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Sustainability assessment of restored historic buildings: Case study of Baron Empain Palace in Heliopolis, Cairo, Egypt – Representation analysis of the building and site

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Abstract. The study examines the sustainability of a restored historical building – Baron Empain Palace in Heliopolis, Cairo in terms of its environmental, social, and economic aspects as well as cultural impacts. It assesses how the restoration of a deserted palace brings about a sustainable and cultural node, yet transforms the landscape use and sustains the district's heritage. Two approaches were exploited to assess the historical building: the first approach is inductive (review of the case study before and after restoration, its impacts on livability); and second is a field approach based on site visits to collect data on the environmental and energy consumption (energy audit); social sustainability (visitors' patterns); and economic sustainability (jobs opportunity). Results revealed that the social and cultural values prioritized and the youth represents 71% of the visitors/hr during COVID-19. The environmental and energy audit assessment shows that the restoration met RIBA's energy efficiency benchmark (50kWh/m² (good) and 70kWh/m² (typical)). For the economic sustainability, tickets are affordable and the palace creates 38 jobs. The social media analysis indicates a high interaction. The restored palace is a unique example of adhering to the city's cultural values. Finally, it shows the significance for historical palace transformation on the community.

Keywords – Sustainability assessment; restoration; historic buildings; landscape transformation; Baron Empain palace; Egypt.

1. Introduction

The historical architectural heritage is not only a testimony of identity, multiplicity, and cultural richness, but also an element of social cohesion that needs to be protected due to its significant contribution to cities to be inclusive and sustainable. The restoration of historical buildings has until now been a research field with little interest in the sustainable paradigm but is recently growing quantitatively and qualitatively since it occupies a substantial part of the built heritage. The historical buildings are generally under protection due to their high cultural potential and material merit, and cultural assets as well as the sustainability and liveability of cities since mounting demographic, economic, and ecological challenges limit possibilities for new construction, architects increasingly focus on transforming and adapting existing buildings [1]. The evaluation system of sustainability in existing historic buildings is a new field that presents many difficulties because historic buildings have their own variability of technology and construction solutions, which are difficult to standardize



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[2]. Historical buildings play a vital and integral role in attaining sustainable development goals (SDGs) since they considerably depict models and provide lessons on sustainability. Bertolin and Arian developed a categorized decision-making tool for different types of environmental sustainability interventions to a historical building [3]. Othman and Elsaay studied the economic, environmental, and social sustainability characteristics and challenges for heritage adaptive reuse, and they demonstrated their vital effect on two Egyptian case studies [4]. A study also focused on analysing the sustainability indicators for a high-performance building reuse in a European country and developed a framework to prioritize the historical buildings viability to restoration [5].

Based on the previous research, environmental sustainability has been a major concern in historical and heritage buildings [6, 7], yet this cannot attain sustainability without involving more than one pillar as indicated by SDGs. Yung, et al. highlighted the social factors' benefits for heritage conservation and developed an analytical framework for social aspects of heritage conservation [8]. Šekularac et al. analysed the restoration of a historical building in Serbia, they emphasize the importance of improving the energy performance without altering the historical identity [9]. Another study examined LEED (Leadership in Energy and Environmental Design) historical restoration for a school project that thrived to sustain the historical identity, reduce energy use to 39%, and improve the indoor air quality [10]. The heritage rehabilitation impact was studied to evaluate the successfulness of the historical adaptive reuse through users' feedback based on a multi-criteria assessment in Italy [11].

It is clear from the literature that the restoration was significant to preserve the unique architectural beauty. However, recent studies that focus on sustainability of built heritage, overlooked the social sustainability pillar, while that should be the main motive to any heritage restoration commotion as people in the community are considered key role indicators for the success of any restoration plan. Thus, this study focuses on examining the sustainability of a recently restored historical building in Cairo, Egypt in terms of sustainability pillars: social, economic, environmental, and cultural impacts.

2. Objectives

This study aims at investigating how the restoration of a deserted historical building can be sustainable, and culturally and socially viable; yet transforming the landscape use and maintaining the heritage of the district – Heliopolis in Cairo.

3. Methodology

The visual survey and analysis of the Genius loci as a propaedeutic tool in the sustainable work on historic buildings will be conducted to address how the restoration meets the sustainability measures and dimensions. In this study, two approaches (quantitative and qualitative) were exploited to examine the restored historical building of the Baron Empain Palace and the new museum. The inductive is a theoretical approach that includes a literature review and highlighting the case study before the restoration and its impacts on the city livability; it also aims at assessing the environmental sustainability of the Baron Empain Palace in order to understand the energy use and efficiency, but as the palace was built more than 110 years ago and was deserted for around 45 years, there is no record of the previous energy consumption, therefore, we carried out an energy audit instead. The deductive is a field study approach, which is based on site visits to collect data on the case study in terms of the sustainability dimensions, such as:

- Environmental and energy audit assessment (energy consumption, energy efficiency, lighting, etc.) of the historical building after the restoration;
- Social sustainability (impact of the building on the district's residences, visitors);
- Economic and the financial sustainability (assets and revenues); and
- Cultural sustainability (the impact of the restored palace and transformed it to a museum).

4. The case study and scope of work

The case study presents a background of the historical building before restoration, after retrofitting in terms of the site and palace itself, and the transformation to a museum. The study focuses on two main

parts: the palace building (externally and internally) and the related site before and after restoration to assess whether the restoration of the palace and its transformation, addresses the sustainability pillars (social, economic, environmental, and cultural). The scope explores to what extent the restoration and transformation of the Baron Empain Palace will foster livability in the district and the city.

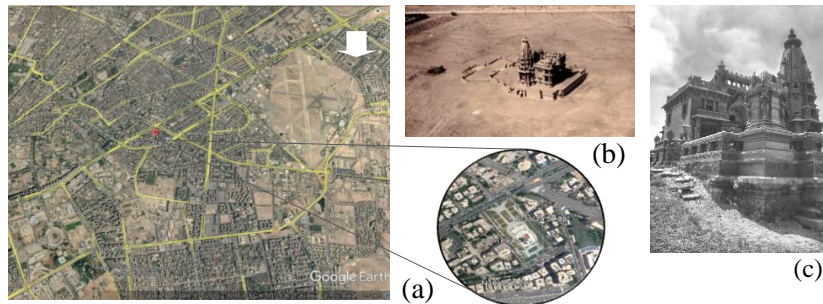


Figure 1. The location and view of the deserted Baron Empain palace – until 2018 (Images' source: (a) www.googleEarth.com); (b) Old Baron Palace.jpg, (c) Who Built The Palace, Count Dracula or Baron Empain? May 1997 (egy.com).

4.1. Heliopolis and Baron Empain Palace before restoration

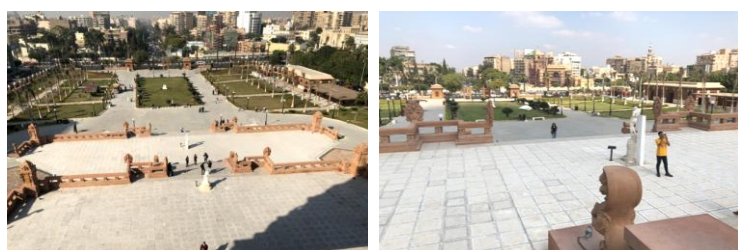
The Heliopolis district is a self-sufficient garden city created in the north desert of Cairo in the first decade of the twentieth century, conceived in utopian concept and realized in eclectic forms of Moorish inspiration [12]. The iconic 115-year-old palace was founded by a Belgium businessman, Edward Louis Joseph Empain, who was awarded the title 'Baron' by the King of Belgium due his economic contributions [12]. The historical building designed and built by the French architect, Alexander Marcel between 1907 and 1911 [13]. The palace bears a unique architecture inspired style characterized by a limestone facade richly carved with symbols and Hindu deity (figure 1) [14].

4.2. Representation analysis of the building and site

The mix of tangible and intangible elements of the palace needs to be analysed in its evolution through the two most important factors of the genius loci [15]: space and time [16]. The transformation of Heliopolis, into a capital suburb means that today the context of the complex consists of the tall buildings that have gradually replaced the elegant villas that once formed a sparse and stretched urban pattern and therefore it presents the complex as an isolated element without visual and formal references to its surroundings. Moreover, the long-time abandonment, estimated at about 48 years, is related to the loss of direct memory from people. The genius loci of Heliopolis does not therefore rest on the material component of uniformity of the context nor on the continuity of frequentation of the place, hence, its current success story seems to be entrusted only to the immaterial pivot, the only active strengths and powerful resilience factor. The visual analysis of the site allows for identifying the main components of the townscape making up the structure perceived as the shape of this place, both on the architectural and the urban scale.



(a) Main façade (b) Entrance (c) Arcade's details (d) Palace's main hall (e) Reading room
Figure 2. The Baron Empain Palace opened to public, June 2020 (Images' source: M Aboulnaga).



(a) Site's landscape, sidewalks, and gardens (b) The Palace's plaza.
Figure 3. The palace surrounding landscape after renovation (Images' source: M Aboulnaga).

The representation has been therefore, used as a tool for reading the different levels of meaning layered over the decades around the Baron Empain Palace, which are condensed in its role as an emerging landmark, particularly along the route of the speed road that connects the international airport to the capital of the country [17].

5. Assessment of Sustainability

The restoration plan was initiated by the Ministry of Tourism and Antiquates – MoTA in close collaboration with the Supreme Council of Antiquities – SCA [18], as part of Egypt’s vision 2030 and Sustainable Development Strategy. The restoration started in July 2018 and ended in mid June 2020. The President of Egypt, accompanied by the Prime Minister and the Ambassador of Belgium to Egypt, inaugurated the Palace on July 19, 2020 [19]. Latest technologies were involved in the restoration process (figure 2 and figure 3), where HBIM (Heritage Building Information Modelling) capabilities integrated since the beginning to the recent operation. Documentation, data acquisition and complex shapes capture were much convenient using recent BIM (Building Information Modelling) tools [20].

6. Restoration and Sustainability

In the sustainability assessment, four pillars will be analysed including environmental and energy audit assessment (energy consumption and efficiency supported by an energy audit); the social sustainability and how the combination of these pillars revealed liveability through walkability in the surrounding renovated landscape (soft and hard); economic sustainability including assets and revenues; and cultural sustainability in order to provide a comprehensive sustainability mapping.

6.1. Environmental and energy audit assessment

The environmental sustainability concentrates on assessing the energy consumption and efficiency of the Palace and the impact of the site’s pavements on urban heat island effect (UHIE) after restoration.

6.1.1. Energy audit. To understand energy consumption of the Palace’s after restoration, and assess its efficiency, an energy audit was conducted through walking visits of the palace to record the lighting systems (lamps, power), heating, ventilation and air conditioning (HVAC) and equipment inside and external lighting of the palace. The energy audit records the number/types of lamps, HVAC units, and equipment/apparatus in the palace as well as their efficiency as shown in table 1 and figure 4.

Table 1. Energy sources and efficiency of the restored Baron Empain Palace in Cairo

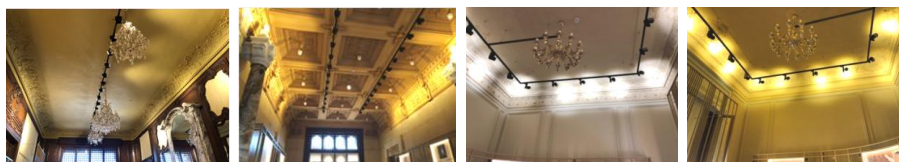
Sources (HVAC)	No.	Power W	Energy use ^a kWh/year	Sources (Lighting ^c) Palace’s internal and external	No.	Power W	Energy use ^a kWh/year
VRF Multi V 5 dual sensing unit 48 HP + Inverter ^b	5	900	8845.30	LED spotlights	178	30	14994.72
				LED bulbs	186	25	13057.20
VRF Multi V 5 dual sensing unit 26 HP + Inverter ^b	4	450	3538.10	Light strips (display frames)	234m	14/m	9199.01
				Ceiling lamps	11	25	772.20
				Chandelier & oblique lamps	59	25	4141.80
				One-space lumen fixtures	16	190	8536.32
				LED bar wash light L 1200 ^d	38	15.5	2149.85
				LED bar wash light L 300 ^d	33	4	481.80
				LED F spotlights ^d	22	50	4015.00
				LED T spotlights ^d	97	30	10621.50

^a Working hours are 9 hrs daily, 6 days/week (231 hrs monthly & 2808 hrs yearly; in offices, it is 3210 hrs/yr).

^b All AC units are LG and work for 70% of the year due to comfortable weather, i.e., 8.4 months.

^c All lighting bulbs and fixture are Philips’ efficient products.

^d External lighting of the Palace’s building at night, an average of 10 hrs daily (3650 hrs/yr of night operation).



(a) Reading room lighting (b) Main hall lighting (c) Ceiling spotlights - H2 (d) LED lights H3

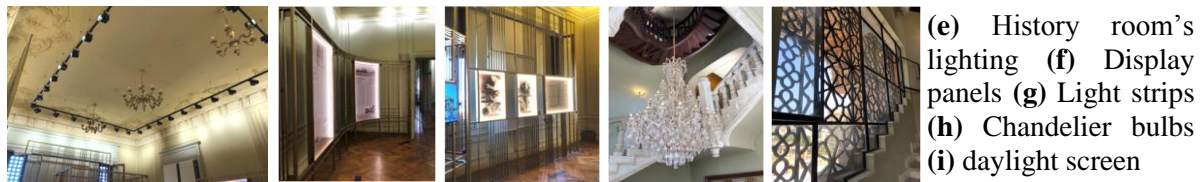


Figure 4. Lighting types in the restored Palace and new museum (Images' source: M Aboulnaga).

6.2.1. Occupancy pattern (visitors and staff) panel. The assessment follows the social aspects addressed by Yung, et.al [8], mainly: a) enhance social interaction and social networks; b) improve sense of community; c) recall collective memories for all citizens; d) enhance cultural diversity; and e) provide affordable entrance fees; the latter addressed in the economic sustainability. For the social interaction and social networks, the pattern of visitors in the time of COVID-19 was measured. The social interaction by recording the visitors' age group and activities (nationals/residents and tourists/travellers) were addressed to identify how the Baron Empain Palace after restoration influences the social and cultural sustainability (table 2). The age group was selected to represent three categories: students, youth, (school and university students, graduates, and working people), and elderly populations. Visitors were observed (45 minutes), the total number of visitors is 96 persons; thus, near to the allowed hourly number of visitors (100 persons/hr.) – the limitation added to visitors/hour in the time of COVID-19. Considering the opening hours of the Palace (09:00 -16:00), the expected daily visitors would be 700 persons per day in the age of COVID.

Table 2. Visitors' pattern of the restored Palace and Museum in the time of COVID-19

Type	Nationals					Tourists
Age group (year)	4-13	14-21	22-30	31-50	> 51-65	-
Number of visitors/hr	6	32	29	14	5	10
Total	96 visitors ^d					

^d The palace and museum limits the number of visitors to maximum 100 persons per hour.

6.3. Economic sustainability

In order to define the economic sustainability of the restored palace, it was imperative to identify the assets' value of the restored palace revenues, which pursued by obtaining the cost of restoration and number of employees as well as an annual operation cost. For the occupancy pattern – staff, the restored palace and new museum created direct new jobs for 38 persons, including the operating staff.

6.3.1. Assets and revenues. The asset of the site is estimated through the price of land, but the palace's value is priceless since it is a historical building. In 2019, Egypt and Belgium governments signed a memorandum of understanding granting the palace EGP 16 million (about US\$ 1.1 million) as extra funding for the restoration [21]. The total cost of restoration sums EGP 175 million (US\$ 11.2 million) [12]. The annual revenues were estimated by calculating the number of national visitors and tourists based on the ticket types and prices (table 3). Assuming 50% visit the roof (19 Egyptian students, 24 adults, and 10 tourists per hour), the revenue amounts to EGP 3,680 (US\$ 236). The return on investment will be after 720 years, but in the normal time (9,000 visitors/hour), it is EGP 2.43 million (US\$ 155,593) annually and the RoI after 72 years, at a modest estimation, but it could be less.

Table 3. Estimated Revenues from visitors and tourists to the Palace in the age of COVID-19

Type	Nationals		Tourists (Foreigners)	
Age group (year)	4 - 21	22-59	> 60 ^e	
Visitors/hour	38	47	1	10
Cost	20 EGP (1.28 US\$) Egyptian citizens		100 EGP (US\$ 6.41) foreigners (tourists)	
	10 EGP (0.64 US\$) Egyptian students		50 EGP (US\$ 3.20) foreign students	
	20 EGP (1.28 US\$) roof visits, Egyptian citizens		50 EGP (3.20 US\$) roof visit, tourists)	
Total annual revenues	EGP 242,880 (US\$ 15,560)			

^e Elderly above 60 years are exempted (free entry).

6.4. Cultural sustainability

The analysis carried out above shows that the abandonment of the Palace caused a situation of spatial and temporal obsolescence, a kind of strong caesura that made it almost transparent to the community for a long time, if not as a symbolic presence. However, the genius loci of a place, usually grows in a low and continuous “layerification”. If, and when occurs, a break in the time or space continuity (and in the case of the Baron Empain Palace both have been), it is not simple to re-tie the broken plot [22]. In our opinion, the success opening of the palace shows that the memory of this place remained alive over the temporal obsolescence (break in time) and the caesura (break in space accessibility).

In all similar cases of abandoned historical complexes, the building continues to be present in the tales and legends that slowly grow and settle to form an imaginary, which in the case of the Palace, was certainly fed by the complex’s exotic image before the restoration, probably seemed only a legendary example of Cambodian Hindu Templar architecture transplanted to Egypt.

Many factors contributed to the recovery of the memory of the place too, transforming the symbol into a concrete resource accessible in many meanings. Such points seem to be the main elements that have made it possible to rediscover the genius loci of the place leveraging the cultural function as the vocational driver of the adaptive sustainable reuse of this district. Such elements are the reasons for the great success that the public has reserved for the opening of the new museum – a strong factor of rehabilitation and resilience of the entire district.

To map the cultural impact, it is important to assess such influence of the Baron Empain Palace’s restoration on the social media, particularly, Instagram, Facebook, and Twitter by virtue of Data Scraping technique, and exploiting GitHub [23] to measure the word counts based on age group, gender, nationality, sentiment, occupation, and top interests’ group. This was conducted from 20 June to 30 December 2020 and comparing it with the same period in 2019.

The palace’s site provides a landmark in Heliopolis, especially since it bears historical and heritage meanings within the society inclusively, adding to that the prime location in Cairo and its proximity from Cairo International Airport (CIA) terminals 1, 2, 3, and 4 as well as any tourist or citizen coming to CIA from aboard or leaving the capital should pass by the newly resorted palace. Data are gathered from Cairo Airport Company (CAC) on the flights departed from and arrived to airport. Since data for the whole period cannot be obtained, the numbers of passengers passing by the Palace (from 5 July to 23 December 2020) were considered as random.

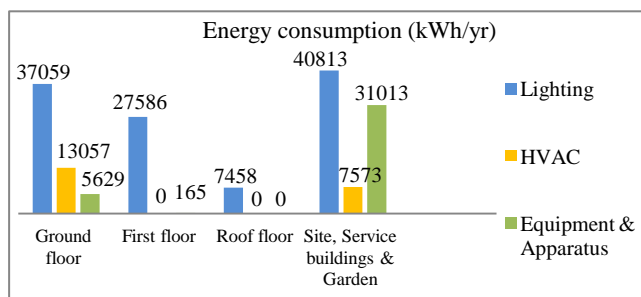


Figure 5. Annual energy consumption of the restored Palace, service building, and the site’s gardens.

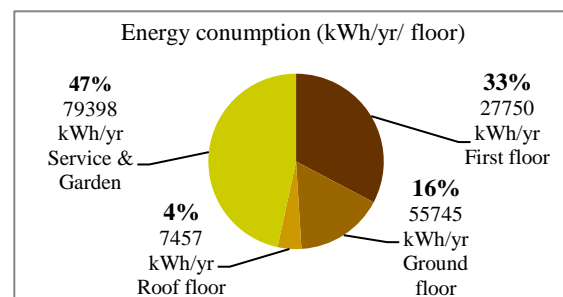


Figure 6. Total energy use per floor and the gardens of the Palace based on energy audits.

7. Results and Discussions

Figures 5, 6, 7 and tables 1, 2, 3 present the environmental and energy audit assessment as well as the social, economic and cultural sustainability of the restored Baron Empain Palace.

7.1. Environmental and energy audit assessment results

The annual of energy consumption of the restored Palace is 69.7, 34.7, 9.6kWh/m² for the ground, first and roof floors respectively (figure 5). The percentages of the lighting, HVAC, and equipment for each floor is shown in figure 5. Such values reflect energy efficient floors when compared with the RIBA (Royal Institute of British Architects) benchmark performance of public gallery and museum

[24], 50kWh/m² (good) and 70kWh/m² (typical). Figure 6 shows the total annual energy use for floors, service building and gardens. The energy audit indicates that the annual energy use is estimated 170351.4 kWh (170.35 MWh). It is also clear from figure 3.a and figure 3.b that the restored landscape uses bright colour materials for pavements with Solar Reflectance Index of 70 – 80, very good to mitigate UHIE and climate change as well as to contribute to outdoor and indoor comfort.

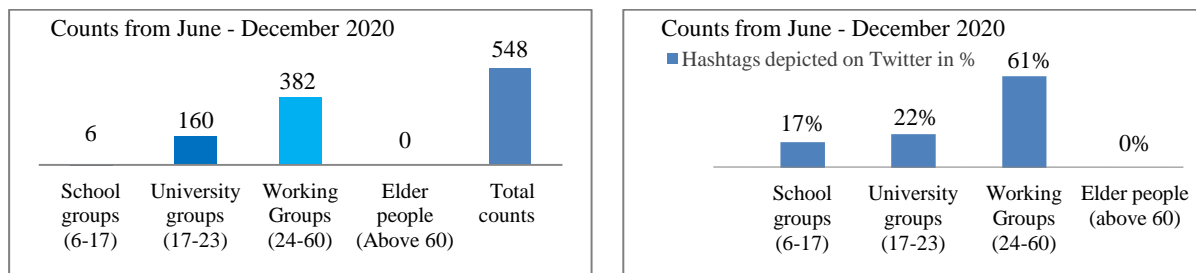
7.2. Social sustainability results

It is clear from table 2 that the youth (14-30 years) forms the highest portion of the visitors (about 71%) compared to 17% and 6% for men/women, children and elderly, respectively. It could be, however, 10 times higher (9000 persons) in normal days, i.e., post-COVID age. Figure 7 presents the findings on Instagram and Twitter. It was difficult to find the data on Facebook due to security of accessing the data. Record from the data scraping indicates that no single picture posted on Instagram from June to December 2019.

Results indicate that the total counts on Instagram are 548 counts, whereas on Twitter 3168 counts (figure 7.a). The highest nationality used Hash-tags to depict the impact of restoration on social media on Twitter is of Egyptian nationals of 54% and the positive and neutral sentiment scored 67.2% and 24.6% respectively, and the negative respond is as low as about 8%. In terms of occupation and the highest recorded in top interested segments are engineers/architects and college/university at about 67% and 83% respectively.

On Instagram, the highest age group posted photos of the palace (382 counts) is the working group of 24 to 60 years followed by university students of 17-23 years (160 counts), and then the lowest is the school students and pupils of 6-16 years (6 counts) as shown in figure 7.a . In terms of the gender analysis, results show that the male scored 69%, whereas the female 31%.

On Twitter, the words counts by age group are 61%, 22%, 17% for working group (24-60 years), university students (17-23 yrs), and school group – students/pupils (6-16) respectively. For gender analysis on Twitter, the female (54%) is higher than the male (46%). The elder group shows no interaction, this may be due to the COVID-19. The working group is the highest in all groups on Instagram and Twitter, which may interpret the palace's nostalgia among such groups (figure 7.b).



(a) Word counts on Instagram by age group

(b) Word counts on Twitter by age group

Figure 7. Impact of the restored Baron Empain Palace on the social media.

7.3. Economic sustainability results

Although the annual revenues from visitors (tourist and citizens) tickets' sales in the time of COVID-19 is EGP 242,880 (US\$ 15,560), but it anticipated the annual revenue of EGP 22,085 (US\$ 1,415) and EGP 2.4 million (US\$ 155,593). The direct economic impact is the creation of 38 jobs (palace staff) and about 1400 indirect jobs (engineers, restoration experts, workers and suppliers) during the 2-year restoration of the palace and site. As explained above, many systems allow the assessment of the adaptive reuse and their interventions in terms of environmental, social, and economic impact.

7.4. Cultural sustainability results

Asset-based approaches necessarily tend to focus on material assets, rather than considering intangible assets that constitute and influence human behaviour, such as culture. Due to its intrinsic characteristics of being made up of tangible and intangible dimensions at the same time, the structure

of the city influences the life of the inhabitants and vice versa. This is an added cultural value of the Baron Empain Palace as passengers who passed by the restored Palace to CIA is approximately 78,923 persons (estimate in 12 days) and 49,844 passengers from the airport (9 days). Although the random number of passengers passed by the Palace to and from CIA, in the time of COVID, is approximately 78,923 persons and 49,844 persons respectively; but, this number could be more than 18.5 million (2019 record) in the post COVID-19 time. The resorted palace creates impacts during the day and at night as illustrated in figure 8.



(a) The deserted palace (Image credit: www.worldarchitecture.org) (b) The restored Palace (Image credit: authors) (c) The palace at night (Image credit: Philips, www.images.philips.com)

Figure 8. The Baron Empain Palace before and after restoration (day and night).

8. Conclusion

The study assessed the sustainability pillars – environmental, social, economic, and cultural. The restoration carried out on the Baron Empain Palace addresses the sustainability pillars and testifies to how powerful and profitable the immaterial component of architecture is in the intervention on historic buildings. The Palace contributes to attaining SDG 4, 7, 11 and 13. For goal 4 (Quality education), it has been attained by training the involved restoration parties on utilizing efficient tools such as BIM as well as raising the cultural awareness of the youth by educational trips; goal 7 (Clean energy) is accomplished via using smart equipment (some utilise solar PV); and for goal 11 (Sustainable cities), it is achieved by providing a unique example of enhancing the sustainable community development; and goal 13 (Climate action) is realised by minimising operational energy use.

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