDM) was employed to assess the suitability of reuse strategies. Key criteria include urban context, cultural heritage, economic viability, environmental sustainability, and stakeholder needs. Findings highlight diverse reuse proposals, such as business and innovation centers, cultural hubs, mixed-use developments, and green spaces, aligning with Egypt's urban revitalization goals. This framework provides a data-driven approach to heritage preservation, economic growth, and sustainable urban transformation.

Based on the study conducted by the Ministry of Education and Technical Education, as well as the Ministry of Housing, Utilities, and Urban Communities, and the surrounding

land uses as illustrated in Figure 4, such as health, education, residential, administrative, foreign embassies, various ministries, and a limited number of cultural and recreational services, it is evident that the area lacks several uses in Figure 5 by using overlay analysis for the services and using heatmap for land use and density, that could significantly contribute to improving the quality of life, achieving sustainable development standards, and benefiting the local community and economy. Accordingly, the following adaptive reuse proposals for the ministry buildings can be suggested:

- **Innovation and Entrepreneurship Centers:** The buildings could be transformed into centers for innovation and entrepreneurship, especially to support youth and startups in fields like technology and creative industries. These centers could contribute to job creation and foster innovation.
- **Cultural Centers and Museums:** The buildings could be allocated for museums and cultural centers that showcase Egyptian history and cultural heritage or host art exhibitions and both permanent and temporary displays. This would encourage cultural tourism and help preserve the city's identity.
- **Hotels and Tourist Facilities:** Some buildings could be repurposed as hotels or tourist lodges to attract visitors, especially given their proximity to Cairo's tourist landmarks.
- **Research and Development Centers:** Some buildings could be utilized as research and development centers in fields such as health, science, and technology, including environmental and sustainable development research centers, thereby enhancing knowledge, and fostering researcher collaboration.
- **Commercial Centers:** The buildings, or parts of them, could be converted into shopping malls, restaurants, cafes, and various entertainment venues such as cinemas and theaters, generating economic returns.

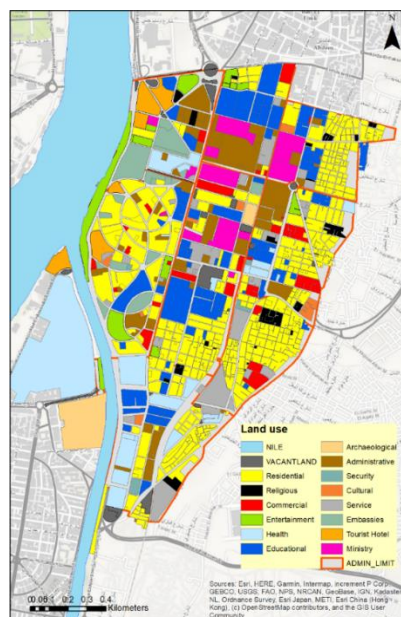


Fig. 4: The land use of the Ministry Square in downtown Cairo, by authors using ArcMap 10.5.

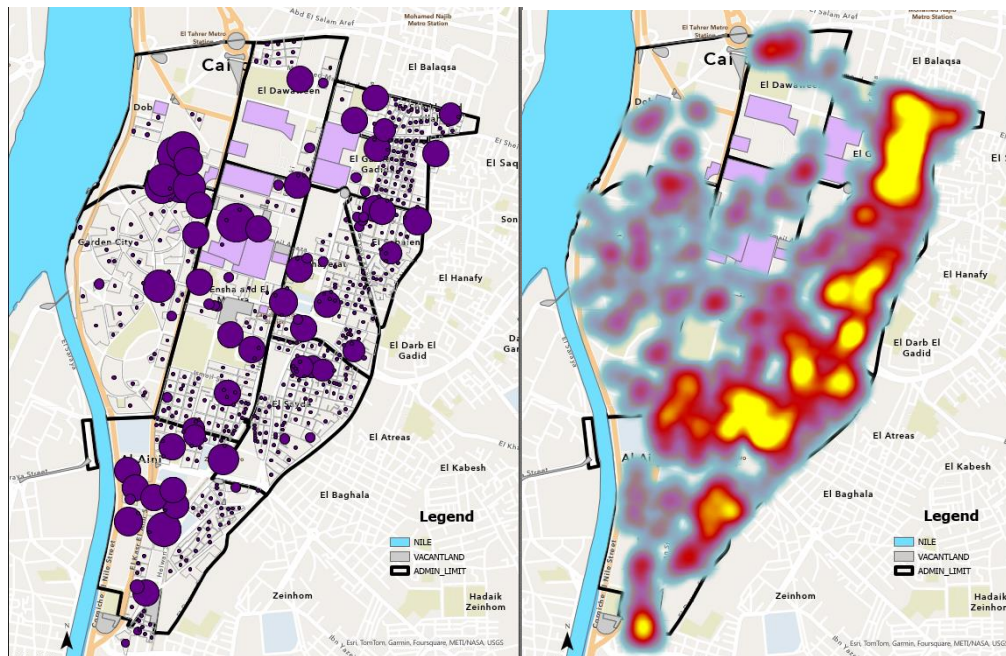


Fig. 5: The overlay analysis for the services and heatmap for land use and density of the Ministry Square in downtown Cairo, by authors using ArcMap 10.5.

To establish a robust framework for adaptive reuse, a comprehensive set of criteria has been identified through an in-depth review of existing literature on the subject. This systematic literature review employed a targeted selection of keywords, including adaptive reuse, successful standards, sustainable development, and decision-making. An analytical review was conducted to pinpoint effective criteria for adaptive reuse, leading to a multi-criteria assessment categorized under four primary dimensions: economic, technological, environmental, and social. Some studies further expanded the evaluation criteria into five distinct areas: architecture, economics, environmental considerations, legislative factors, and social implications. The methodology relied on:

1. **Site Visits and Direct Observations:** The selected ministerial buildings were examined to assess their current condition, spatial configuration, and relationship with the surrounding urban context.
2. **GIS and Spatial Analysis:** Mapping analysis was utilized to evaluate urban connectivity, land use, and accessibility, providing quantitative data to support reuse decisions.

By incorporating these criteria into the decision-making process shown as Table no.3, stakeholders can develop more informed and sustainable approaches to the adaptive reuse of heritage buildings.

Table 3: The evaluation criteria for adaptive reuse: Source: [30], [41], [15], and by authors

Primary dimensions	Secondary dimensions
Urban and Architecture	Strategic Map Model (SMM): integrate spatial data, urban zoning, and sustainability goals into decision-making.
	Compliance with Regional Development Policies: Ensure the reuse aligns with local and national development plans.
	Evaluation of Spatial Efficiency: Assess how effectively the space can be utilized post-reuse.
	Structural Condition: Assess the integrity and historical value of buildings to identify reuse potential without extensive renovations.
	Availability of Technical Support Information: Ensure the presence of necessary technical resources for the assessment.
Environmental	Material Consumption and Recycling: Promote the reuse of existing materials and effective recycling strategies.
	Green Infrastructure: Encourage the integration of green roofs and sustainable drainage systems.
	Energy Efficiency: Evaluate the potential for retrofitting to reduce energy consumption.
Social	Historical and Cultural Value: Preserve the heritage of buildings to maintain the community's cultural identity.
	Accessibility: Ensure the site is inclusive and accessible for all demographic groups.
	Public Awareness and Sense of Place: Gauge community sentiment and attachment to the reused buildings.
	Key Performance Indicators (KPIs): Set KPIs related to sustainability goals, community satisfaction, and financial performance.
	Consultation with Government and Planners: Collaborate with urban planners, architects, and government officials to ensure alignment with local development goals
	Community Participation: Engage local communities to assess their needs and preferences and involve the community in the design process to strengthen projects.
Economic	Market Potential: Assess demand for the use of spaces and the potential for income generation from businesses.
	Diverse Commercial Activities: Identify different activities that can sustain the project financially.
	Cost-Effectiveness: Compare the costs of repurposing versus demolishing and rebuilding.
Primary dimensions	Revenue Generation: Analyze the potential for long-term income streams through mixed-use developments.
	Jobs: The number of jobs created by the new use which contributes to the local and national economies.
Technological	Geospatial Analysis: Use Geographic Information Systems (GIS) to map ministerial buildings, infrastructure, and surrounding land uses.
	Location, Accessibility, and Integration: Evaluate how the buildings integrate with surrounding urban landscapes and access to public services.
	Environmental Features: Analyze proximity to green spaces and ecological benefits.

This methodology for evaluating the reuse of ministerial buildings in Egypt combines data-driven decision-making, sustainability assessments, and stakeholder engagement. By

utilizing tools such as the Strategic Map Model (SMM) and focusing on economic, social, and environmental sustainability, reuse projects can significantly contribute to the country's sustainable urban development agenda. Based on the proposed uses and criteria for adaptive reuse evaluation that align with the region's needs while considering economic and social aspects and achieving sustainability standards, the following proposals have been made:

- **Ministry of Education and Technical Education Building:** Based on a study of surrounding land uses, this building could be adaptively reused as a center for scientific and health research and conferences, aligning with its status as a historic structure. This repurposing would serve Kasr Al-Ainy Medical School, Kasr Al-Ainy Hospital, and the Cancer Institute, in addition to supporting other research activities.
- **The General Organization for Physical Planning Building (affiliated with the Ministry of Housing):** Although this building is not listed as a historical monument in the records of the Ministry of Tourism and Antiquities, it may possess architectural or historical value that qualifies it as a heritage asset under the **National Organization for Urban Harmony**. It could be reused to support projects aimed at enhancing urban heritage and advancing urban planning development.
- **Ministry of Housing Utility and Urban Communities Building:** This building could be adaptively reused as follows:
 - ✓ **Ground floors:** Converted into commercial malls featuring restaurants, cafes, cinemas, and theaters.
 - ✓ **Middle floors:** Allocated for startups to promote entrepreneurship.
 - ✓ **Upper floors:** Utilized as tourist hotels to support the tourism sector.

The primary goal of these proposals is to optimize the use of these buildings while promoting sustainable development and preserving their unique cultural and architectural character.

3. Results and Discussion

Adaptive reuse projects for ministerial buildings in Egypt present a valuable opportunity to promote sustainable development by integrating economic, social, and environmental objectives. These initiatives reduce the need for new construction, minimizing resource consumption and environmental impact. Their success lies in aligning new uses with local community needs, requiring thorough assessments of societal demands, and building conditions. Effective adaptive reuse depends on well-defined criteria, encompassing economic factors such as job creation and revenue generation, social elements like heritage preservation and community engagement, and environmental aspects including energy efficiency and material reuse. Furthermore, these projects safeguard the cultural and architectural value of historic buildings while repurposing them for modern functions, as seen in proposals to transform the Ministry of Housing Utility and Urban Communities into a commercial hub that simultaneously supports economic activity and cultural preservation. Advanced tools like geospatial analysis and Strategic Map Models (SMM) enable the seamless integration of reused buildings into urban landscapes, ensuring alignment with

broader sustainability goals. Engaging local communities in planning and execution fosters a sense of ownership, enhances project acceptance, and guarantees long-term viability. The selected ministerial buildings are evaluated through a set of criteria covering five distinct areas: architecture, economics, environmental considerations, legislative factors, and social implications. They are analyzed and evaluated as follows:

- **Ministry of Education and Technical Education Building**

- ✓ **Architectural:** The building has high structural integrity and significant historical and cultural value, making it suitable for adaptive reuse. It is strategically located and integrates well with the surrounding urban fabric.
- ✓ **Economic:** While the building may not show immediate market potential, its reuse can support job creation and generate reasonable financial returns through the development of educational and research activities.
- ✓ **Environmental:** The use of recycled building materials is supported, with the potential to develop green infrastructure such as green roofs. It also allows for energy efficiency improvements through environmental retrofitting.
- ✓ **Legislative:** It aligns with regional development policies and requires the provision of additional technical data to support reuse decisions.
- ✓ **Social:** It contributes to enhancing cultural identity through heritage preservation and supports community involvement in planning processes to meet local needs.

- **General Organization for Physical Planning Building**

- ✓ **Architectural:** The building has acceptable architectural value, with the need for a comprehensive structural assessment. It can be utilized to support urban and heritage-related activities.
- ✓ **Economic:** It provides potential for economic returns through the development of new uses that align with urban planning, with moderate opportunities for job creation.
- ✓ **Environmental:** The integration of green infrastructure systems and recycling technologies is supported, along with energy efficiency improvements.
- ✓ **Legislative:** It aligns with regional policies and requires careful planning to ensure compliance with heritage building regulations.
- ✓ **Social:** It strengthens community ties through innovative uses that support a sense of place, encouraging interaction with the public and planners.

- **Ministry of Housing Utility and Urban Communities Building**

- ✓ **Architectural:** The building has good structural integrity and a strategic location that supports integration with its urban surroundings, making it suitable for mixed-use development.
- ✓ **Economic:** It is the most economically viable, offering significant market potential to host diverse commercial activities and tourist hotels, supporting long-term financial sustainability.
- ✓ **Environmental:** It supports the reuse of existing materials and the creation of environmentally friendly infrastructure, with significant potential for improving energy efficiency.

- ✓ **Legislative:** It aligns with national development plans and requires adherence to regulations related to heritage preservation.
- ✓ **Social:** It promotes community participation and ensures the preservation of the building's cultural value, balancing the needs of local residents with development goals.

Table 4: The evaluated criteria of buildings by five distinct areas: Source: by authors

The building	The evaluated criteria by five distinct areas	
Ministry of Education and Technical Education Building	Architectural	High structural integrity, cultural value, and strategic location make the building ideal for adaptive reuse.
	Economic	While lacking direct market potential, the building's reuse supports job creation and educational development returns.
	Environmental	Encourages recycled materials, green infrastructure like roofs, and energy efficiency through eco-renovation enhancements.
	Legislative	Aligns with policies but needs technical data for reuse decisions.
	Social	Preserves cultural identity through heritage conservation and fosters community participation to address local needs.
The General Organization for Physical Planning Building	Architectural	Preserves cultural identity and supports community participation in planning.
	Economic	Offers economic returns through new uses aligned with urban planning and job creation.
	Environmental	Supports green infrastructure, recycling, and energy efficiency improvements.
	Legislative	Complies with regional policies, requiring careful planning for heritage regulations.
	Social	Strengthens community ties through innovative uses, fostering interaction between public and planners.
Ministry of Housing Utility and Urban Communities Building	Architectural	The building has strong integrity and a strategic location for mixed-use development.
	Economic	Economically viable, with market potential for commercial activities and tourism sustainability.
	Environmental	Encourages material reuse, eco-friendly infrastructure, and significant energy efficiency improvements.
	Legislative	Aligns with development plans, requiring adherence to heritage preservation regulations.
	Social	Promotes community engagement, preserving cultural value and balancing local needs with development.

The analysis of the selected ministry buildings—Ministry of Education, General Organization for Urban Planning, and Ministry of Housing—reveals unique opportunities for adaptive reuse based on their architectural, economic, environmental, legislative, and social characteristics, as shown as Table no.4. The Ministry of Education building stands out for its high structural integrity, historical value, and potential to enhance cultural identity and community participation through educational and research activities. The General Organization for Urban Planning building offers moderate architectural value and economic potential, with opportunities for urban planning-related uses that foster community ties and

energy efficiency. The Ministry of Housing Utility and Urban Communities building emerges as the most economically viable option, with its strong structural integrity, strategic location, and potential to support mixed-use activities, including commercial and hospitality functions, while promoting environmental sustainability. Together, these buildings represent valuable assets for sustainable development and heritage preservation strategies.

The analysis of the ministry buildings using extended criteria highlights that each building has unique features and opportunities for adaptive reuse. These buildings can play a significant role in a comprehensive strategy that supports sustainable development and heritage preservation. By integrating these criteria into the decision-making process, stakeholders can develop more informed and sustainable approaches to the adaptive reuse of buildings, as shown in the following Table no.5:

Table 5: The evaluated criteria of buildings by five dimensions: Source: by authors

Major Groups	Evaluation criteria	The buildings		
Urban and Architecture	Strategic Map Model (SMM)	—	—	—
	Compliance with Regional Development Policies	✓	✓	✓
	Evaluation of Spatial Efficiency	✓	✓	—
	Structural Condition:	✓	—	✓
	Availability of Technical Support Information	—	—	—
Environmental	Material Consumption and Recycling	✓	✓	✓
	Green Infrastructure	✓	✓	✓
	Energy Efficiency	✓	✓	✓
Social	Historical and Cultural Value	✓	✓	✓
	Accessibility	✓	✓	✓
	Public Awareness and Sense of Place	✓	✓	✓
	Key Performance Indicators (KPIs)	✓	✓	✓
	Consultation with Government and Planners	✓	✓	✓
	Community Participation	✓	✓	✓
Economic	Market Potential	—	—	✓
	Diverse Commercial Activities	—	—	✓
	Cost-Effectiveness	✓	✓	✓
	Revenue Generation	✓	✓	✓
	Jobs	✓	✓	✓
Technological	Geospatial Analysis	✓	✓	✓
	Location, Accessibility, and Integration	✓	✓	✓
	Environmental Features	✓	✓	✓

The adaptive reuse evaluation of key ministry buildings highlights their alignment with sustainability and regional development goals. The Ministry of Education and Technical Education building demonstrates strong spatial efficiency, structural integrity, and cultural significance, with a focus on material recycling, green infrastructure, and energy efficiency. It shows potential for job creation and revenue generation, though its market potential is limited. Community engagement and geospatial analysis confirm its integration within the urban landscape. The General Organization for Physical Planning building complies with regional policies and incorporates sustainable practices like green infrastructure and energy efficiency, but its structural condition requires further assessment. While it has moderate economic potential, its historical and cultural value adds to its redevelopment appeal. The Ministry of Housing Utility and Urban Communities building stands out for its robust economic viability, offering opportunities for mixed-use developments and diverse commercial activities. It is well-preserved structurally and historically, making it a prime candidate for adaptive reuse with a focus on sustainability and community engagement. Geospatial analysis supports its strategic location and integration with the surrounding urban environment.

However, challenges such as legal and administrative barriers, high restoration costs, and the need to maintain historical accuracy require attention. Despite these hurdles, adaptive reuse creates significant opportunities, including job creation, tourism enhancement, and improved urban quality of life. To maximize these benefits, it is essential to adopt strategic frameworks like SMM to guide projects while aligning them with national development plans. Collaboration among government bodies, private sectors, and civil society is critical for securing financial and technical support. Community participation in decision-making ensures that projects meet local needs and preferences, while infrastructure modernization through green technologies enhances sustainability. Policy reforms are also necessary to facilitate smoother implementation and safeguard heritage values. Establishing key performance indicators (KPIs) allows for the measurement of success in terms of economic impact, community satisfaction, and environmental outcomes. Finally, documenting and replicating successful reuse models ensures their application across other heritage buildings in Egypt.

Finally, adaptive reuse of ministerial buildings in Egypt provides a strategic approach to sustainable urban development. By balancing economic, environmental, and cultural objectives and incorporating modern technologies and stakeholder engagement, these projects can significantly contribute to preserving Egypt's heritage while fostering urban revitalization.

4. Conclusions

The adaptive reuse of ministerial buildings in Egypt presents a strategic opportunity for sustainable urban development, balancing heritage conservation, economic growth, and environmental responsibility. This study has demonstrated that repurposing buildings such as the Ministry of Education, General Organization for Physical Planning, and Ministry of

Housing Utility and Urban Communities can address critical urban challenges, including inefficient land use, overcrowding, and the need for modernized infrastructure. By integrating new functions while preserving historical significance, adaptive reuse can enhance urban livability, stimulate economic activity, and contribute to a more sustainable built environment. However, the success of such projects depends on regulatory flexibility, financial incentives, and strategic planning frameworks to ensure their feasibility and long-term impact.

The analysis of the Ministry of Education building reveals its strong potential for conversion into a scientific research and conference center, leveraging its proximity to key educational and medical institutions. Its transformation would foster knowledge exchange, academic collaboration, and innovation, benefiting both the local and national research landscape. The General Organization for Physical Planning building, though not officially classified as a heritage site, possesses significant architectural and historical value, making it well-suited for an urban heritage and planning center. This reuse would not only preserve its unique character but also support research and policy initiatives related to urban development and cultural conservation. Meanwhile, the Ministry of Housing Utility and Urban Communities building has the highest economic potential, with its prime location and structural adaptability making it ideal for a mixed-use commercial and hospitality hub. Such a transformation would attract investment, create jobs, and enhance the city's urban fabric.

Despite these promising prospects, several challenges must be addressed to facilitate adaptive reuse. Regulatory barriers, high restoration costs, and the need to balance heritage conservation with modern functional requirements present obstacles that require coordinated efforts from policymakers, urban planners, and investors. Amending Law No. 117 of 1983 to allow greater flexibility in reusing historic buildings, particularly for mixed-use and commercial purposes, is a crucial step. Additionally, financial incentives such as tax breaks, grants, and public-private partnerships can help mitigate the economic burden of restoration and encourage investment in adaptive reuse projects. Moreover, incorporating GIS-based decision-making and multi-criteria evaluation models can enhance site selection and project planning, ensuring that reuse initiatives align with broader sustainability and urban development objectives.

In conclusion, the study reinforces adaptive reuse as a transformative strategy for Egypt's ministerial buildings, offering a practical solution to urban challenges while preserving architectural heritage. By adopting progressive policy reforms, strategic financial mechanisms, and interdisciplinary collaboration, Egypt can maximize the potential of its historic structures, turning them into dynamic, sustainable urban assets. This approach not only aligns with global sustainability goals but also sets a precedent for other cities facing similar heritage conservation and urban revitalization challenges.

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إعادة استخدام المباني الوزارية فى مصر لتحقيق التنمية العمرانية المستدامة

إعادة الاستخدام التكيفي هي استراتيجية مستدامة تهدف إلى إعادة توظيف المباني القائمة لتقليل التأثير البيئي، والحفاظ على التراث الثقافي، ودعم التجديد الحضري. تهدف هذه الدراسة إلى تقييم إمكانية إعادة الاستخدام التكيفي لبعض المباني الوزارية الرئيسية في القاهرة بعد نقل المكاتب الحكومية إلى العاصمة الإدارية الجديدة. تم استخدام نهج صنع القرار متعدد المعايير (MCDM) المدمج مع أنظمة المعلومات الجغرافية (GIS) لتقييم مدى ملاءمة استراتيجيات إعادة الاستخدام بناءً على خمسة أبعاد: السلامة المعمارية، الجدوى الاقتصادية، الاستدامة البيئية، الاعتبارات التشريعية، والتأثير الاجتماعي. اعتمدت المنهجية على التحليل المكاني، الزيارات الميدانية، بالإضافة إلى استخدام تحليل التراكب والخرائط الحرارية لتحديد الفرص المثلى لإعادة الاستخدام. أظهرت النتائج إمكانية إعادة توظيف هذه المباني لتصبح مراكز ابتكار، مراكز ثقافية، منشآت بحثية، فنادق، ومشاريع متعددة الاستخدامات، مما يساهم في التنمية الحضرية المستدامة للقاهرة. حيث تبين أن مبنى وزارة التربية والتعليم مناسب ليكون مركزاً للأبحاث العلمية والطبية، بينما يمكن توظيف مبنى الهيئة العامة للتخطيط العمراني لدعم مشاريع التراث الحضري والتخطيط العمراني، في حين أن مبنى وزارة الإسكان يتمتع بإمكانات اقتصادية عالية تجعله مناسباً لإنشاء مرافق تجارية وريادية وفندقية. تؤكد الدراسة على أهمية البنية التحتية الخضراء، التعديلات الموفرة للطاقة، والإصلاحات التشريعية لدعم عمليات إعادة الاستخدام التكيفي. ومن خلال تحليل البيانات المكانية وتقييمات الاستدامة، يمكن تحويل الأصول الحكومية غير المستغلة إلى مساحات اقتصادية قابلة للحياة، ومستدامة بيئياً، وذات أهمية ثقافية، بما يعزز أجندة التنمية الحضرية في مصر.

كلمات مفتاحية: إعادة الاستخدام التكيفي، المباني الوزارية، التنمية العمرانية المستدامة.