Framing the parameters of 'Sustainability' in Adaptive Re-use of buildings & analyzing the case of Gayer Anderson Museum at Cairo, Egypt

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Abstract

Demolishing an existing building and constructing a new one leads to the consumption of high amounts of energy, raw material and other resources while producing construction debris and emissions which contribute to environmental pollution and global warming. These aforementioned consequences can be minimized significantly by the adaptive reuse of existing buildings, which requires significantly lesser amount of energy, monetary resources and materials to adapt the building for a new use as compared to the demolition of the existing building and construction of a new one.

In order to achieve its purpose, adaptive reuse must be done in a sensitive, and systematic way while following the key principles of sustainability. This paper aims to frame the parameters to be considered in the sustainable adaptive reuse process and compile all the factors to be assessed in any such project. Finally, the listed aspects are discussed in an existing case of Gayer Anderson Museum at Cairo, Egypt to demonstrate the effectiveness of the compiled parameters of sustainability to assess any reused building.

Keywords: *Adaptive Re-use, Building retrofit, Sustainability parameters, Feasibility study.*

1. Introduction

Adaptive reuse in architecture is the process of redesigning the programming of a building and its site to use it for a 'new' purpose, other than for what it was originally designed. Adaptive reuse done is to prolong the cradle-to-grave period of a building by retaining all or most of the structural system and as much as possible [1]. The other non-structural elements, if not retained in their original location can be re-used within the site after appropriate modifications. Adaptive reuse, according to Burchell and Listokin (1981), is defined as a "revitalization strategy which employs a series of linked procedures to plan for, inventory, acquire, manage and reuse surplus or abandoned real estate. If a building which had a previous use that is no longer suitable in that type of building or location, then the potential value of the property will be maximized by adapting the space" [2].

This Adaptive Reuse Manual published by the Long Beach Development Services, which was drafted in accordance with the 2013 California Building Standard Codes, gives an overview of the necessities of Adaptive Reuse of buildings. According to the manual, the energy required to create any new spaces, the material waste generated from the demolished structures, and the use of new virgin building materials are all

reduced considerably by re-using existing buildings. The costs associated with new construction are reduced and an opportunity of economic development is generated with new housing and employment prospects. The revitalization of buildings leads to the stabilization of otherwise deteriorating neighborhoods and communities. The city's essential identity through historic character and architecture is preserved and incorporated in the newer developmental schemes. Overall, the community profits from the additional virtues of context, culture, history, and ambiance resulting in sustainable community redevelopment [3].

1.1 Principles of Adaptive Reuse

The principles of adaptive reuse [4] state that the process should be adopted in such a way that the buildings are:

i. Functional. They must be able to perform the functions efficiently for which they are redesigned.

ii. Durable & Flexible. They must be long lasting and adaptable to new uses.

iii. Contextual. They must be able to interact with their surroundings and enhance their context

iv. Aesthetic. They must be having visual coherence and aesthetic appeal.

v. Sustainable. The methods adopted must be non-polluting, energy efficient and have a minimal environmental impact.

1.2 Sustainable Benefits of Adaptive Reuse

Sustainability is an umbrella term which encompasses a tri-faceted approach towards an equitable future- namely Environment, Economy and Society. A balance between the three criteria makes any aspect sustainable. The benefits of preserving and re-programming old buildings under the three main sustainable criteria are listed below. [5][6][7][8]

1.2.1 Environmental Benefits

i. reuse and recycling of the existing materials and structure reduces the amount of waste entering landfills

ii. older buildings are often constructed with materials of a higher grade and quality and therefore have a longer lifespan

iii. use of the existing public infrastructure reduces the pressure on municipalities and reduces urban sprawl

iv. selection of appropriate materials and technologies lead to achieving energy efficiency

1.2.2 Economic Benefits

i. municipality benefits from the increased property tax that the developed site creates as compared to a vacant site

ii. municipality doesn't require to extend public infrastructure services to the site as it is already existing

iii. for the developer: lower construction costs as compared to new building projects

iv. developers have less legal constraints in re-use projects

1.2.3 Social Benefits

i. retains the character of an area and the locational context
ii. create a diverse community through varying building types and ages
iii. reduces the crime rate and other antisocial behavior associated with unsupervised dilapidated and abandoned sites
iv. revitalization of the surrounding neighborhood is accomplished.

2. Framing the parameters of 'Sustainability' in Adaptive Re-use

In order to make any project sustainable, the three components of sustainability suggested by the United Nations General Assembly in 2005 [9], namely: Economic, Social & Environmental aspects must be satisfied. In the case of re-use of a building too, the analysis of the three aspects is essential to ensure that the process is leading to the creation of a sustainable project. The three broad categories can be fulfilled by scrutinizing the following criteria: Economic Feasibility under the economic aspect, Legislative Adherence & Locational Analysis under the social aspect and Environmental & Architectural criteria for addressing the environmental aspects. Fig.1 further illustrates the five criteria.

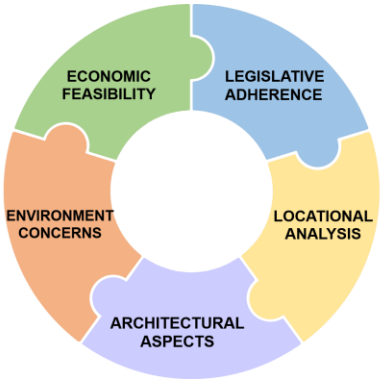

Figure 1. Criteria for Sustainability Assessment of Buildings to be Re-used

An overview of the assessment points under each of the headings is listed in Fig.2.

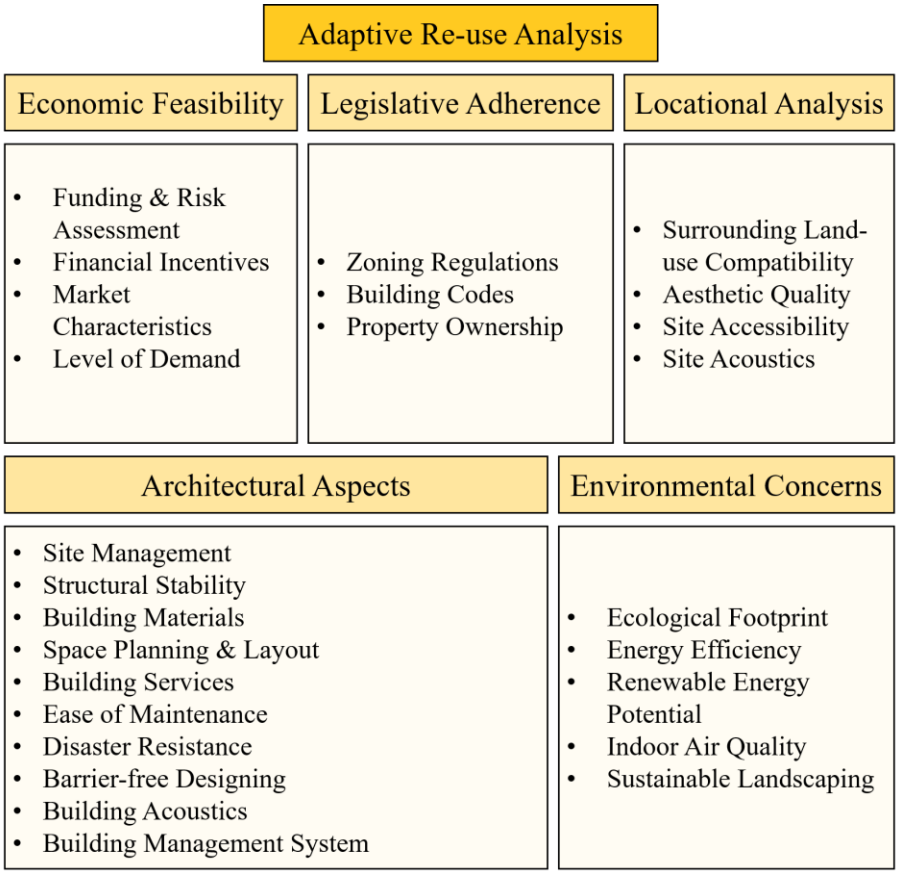

Figure 2. Overview of Assessment points for Sustainable Adaptive Re-use

2.1 Economic Feasibility

The financial feasibility of reusing a building can be complex, considering the variability of the elements of an existing structure. The value of the land for its highest and best use, less the demolition and construction costs of existing buildings and new buildings respectively, must be lower than the value of the land with its existing buildings, less the costs of adaptive reuse, for a project to be considered financially feasible for conversion instead of new construction. Typical to adaptive reuse projects, there may still be issues that materialize throughout the construction period and therefore it is vital that appropriate assessments have been completed to reduce the costs that could appear further along in the project timeline. [10]

2.1.1 Funding & Risk Assessment

Obtaining financing for the projects is crucial. Typically, there are three types of financing options for developments: private, public and public/private partnerships. The scale of the project determines the amount of financing that is required. The level of financing from banks and finance/investment companies depends on the risk of the proposed project. Greater the level of uncertainty in the project, the higher the risk of the project and financing will become more difficult to obtain.

2.1.2 Financial Incentives

Incentives through various government agencies can be obtained depending on the nature of the project to fund a portion of the estimated costs of the heritage restoration work. The tax rebate program provides designated heritage properties and brownfield sites with property tax rebate on the property that contains the heritage building.

2.1.3 Market Characteristics

Before a project is completed, the fast-moving markets can change the demand. Understanding the current and future market requires expertise in the field through consultation with real estate appraisers and solid knowledge of the historical background of the area in which a development is to occur. The market demand for adaptive reuse projects is similar to that of new developments and what needs to be considered are the level of demand, target market and building location. Through the completion of a demographic study and first-person observations, much can be learned about a neighborhood, including the population, social aspects and travel behaviors. The results of a demographic study can be utilized to determine if a certain location will be able to accommodate the development plans and, if so, to finalize the details of the plan to match the desired needs of the market.

2.1.4 Level of Demand

The demand in the market for the type of proposed development should be estimated by the developer and should determine how much of the demand can be captured by a specific project. Similar to new construction projects, if the demand is not present for the proposed development, either the project must be postponed or redesigned to adapt to the present needs of the market. The population percentage of the area which might benefit from the project, and the subsequent profits due to them is crucial.

2.2 Locational Analysis

The capability of the developer to understand the local environment and how it changes over time can be a great benefit in determining the best location for development. The considerations related to the location of adaptive reuse projects are the same for those of a new building construction, including quality of the environment, safety and security, surrounding land uses, views, accessibility to services and transportation, and convenience of personal vehicle parking. With a limitation on the availability of potential adaptive reuse sites, the factors relating to the location become crucial as the design for the building is unique and cannot be transferred to another site. [10]

2.2.1 Surrounding Land Uses and Compatibility

The location advantage of old buildings is that they may be situated in the heart of established and highly desirable neighbourhoods with the advantage of utilizing the amenities and services such as public transportation, retail, and community facilities. This aspect is a strong marketing tool that the developers can use to attract potential tenants to their development. A building developed in an existing neighbourhood has the possibility of creating a live/work situation. Additionally, the adaptive reuse of a building could be a catalyst for the renewal of a neighbourhood if located in a neglected area.

2.2.2 Quality of the View

The view from within a building to the outside is highly valued by some people who are willing to pay a higher amount for a space with a better view.

2.2.3 Site Accessibility

A difficulty that some buildings may possess is their inaccessibility and awkwardly located entrances. These can create complications for the developer in planning and completion of the construction. The location in which the building is situated on the site can create issues. Although the building may physically be ideal for adaptive reuse, the configuration may not allow it to occur and a complete renewal of the site may be a more appropriate option.

2.2.4 Site Acoustics

The surrounding land uses may create high levels of sound which makes it difficult to carry out the functions of the proposed re-use. High sound vibrations also affect the structural strength of old structures.

2.3 Legislative Adherence

The municipal, provincial, and federal governments along with agencies, boards, councils, and commissions within these levels of government, both individually and collectively, have control over and/or regulate the use of land and the buildings situated on them. Through means such as Zoning By-Laws, Building Codes, Heritage/Conservation guidelines and property laws, the reuse of buildings is controlled as well as encouraged.

2.3.1 Zoning Regulations

Zoning By-Laws guide the growth and development of spaces. They can be restrictive with regard to adaptive reuse projects, where it can conflict with the existing land uses as well as specifying standards for things like building height, setbacks, parking, density, and open space. A variance or amendment may be required in order to deviate from those standards or to change a designated land use from existing to an alternate desired use.

2.3.2 Building Codes

The building itself is regulated through the local regulations, ensuring a standard level of safety for the occupants of the buildings. Regulatory agencies set minimum requirements that must be met and do not distinguish between new construction or reuse. In many instances, the buildings were constructed before the current Building Code was enacted and therefore are not in full conformity with the current Code.

2.3.3 Property Ownership

Existing buildings sometimes demonstrate complicated issues such as disputes over property line, lease duration extensions and ownership issues that have to be addressed prior to permitting any new project.

2.4 Architectural Aspects

A building's specific physical conditions such as size, construction material, structural integrity, and space layout are elements that form a solid foundation for a project's design. A developer, along with a professional team of engineers and architects, will look at these physical elements to ensure a project can be adapted for an alternate use while still remaining profitable given the existing conditions.

2.4.1 Site Management Aspects

Utility connections, demolition, paving, and grading form the basis for site work and are elements for which the cost can range significantly and therefore must not be overlooked during the assessment of the building and site. As the prior use may not have required all utility connections it should be ensured that it is feasible to extend the required water, sewage, electricity, or gas lines to the development. If the required connections are present, it must also be ensured that the capacity of the existing utilities is adequate for the potential increased demands that may be required by the development as it may be the financial responsibility of the developer to increase the capacity of the utilities.

If demolition is required, the task of disposing of or recycling the unusable debris will be necessary, lengthening the timeline of the project. Some items may be recovered from

the existing structure prior to demolition such as historic fittings, fixtures, and finishes and may be incorporated into the new development giving character and a link to the previous use of the building. If a building is on the heritage protection list there may be specific requirements to be abided by that limit or specify the construction and/or demolition of the building.

The provision for onsite parking may already be available from the existing use if it can be incorporated into the design and remain intact during the construction period. Paving a portion of the site for parking purposes may be required if there are not enough existing spaces, unless the parking requirements can be satisfied by economically and physically viable underground parking. Where paving is required, site grading must occur to allow for proper site.

2.4.2 Structural Conditions

The construction type is typically a reflection of the time period during which the building was constructed. A detailed assessment will determine if the existing structure is capable of handling the loads resulting from the future use and that the construction meets the present Building Code standards. Foundation and load transfer elements need to be examined for strength.

2.4.3 Materials

Building materials contribute to the structural strength, embodied energy and operational energy (through thermal performance) of any building. They must be assessed in detail for optimizing design decisions during retrofitting or re-use.

2.4.4 Building Plan and Space Layout

The flexibility of the space within the building, and the ease with which it can adapt to alternate uses, can be attractive to developers. The range in the types of tenants that can be accommodated also increases with flexible open space concept buildings, broadening the market for leasing opportunities.

2.4.5 Building Services

An analysis of the building's systems for functional and aesthetic purposes can assist in determining the suitability of the building for its intended use. The buildings consist of structural, electrical, mechanical, and plumbing elements which are all interconnected and vital for any building's operation. The evaluation is done through on-site inspections and review of original drawings and documents where available.

The electrical, mechanical and plumbing systems are similar in that they may still be functional at the time of inspection but not adequate for the new development in terms of being able to handle the required loads. Unlike the structural system, it may be economically viable to replace any or all of these systems in their entirety during construction, providing a higher level of assurance that the systems will function properly and efficiently during the remaining lifespan.

2.4.6 Ease of Maintenance

Elaborate techniques undertaken in order to adaptively re-use a building may be rendered worthless if the maintenance of the systems & technologies become tedious for the owners and managers. Methods of re-use should be chosen such that they are easy to monitor and maintain.

2.4.7 Disaster Resistance (Fire/Cyclone/Earthquake)

After considering all social, economic, architectural, legal parameters, if the considerations for disaster resistance is neglected, then the building can collapse or get damaged within minutes if some disaster strikes. The building and site must be assessed for disaster vulnerability and designed accordingly. Identifying the disaster zones the site lies in, previous history of disasters in detail- magnitude, frequency, patterns, damaged incurred, etc. must be analyzed in detail.

2.4.8 Barrier-Free Design

Barrier-free design considerations have been made mandatory in new constructions in all building by-laws. The old structure might have been constructed before these by-laws were made mandatorily applicable. The re-use of such structures must ensure that the building is accessible to all.

2.4.9 Building Acoustics

New uses of old spaces might lead to unwanted sound vibrations and subsequent disruption of activities and productivity. The functional aspects must be considered and managed keeping in mind the decibel levels of activities or machinery.

2.4.10 Building Management System

BMS helps in regular monitoring and controlling of all systems within the building and site. Switching on/off of systems, controlling the levels (like dimming systems that regulate lux levels/ regulating the air-flow in AC ducts, etc.), security systems (surveillance cameras, biometric access doors, etc.) contribute towards the management of the entire building and its systems for greater functional efficiency.

2.5 Environmental Concerns

2.5.1 Ecological Footprint

Ecological Footprint is the amount of land required to sustain a system. It is essential to know how far the sources of food; energy & raw materials are. Local sources are more sustainable. Any building undergoing adaptive re-use must not rely on materials or technologies sourced from remote locations.

2.5.2 Energy Efficiency (Lighting/Ventilation/ Heat Gains and Losses)

Any building being considered for adaptive reuse must be assessed for energy efficiency. To preserve the local historical sentiments, the quantity of energy consumed must be justified. Various methods can be adopted to optimize the energy used for lighting, ventilation & other purposes.

2.5.3 Renewable Energy Potential

Renewable energy options that can offset the purchase of fossil fuel-based energy must be investigated. Wind and Solar Power harnessing have been researched upon extensively and there are various products available in the market for the same.

2.5.4 Indoor Air Quality

IAQ is directly linked to the heath, comfort and productivity of occupants. Old buildings tend to have issues like growth of molds on walls/ceilings, moisture seepage, low oxygen levels, etc which lead to Sick Building Syndrome and Building Related Illnesses. These can be overcome by regular maintenance of surfaces, waterproofing and providing adequate ventilation, etc. The interior paints, adhesives and finishes are to be carefully chosen for low-VOC (Volatile Organic Compounds) and low ODP (Ozone Depleting Potential) options.

2.5.5 Energy Efficient Landscaping

Choice of landscaping options and species of vegetation affect the water usage of the site. Usually, the choice of native species is beneficial for less usage of water for gardening and maintenance of vegetation. They are the lung spaces of the site and are essential in ventilation and overall air-quality. Shading of buildings in hot climates & solar gains in cold climates can be designed efficiently with the help of efficient landscaping.

3. Analysis of the Adaptive Re-use of Gayer Anderson Museum at Cairo, Egypt

The Gayer Anderson Museum or Bayt al – Kritiliya was a residence in Cairo, Egypt which was commissioned to be reused as a Museum by the Egyptian Ministry of Public Instruction. The restoration was done in a phase wise manner in order to ensure that restoration was done in a sensitive way. The project aimed at preserving the house and its diverse collections as well as its unique setting – having two houses linked together [11].

Figure 3. Photograph of The Gayer Anderson Museum

3.1 Legislative Adherence

3.1.1 Property ownership

The house was initially under the ownership of Gayer Anderson (after whom the museum is named). When he left Egypt, owing to ill health, the house along with its contents were entrusted to the Government of Egypt. The Egyptian Ministry of Public Instruction converted this great collection – owning house to what currently is called "The Gayer Anderson Museum" under the supervision of Sector of Islamic and Coptic Antiquities, Supreme Council of Antiquities (SCA), Egyptian Ministry of Antiquities [12].

3.1.2 Zoning regulations

The structure was built in a residential zone. It is attached to the wall of the Ahmed Ibn Tulun Mosque, which was a common practice at the time. In 1928 all the surrounding houses were dismantled. Today the area is no longer a residential zone and the structure is no longer a place of residence. Hence the land use & zoning have changed along with the function of the structure [12].

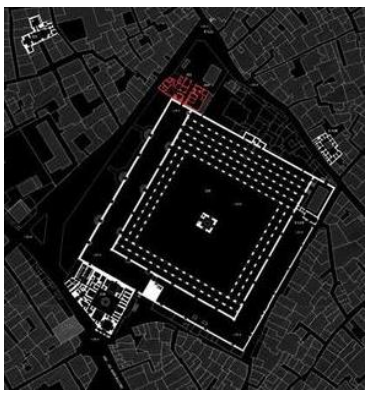

Figure 4. Museum attached to the Mosque compound

3.2 Economic Feasibility

Fees is collected for attending training workshops and other occasions as per their cultural festivals calendar. The total amount of revenue via fees is annually around one and half million L.E. For Egyptian culture heritage properties, Egyptian government is responsible for cultural heritage sites via the supervision of the Ministry of Antiquities and Heritage and MoA allocates annual budget for the employee's salaries and contracts with conservation institutions such as Archnet Organization, or Agha Khan Trust for Culture. The museum's income distribution: 30% for the Ministry of Culture & 70% for the Ministry of Antiquities and Heritage [13].

Museums					Cinema & video						Photo					
Museums	Site	Prices		Visit time	Advertising		Novelist & Commercial		Documental		Advertising		Novelist & Commercial		Documental	
		Egy	Forei		Egy	Forei	Egy	Forei	Egy	Forei	Egy	Forei	Egy	Forei	Egy	Forei
Historical museums																
Manial palace museum	Manial – Cairo	2	25	9: 5	*	*	1000	2000	1000	2000	250	500	250	500	150	300
Gayer Anderson museum (sayyeda zainab)	Ahmed ebn Toloun square	2	30	9: 5	*	*	1000	2000	1000	2000	250	500	250	500	150	300
Abdin palace museum	Cairo	1	5	9: 5	*	*	1000	2000	1000	2000	250	500	250	500	150	300
The open museum at Karnak	Luxor	1	25	9: 5	*	*	1000	2000	1000	2000	250	500	250	500	150	300

Figure 5. Museum Entrance Fees

3.3 Location Analysis

3.3.1 Surrounding Land Uses and Compatibility

There is a small market, few restaurants, the Ahmed Ibn Tulun Mosque and few other tourist activities surrounding the Gayer Anderson Museum. Any type of accommodation like hotels or guest rooms, which could increase potential visitors is not present.

3.3.2 Site Accessibility

The site is very easily accessible by a local cab. The Sayyida Zeinab metro station is only 1km away from the Museum. The museum has two entrances – the main entrance from the Mosque and the other entrance is at the back end of the site compound.

3.3.3 Quality of the View

A beautiful view of the, adjacent Ahmed Ibn Tulun Mosque, the minaret of the Satghatmash mosque and the newly landscaped garden of the Museum can be enjoyed from the terrace of the structure.

Figure 6. View of Minarets and dome of the Mosque from terrace of the Museum

3.3.4 Site Acoustics

The museum is located in a very calm area. The prayers which can be heard from the adjacent mosque 5 times a day only add to the cultural experience the visitor feels.

3.4 Architectural Aspects

3.4.1 Site management

A conservation and site management project were initiated in 1999 with an aim to safeguard the structure, conserve its contents. Addition of toilets for staff and visitors, re - landscaping of the outdoor lawn area, office areas for curators and a cafeteria have been added on site as part of the restoration. This has been integrated with practical and preventative conservation of their contents of the site and its contents. Mashrabiys or turned wood work has been set up on the terrace of the Museum which adds to the vernacular beauty of the space. The complex was open to visitors throughout the process of restoration while closing only particular spaces where work was going on in phases.

- First Phase

Work commenced with construction of two storey conservation laboratory for conservation staff of the museum, renovation of courtyard of one house, and the initiation of a program of documentation of the collections.

- Second Phase

This phase initiated in 2001 included the renovation of roof terrace of the museum, the restoration of 4 ground floor rooms, historic cistern and sabil (charitable water dispensary), and the initiation of training workshops for museum conservation staff [14].

3.4.2 Building Plan and Space Layout

•The building has very spacious rooms which allowed easy transition of function i.e. from residence to museum.

•The new elements added to the structure were the visitor toilets and a conservation lab or workshop. The conservation workshop having been built with very light and materials which has made the space quite flexible to alternate use [14].

•The house has been retrofitted with least possible intervention. Hence the capability to adapt itself to a different use or function would depend on the respective re-use.

•Based on the architectural style of the structure, the most apt re-use (should the need arise) must be in accordance with its cultural significance which has been practiced in this case.

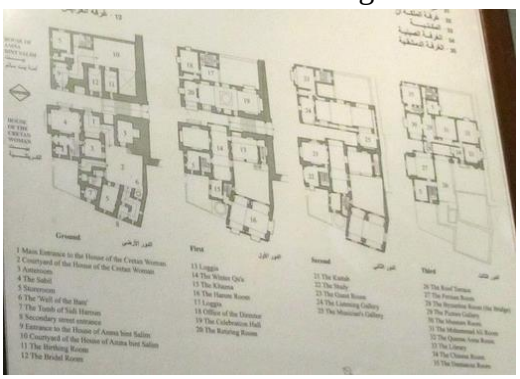

Figure 7. Museum Floor Plans

3.4.3 Amenities

The newly landscaped garden space serves as an open-air theatre for cultural events and outdoor workshops. A new cafeteria, toilets for staff and visitors, office rooms for curators have been added during retrofitting. Also, the visitor experience has been augmented with new object displays and descriptions, visitor information panels, and publications [14].

3.4.4 Building Services
Toilet block for staff and visitors were added during one of the retrofitting phases as an additional service.
3.4.5 Disaster Resistance
Although Cairo, Egypt is prone to Earthquakes, rock slides and sand storms, the addition of disaster resistance treatment / features has not been considered.
3.4.6 Barrier-Free Design
The Museum does not have any ramps or lifts. The only mode of vertical transportation is staircase.
3.4.7 Materials, Structure and conservation & maintenance
The project has utilized a great variety of craft-based skills and technologies during its duration. These include:
•Turned woodwork (mashrabiya) used for the restoration of the roof and the cafeteria terrace
•Marble and limestone carving used for elements on the roof terrace
•Limestone masonry and paving
•Stained glass (qamariyyal) for interiors
•Traditional joinery for display cabinets [14].
Modern materials have been used where necessary. The conservation lab, for example, is constructed from a steel frame structure with an insulated metal sheet roof. This contributed to speed of construction (three months), and will allow for easy removal at any point in the future should this be required. [14]
•New staff accommodation and storage has been constructed from fired brick, rendered with an integral colored render to avoid the need for painting
•Stainless steel is used for concealed fixings for the panels of Mashrabiya on the roof terrace, and for new display mounts
•A purpose designed versatile polyester resin and aluminum wire of the objects on display has been introduced as well as new forms of low maintenance lighting, such as LED [14].
3.5 Environmental Concerns
3.5.1 Energy Efficiency
•The museum has natural ventilation. There are no air conditioners in the building.
•The thick external walls, provision of self-shading walls & areas and courtyards eliminate the need for air conditioning systems.
•LED lights have been used post restoration to reduce energy consumption.
Hence, the preservation of vernacular architectural elements in the structure help to reduce the energy consumed by a huge extent when compare to a conventional museum building.

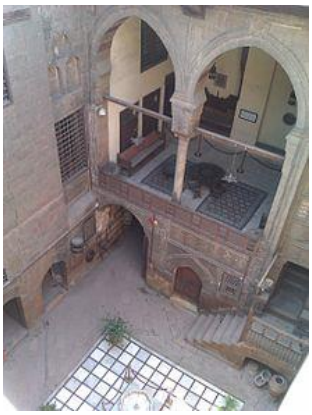

Figure 8. View of Courtyard

3.5.2 Indoor Air Quality

The structure has adequate natural ventilation. There is a very small percentage of painted surface. All other materials are vernacular, hence do not release any emissions like VOCs. Waterproofing and termite proofing was done as part of the restoration.

3.5.3 Ecological Footprint

All materials used for restoration and retrofitting are locally sourced.

•Cairo has vast reserves of limestone.

•Most of the retrofitting techniques were vernacular and required manpower rather than machinery.

•The use of fired bricks however, hampers the effort taken to use locally available materials up to an extent.

3.5.4 Renewable Energy Potential

Renewable energy harnessing features have not been installed anywhere in the complex.

3.5.5 Energy Efficient Landscaping

Xeriscaping has been done. Native plants which require very little maintenance and water have been largely used in the complex. Turf has been used for the re-landscaping of the garden which serves as an open-air theatre for the Museum. Maintenance and water requirements of turf is considerably high.

Figure 9. Turf used in the Garden / OAT

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