# Saudi Vision 2030: Applying a Sustainable Smart Techno-Cultural Assessment Method to Evaluate Museums' Performance Post-COVID-19

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## Abstract

UNESCO has defined world cultural heritage as either tangible or intangible cultural heritage. Saudi Vision 2030 strategies is the Culture of Community and Dynamic Supportive Environment, which supports the national identity, maintains the museums, and encourages tourism. This research aimed to assess museums' performance in four focus areas (sustainability, smart solutions, techno-cultural solutions, and health procedures) during the post-COVID-19 period in Riyadh city. The method consisted of a survey distributed during 04/2021 to stakeholders at the University in two sample case studies: Al Masmak Fort Museum and Riyadh National Museum. The main research aspects of the two samples were compared. The results are average results from survey records and respondents' responses to survey questions between RNM and MFM to each category: sustainable access (31%) material (31%) water efficiency (29.5%) energy efficiency (32%) smart solutions (31%) and techno-cultural solutions (33%). The health procedures (50.5%) in Table 2. The improvement will be reflected in more advanced and innovative solutions for the museum buildings. could be applied to museum buildings locally and internationally.

**Keywords:** Saudi Vision 2030, post-COVID-19, museum building, assessment method, sustainable smart techno cultural education in museums, future solutions

## 1. Introduction and Literature Reviewed

Internationally, only 30% of all museums have opened after the lockdown; therefore, 70% of museums all over the world are still closed. In Saudi Arabia, only the administrative staff are working, and most of these museums are now u0nder maintenance and remain closed, even after the lockdown was removed in 2020. This research study is focuses on studying the museums situation during COVID-19 and finds an assessment method to evaluate museums performance, the literature reviewed sustainability performance in (sustainable site, material, water, energy) and smart solutions, techno-cultural solutions, and health procedures. Focuses on Saudi vision 2030 is support the culture of Community and Dynamic Supportive Environment, which supports the national identity, maintains the heritage sites, and encourages tourism The literature reviewed the last eight years.

Research questions:

The research was conducted to answer these questions:

1) Are museums open during COVID-19?

2) Are health procedures applied in these museums?

3) Are there evaluation criteria for the museum building regarding maintenance, durability, sustainability, and smart techno-culture?

4) What is the future vision for the museums?

1.1 Definition of Heritage Culture

The term cultural heritage encompasses several main categories of heritage that are defined by UNESCO [1]. These are: cultural heritage, tangible cultural heritage, movable cultural heritage (paintings, sculptures, coins, manuscripts), immovable cultural heritage (monuments, archaeological sites, etc.), underwater cultural heritage

(shipwrecks, underwater ruins, and cities), and intangible cultural heritage (oral traditions, performing arts, and rituals).

## 1.2 Saudi Vision 2030 in Heritage

One of the Saudi Vision 2030 strategies is the Culture of Community and Dynamic Supportive Environment, which supports the national identity, maintains the heritage sites, and encourages tourism. This calls our attention to the importance of preserving our heritage buildings and reusing them as museums and tourist sites.

## 1.3 Sustainability in Heritage Buildings

Sustainability in heritage applies three principles: energy, water, and materials. Smart solutions, health procedures, redesigning the interior, and managing the building envelope will be addressed in the Methods section. In addition, [2] discussed sustainability in heritage buildings.

## 1.3.1 Energy

[3] introduced an energy efficiency study in heritage housing buildings through a rigorous double-coded, thematic analysis of 59 in-depth, semi-structured interviews (totalling 206,771 words) carried out in Greece, Mexico, and the UK. The thematic analysis was combined with dynamic systems analysis, essential for identifying which parameters affect inhabitants'

decisions over time. Additionally, [4] discussed how the life cycle (LC) model was implemented to assess different energy efficiency measures: roof, exterior wall and floor thermal insulation, window replacement, and two different heating systems with thermal dynamic simulation. The results showed that optimal life cycle environmental performance is obtained for insulation thicknesses lower than 80 mm; the study ignored other solutions that could affect energy efficiency, such as thermal insulation. In addition, [5] and [6] discussed the energy in heritage buildings.

#### 1.3.2 Water

It is very important to bring sustainable water solutions to heritage buildings. [7] discussed in her book how we can bring sustainable water solutions to heritage sites, especially in the landscape, through terraces, canals, dams, and wells. There are other solutions such as recycling gray water and using smart devices in toilets.

#### 1.3.3 Material

[8] discussed building life cycle and the assessment of historic buildings through a 1930 building with new construction added in 1960. The results underlined the significance of the emissions from materials in the refurbishment process and how residents play a critical part in realizing the expected energy savings. It was concluded that material uses, and user behaviour have a crucial impact on greenhouse gas emissions from a life cycle perspective.

## 1.3.4 Smart Solutions in Public Health

[9] discussed the smart maintenance of heritage buildings and focused on energy efficiency, water efficiency, building material, and data collection. A smart database on one drive allows easy control of the building [10] discussed in his MSc. research the importance of using the thermal image in studying the building envelope because it shows the thermal bridge, damaged insulation, moisture damage, air and water leakages. In addition, [11] discussed solutions that could be applied in smart buildings: presence sensors for real-time usage, desk sensors for actual usage, and comfort sensors for CO<sub>2</sub>, temperature, and humidity.

#### 1.3.5 Techno-Culture

[12] discussed how we can apply cultural values in the museums in India by teaching the children to draw; their drawings were presented in an exhibition about COVID-19. [13] discussed activating the platform in museums and applying digital technologies. [14] encouraged the private sector to fund the museums during the COVID-19 pandemic.[15] discussed social culture and economic factors in museums.

## 1.3.6 Health Procedures

[16], [17] announced that COVID-19 was a global pandemic, and this has affected our social life, health, and education. [18] and [19] published health procedures that should be applied in public spaces such as museums:

- Mask should be available.
- Sanitizer bottles should be kept in various places.

• Social distancing should be practiced reducing the spread of COVID-19, which has resulted in productivity losses and business disruption and may have a cost impact in the long term, according to [20].

• Vaccination is now required in Saudi Arabia to enter public spaces such as museums.

## 1.3.7 Redesign the Interior Space

[16] discussed future trends for interior housing design, and these include building systems in air ventilation, filtration, relative humidity, and temperature in the following:

- Architecture design that redefines the workplace with social distancing of 2 m,
- Improving the design of gathering spaces with plants, water features, social distancing,

- Making use of anti-microbial materials, isolated rooms, flexible rooms, video conference rooms, smart solutions for opening doors and windows. Cleaning the furniture and studying the building envelope through thermal photos.

It is also important to apply safety and health measures at the main entrances and in bathrooms, by providing hand sanitizer and cleaning materials. Additionally, [21] discussed the effect of COVID-19 on interior design spaces, and the study focused on private outdoor spaces, adaptable layouts, WHF functionality, separate entryways, smart systems, multifunctionality.

## 1.4 Align the Hypothesis with the Literature Review of the Latest Research

Here we cite reference papers about museums and COVID-19; a limited number of papers were found, with the latest from 2020, early 2021.

From table 1, the researcher will note the need to introduce smart, sustainable, social-cultural, and health impact categories to the post-COVID-19 assessment method. [12] approached the research in social culture by suggesting art therapy, but our research will go further to explain the techno-cultural solutions that could be applied in the museums. [13] approached this research through smart solutions that could be provided online during COVID-19; on the other hand, our research will provide more techno-cultural, sustainable solutions. Although [14] discussed the health factor, this research will discuss in more detail the techno-cultural and online post-COVID-19 smart solutions. [6] discussed the economic factor in funding the museums during the COVID-19 pandemic; this research will discuss the sustainable, smart, and techno-cultural factors post-COVID-19. The museums in Saudi Arabia are not facing financial problems because they are financed by the government. [22] approached the research by suggesting online public services such as lectures, conferences, and forums using digital technologies. [23] approached this research by suggesting teaching and learning in museums, but during COVID-19 this service can only be provided online. Agostino (2020) approached this research by suggesting online social and cultural activities, but these activities need to be developed and sustained into the future. [24] approached this research by suggesting online social and cultural activities. [25] highlighted the idea that museums should transfer to digital exhibitions; our research proposes online activities such as online tours. [26] offered digital culture solutions such as virtual lectures, forums, and tours, along with digital online resources. [27] agreed with this research in providing new technologies to deal with tourism during COVID-19. [28, 29] both agreed in applying the smart solutions within the museums during COVID-19. The researcher notices that no one of this research wrote about the applying the health procedures in museums during covid-19. Table 1 shows the relation between the literature review and research output.

	Energy	Social -Culture	Economic	Cast Assessment	Building Envelope	Sustainable	Smart	Health	Research Output
[12]		✓						Х	Culture
									Smart
[13]							$\checkmark$	Х	digital
									solutions
[14.7]			1					V	Economic
[14,6]			v					А	factor-
[22]			,					V	Public
[22]			v						services
[22,24]		,						V	Social
[23,24]	v							Х	culture
[28.29]							~	X	Smart solutions
[25, 26]							√	Х	Digital activities
[27]		$\checkmark$	✓					Х	Technologies

Table 1. The relation between the literature review and research output

## 1.6 Research Objectives

1) To introduce an assessment method to evaluate the museum buildings performance post-COVID-19.

2) To find solutions in applying health procedures in the museum buildings.

3) To apply sustainable, smart, techno-cultural solutions in museums buildings suitable to the post-COVID-19 era and the future.

4) To find a future vision for the museums.

#### 2. Methodology

Identifying LEED Sustainable museums requirements as benchmarking and base line in designing the Assessment method, LEED sustainable museum concentrating on the building process, including the design, the construction, and the stakeholders concentrating in energy, lighting, indoor environmental quality, site, water, material, minimum points should be achieving is 40 points to be certifies [30] and [31] discussed LEED main categories.

The research methodology introduces new design assessment method to evaluate museum buildings post-COVID-19 included the following main pillars:

- Sustainable (including site, material, energy, and water) solutions.
- Smart solutions in evaluating the building envelope by thermal imagery.
- Smart solutions in post-COVID-19 and health procedures.
- Techno-cultural solutions in using online platforms, virtual reality, online webinars.

Applying the method to two case studies in Riyadh city during 20 April 2021 to 20 May 2021, Riyadh National Museum (RNM) and Al Masmak Fort Museum (MFM).

Redistribute the survey during 1/09/2021 to 30/09/2021 to increase the response from 25 to 66 respondents

Analyse the data for MNM and RNM in the four main pillar sustainability, smart, techno cultural solutions.

Analysed the data on survey by using Excel program and taking the average result between RNM and MFM.

Meeting with experts in the field of Heritage, green design, and landscape and apply their opinions in the detailed survey and in the conclusion.

To validate the results was compared to (UNHABITAT, 2019) Future City report.

Identifying the weak points and strengths for the future vision of museums. Figure 1 shows the assessment method

## to evaluate the museums' performance post-COVID-19



Figure 1. The assessment method to evaluate the museums' performance post-COVID-19

#### 2.1 Design of the Assessment Method

#### The survey questions

The survey was distributed from 1 April to 1 May 2021 to students, teachers, engineers, visitors, and administrators at the University, Al Masmak Fort Museum, and Riyadh National Museum. The sample size was 100 samples, and only 66% of the targets answered the survey. Distribution of the survey was limited by COVID-19. The survey was written in Google Forms and was distributed the link by the Deanship of Graduate Studies and Research by email to the targets. In addition, it was sent to the administration of both museums. The result was analysed by Excel program.

#### 2.2 Applying the Method to Two Sample Museums in Riyadh City

#### 2.2.1 Riyadh National Museum (RNM)

#### Introduction

The Riyadh National Museum is the most famous one in the KSA, located in the middle of King Abdul-Aziz Historical Center, which was established as a cultural and civilization center highlighting the prominent history of the Arabian Peninsula and its historical message of disseminating Islam.

Riyadh National Museum (RNM) has multiple historical, archaeological, cultural, and scientific museums. The museum's two-story building covers twenty-eight thousand square meters. The storyline leads visitors from the main reception area to The Man and Universe Hall (Figure 3), Arab Kingdom Hall (Figure 4), Pre-Islamic Era in Jahiliyya Era Hall (Figure 5), The Prophet's Mission Hall (Figure 6), and the displays here use smart screens, artworks, and sound effects (Figures 7 and 8). Islam and the Arabian Peninsula Hall the use 3D modelling (Figure 9); they are followed by the Exhibition Hall of the Kingdom's Unification (Figure 10). To reach the last hall you

use the return stairs to the ground floor where you will find Hajj and the Two Holy Mosques Hall (Figure 11), which features a large 3D model.

This museum provides a modern educational environment for different segments of the local community and visitors of all ages and occupations, such as children, families, researchers, specialists, and others.

The RNM used technologies such as an online virtual tour during COVID-19 on their website (Figure 12). Additionally, there is an outdoor plaza used for different cultural activities such as a celebration of the National Day (Figure 13). The following Figures 2 to Figure 13 showing Riyadh National Museum



Figure 2. The main Entrance of Riyadh National Museum (RNM)



Figure 4. Arab Kingdom



Figure 6. The Prophet's Mission Hall



Figure 3. The Man and Universe Hall



Figure 5. Pre-Islamic Era (Jahiliyya Era Hall)



Figure 7. Smart screen in Prophet Mohamed Hall



Figure 8. Art works



Figure 10. Exhibition Hall of the Kingdom's Unification



Figure 12. Virtual tour on RNM website



Figure 9. Islam and the Arabian Peninsula Hall



Figure 11. The Hajj and the Two Holy Mosques Hall



Figure 13. Recycling water

Figure 2 to Figure 13 showing Al Masmak Fort Museum

## 2.2.2 Al Masmak Fort Museum (MFM)

Al Masmak Fort Museum was opened to the public during the King Abdul-Aziz period and presents the history of the kingdoms in Riyadh city. The fort was built from 1319, the era of Imam Abdullah bin Faisal bin Turki bin Abdullah bin Mohammed bin Saud, to 1902, the King Abdul-Aziz era. The main entrance and outdoor (Figure 14). The storyline starts in the main reception hall (Figure 15), then moves to the second hall depicting Riyadh during the period of its seizure (Figures 16 and 17), Historical Riyad, using LCDL displays (Figure 18). The sixth hall, Al Masmak Fort (Figure 19), The ninth hall, the courtyard of the water well (Figure 20) and MFM National Day celebration in outdoor plaza (Figure 21). The museum contains photographs, maps, models, display cabinets, old weapons, traditional and heritage objects, exhibitions, and audio-visual halls. The visitors comprise people from different sectors such as students, teachers, visitors, and tourists (Municipility, 2020). The following Figure 14 to Figure 22 showing Al Masmak Fort Museum.



Figure 14. Al Masmak Fort Museum (MFM) main entrance



Figure 16. Hall of two Majles



Figure 18. Historical Riyad, using LCDL displays



Figure 20. The ninth hall, the courtyard of the water well Figure 14 to Figure 21 showing Al Masmak Fort Museum



Figure 15. The reception hall



Figure 17. Hall two, Coffe made



Figure 19. The sixth hall, Al Masmak Fort



Figure 21. MFM National Day celebration in outdoor plaza

## 2.2.3 The Hypothesis

1) Riyadh National Museum (RNM) and Al Masmak Fort Museum are applying sustainable solutions in accessibility and their sites' energy, water, and materials.

- 2) RNM and MFM are applying smart solutions.
- 3) RNM and MFM are applying techno-cultural solutions post-COVID-19.
- 4) RNM and MFM are applying health procedures post-COVID-19.

## 3. The Result

A survey was distributed from 20 April to 20 May 2021 to the University and the administration staff, and to Riyadh National Museum and Al Masmak Fort Museum to record their responses to the assessment method evaluating the museums' work post-COVID-19. The target sample size was 100. The survey contained 30 questions in 4 focus areas and the results were as follows:

## General questions

The focus samples included students, teachers, tourists, administration, engineers, and visitors.

The results showed that the largest percentage of respondents comprised the students visiting the Riyadh National Museum (RNM) and Al Masmak Fort Museum (MFM); (n = 49, 74.2%). The second largest group was the teachers; (n = 7, 10.6%). The third group was administration staff from RNM and MFM (n = 8, 12%). The results showed that there were zero visitors and zero tourists during 2020 and 2021 because of the lockdown. Shown in Figure 22

The second question was about gender. The results showed that there were 36 males and 30 females

The third question was about age. The responses were from 10-20 years (n = 1), 20-30 years (n = 5), 30-40 years (n = 8), 40-50 years (n = 3), and above 50 years (n = 3). The results showed that most of the museum visitors were 30-40 years old. Shown in Figure 23.

## 3.1 Sustainability

## 3.1.1 Accessibility

The respondents were asked in Question 4 if Al Masmak Fort Museum and Riyadh National Museum were characterized by a clear entrance, good accessibility, and proximity to public transportation. Respondents strongly agreed that both RNM and MFM were characterized by a clear entrance, good accessibility, and proximity to public transportation (n = 23, 35%) were strongly agree. Most of the respondents in RNM agreed on the question (n = 30, 45.5%); however, respondents in MFM had a more average response than RNM (n = 14, 21%). Shown in Figure 25.

#### 3.1.2 Green Space

The respondents were asked in Question 5 if Riyadh National Museum was characterized by green spaces more than MNM in the outdoor environment (n=21, Most of the respondents in RNM agreed that RNM had more green spaces and outdoor environment than MFM (n=9, 32%), while respondents agreed that MFM had a greener outdoor environment than MFM (n=27, 40 %). Furthermore, few respondents in RNM (n=21, 32%) has average result, were few respondents in both MFM and RNM had average results (n=8, 12%) were disagree about the question. Shown in Figure 26.

#### 3.1.3 General Services

The respondents were asked in Question 6 if Riyadh National Museum and Al Masmak Fort Museum were characterized by general services such as a mosque, café, and library. Most of the respondents agreed that RNM had more services for the visitors such as a mosque, café, and library (n = 24, 36.6%), while 41% (n = 27) agreed that RNM had more services. However, MFM has only a mosque for public visitors. Furthermore, few respondents in both MFM and RNM had average results (n = 9, 14%). Shown in Figure 27.

#### 3.1.4 The Material

The respondents were asked in Question 7 if Riyadh National Museum and Al Masmak Fort Museum used local building materials such as Riyadh stone or clay. Most of the respondents strongly agreed that MFM was using local building materials such as stones and clay (n = 31, 47%), while 41% (n = 27) agreed that RNM was using more local building materials than MFM. Furthermore, few respondents in RNM had average results (n = 18, 27%). Shown in Figure 41, while (n=5, 8%) were disagree about the question. Shown in Figure 28.

The respondents were asked in Question 8 if Riyadh National Museum and Al Masmak Fort Museum used recycled building material. Respondents strongly agreed that MFM (n = 20, 30%) was using recycled building materials more than RNM, while both respondents agreed that RNM and MFM were using recycled building materials by 21% (n = 14), such as recycled stones and clay. Furthermore, few respondents in both MFM and RNM had average results (n = 26, 39%). While 9% were disagree about the question. Shown in Figure 29.

## 3.1.5 The Water

Question 9 concentrated on water usage. The respondents were asked if Riyadh National Museum and Al Masmak Fort Museum were characterized by gray water usage for the outdoor landscape. Respondents strongly agreed that both were using it (n = 13, 20%), while 28.7% (n = 19) agreed that RNM was recycling gray water for the outdoor landscape. The respondents were in average agreement by 40% (n = 27) that MFM was recycling gray water more than RNM and disagreed by 13% (n = 9). Few strongly disagreed (n = 2, 3%). Shown in Figure 30.

## 3.1.6 Smart Solutions in Toilets

Question 10 concentrated on the smart devices used in toilets. Both respondents strongly agreed that both MFM and RNM were using smart devices in toilets (n = 19, 28.7%), while both 19.6% (n = 13) agreed that RNM and MFM were using the smart devices in the toilets more than MFM. In addition, 40% (n = 27) were average, few disagreed (n = 6, 24%). While 16% (n=11) were disagree. Shown in Figure 31.

## 3.1.7 The Energy

The respondents were asked in Question 11 if Riyadh National Museum and Al Masmak Fort Museum were using economic lighting such as LED lighting. Most of the respondents strongly agreed that MFM was using LED lighting more than RNM (n = 25, 38%), while only 36% (n = 24) agreed that RNM used LED lighting more than MFM. Few were average (n = 19, 28%). Only 6% were disagreed (n = 4, 6%).

Shown in Figure 31.

## 3.2 Smart Solutions

The respondents were asked in Question 12 if Riyadh National Museum and Al Masmak Fort Museum were using smart solutions. In multiple choice questions, they were asked to select more than one option. Most of the respondents strongly agreed that MNM and RNM were used smart LED lighting (n = 40, 60%). Few of the respondents agreed that RNM used smart solutions more than MNM (n = 24, 36%). Respondents agreed in average numbers that both RNM and MFM were using artificial intelligence in the exhibits (n = 14, 21%). When the respondents were asked whether MFM and RNM were using artificial intelligence in the museum they showed average results of 20% (n = 13) in both MFM and RNM. The respondents were asked whether RNM and MFM were using virtual reality, and few respondents (n = 17, 26%) said that MFM and RNM were using it. The respondents were asked whether MFM and RNM were using the virtual tour in their websites, 22% (n = 15) respondents answered that both were using it. Shown in Figure 32

## 3.3 Techno-Culture

The respondents were asked in Question 13 if Riyadh National Museum and Al Masmak Fort Museum were using techno-cultural solutions, in multiple choice questions. They were asked to select more than one option. Both respondents strongly agreed that MFM and RNM were using smart LCD screens, as shown in Figure 27 and Figure 10 (n = 39, 59%). Most of the respondents agreed that RNM used sound effects more than MFM (n = 39, 59%). The respondents agreed that RNM used video technology (n = 27, 40%) and MNM used video technology (n = 23, 34%). The respondents agreed that both RNM and MFM used the new technology–smart train when showing visitors, the main hall (n = 16, 24%), while the result for RNM was 19% (n = 13). The respondents were asked whether MFM and RNM were offering online conferences and lectures during COVID-19; few answered the question (n = 12, 19%). In addition, the respondents were asked whether MFM and RNM were using the outdoor plaza for cultural activities such as Saudi National day on 23 September every year; 24% answered the question that both were using it (n = 16). The respondents were asked whether MFM and RNM were offering the narrated virtual tour on their websites; the result for MFM was 16.6% (n = 11), while for RNM the result was 24% (n = 16). The last question in this section was whether MFM and RNM were displaying art by the NOOR Initiative on their front elevation, and the response for MFM was 21% (n = 14) and for RNM it was 24% (n = 16). Shown in Figure 34.

## 3.4 Health Procedures

The respondents were asked in Question 14 whether Riyadh National Museum (RNM) and Al Masmak Fort Museum (MFM) were enforcing the health procedures in multiple choices questions. Most of the responders

agreed on the questions (n = 19, 75%). In addition, they were asked to answer more than one question. A total of 56% (n = 14) agreed that everyone was using the sanitizer; 60% (n = 15) agreed that there was a warning (Do not Touch the product); 52% (n = 13) agreed that both MFM and RNM practiced social distancing; 60% (n = 15) agreed that there was a taking of the temperature near the front door; 52% (n = 13) agreed that they open the Tawakkalna app at the entrance. Table 2, Table 3 and Figure 22 show the result of the research evaluating the museums' performance post-COVID-19.

Shown in Figure 35.

## 3.5 Museum Design

The feedback from the experts is very important to develop the museum indoor and outdoor space (Hossam Hassan Elborombaly) stated that there are many solutions for the museums, classic museums it depends on space design and formation, un-classic solutions and smart solutions applying the new technologies. Dynamic solutions the internal walls could be movable.

And he gives some sample Qatar Islamic Museum is classic museum, while Qatar National Museum is dynamic museum. RNM dynamic museum while MFM is classic museum (Elborombaly, H., 2020).

In addition, another feedback was record by Prof Ali Alrouf he presented an online webinar in 2020 (Islamic Art, 2020) and he encourage to manage the outdoor space of the museums and let people to practice art work, sports and enjoy the public space in their weekly visit and the children will ask their father to visit the museum.



Figure 24. The ages



Figure 23. The genders



Figure 25. Q4, entrance and accessibility



Figure 26. Q5, the green outdoor environment



Figure 28. Q7, local building material







Figure 32. Q11, economic lighting used such as LED lighting



Figure 27. Q6, the services







Figure 31. Smart devices used in toilets





Figure 33. Q12, smart solutions

Q.13 Apply Techno-Culture solutions											
540000	3539	39 25	237	1613	168	1212	11 <sup>6</sup>	1 <b>4</b> 6			
U	Use of Lighti ng Effect	use of Sound Effect	use of video techn ology	use of new techn ology- sma	use of the outdo or plaz	apply online confer ences	apply online virtual tour with	apply of art by Noor initi			
■ MFM	35	25	23	16	16	12	11	14			
RNM	39	39	27	13	18	12	16	16			

Figure 34. Q13, techno-cultural solutions



## Figure 35. Q14 shows the result of the health procedures

Table 2. The results of the assessment method to evaluate the museums' p	performance post-COVID-19
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Focus	Question	Response			
		MFM	RNM	Average	The average results of the 4 pillars
Sustainable site	Are the museums characterized by clear entrance-good accessibility-proximity to public transportation?	30.7	32.3	31.5	31% Sustainable site
	Are the museums characterized by green spaces in the outdoor environment?	29%	32%	30%	
	Are the museums characterized by general services such as mosques-café-library?	30%	32%	31%	
The material	Are the museums characterized by using the local building materials such as Riyadh stone or the clay?	32%	32.3%	38%	31% The material
	Are the museums characterized by recycling building material?	31%	30.3%	30.5%	
The water	Are the museums characterized by gray water for outdoor landscapes?	28%	29%	28.6%	29.5% The water efficiency
	Do they use smart devices in the toilets?	30%	29.6%	30%	
The energy	Are the Museums characterized by using economic lighting like LED lighting?	32%	32%	32%	32% The energy efficiency
Smart solutions	Multiple choices				
	Use of smart LCD screens?	62%	60.6%	61.3%	31 % The smart solutions
	Use of smart solutions?	30%	36%	33%	
	Use of a laser to clean the product?	16.6%	28%	26	
	Use of artificial intelligence?	16.6%	19.6%	22.3%	
	Use of virtual reality?	25.7%	24%	25%	
	Use of virtual tour?	23%	18%	20.5%	
Techno- Culture	Multiple choices				
					33%
	Use of lighting effect?	57.5	59	58	The techno-cultural solutions

	Use of sound effects?	37.8	59	48			
	Use of video technology?	34.8	40	27.4			
	Use of new technology-smart train?	24.2	19.6	22			
	Use of the outdoor plaza in cultural activities?	24.2	27	25.5			
	Provide online conferences?	18	18	18			
	Provide narrated online virtual tours?	16.6	24	20			
	Display art by Noor Initiatives?	21	24	22.5			
Health Procedures	Does Al Masmak Fort Museum apply the health procedures post-COVID-19?						
					50.5 %		
	Everyone is wearing a mask?	71	71	72	Apply procedure	the res	health
	Everyone is using sanitizer?	42	48	52			
	Do not touch the product?	51	46.6	58			
	Applying social distancing?	46	45.5	52			
	Taking temperatures at the front door?	51.5	47	50			
	Using TawakkIna software?	31.8	54.5	52			

Table 3. The result of the research evaluating the museums' performance post-COVID-19

The four	Sustainable	The	Water	Energy	Smart	Techno-	The health
pillars	Site	Materials	usage	Efficiency	solutions	cultural	procedures
						solutions	
The Average	31%	34%	29 %	32%	31 %	32.8%	50.5%
results							



Figure 36. The results of the research evaluating the museums' performance post-COVID-19, MFM and RNM and the average results

## 3.6 To Validate the Results

The results are compared with (UNHABITAT, 2019) and (UNHABITAT, 2016) Saudi City Report it showed the sustainable urban development measurement indicators for Riyadh city and the measurement indicator was 42.2% compared by this study the sustainability indicator is 31.5% which near to UNHABITAT report is 42.2% the difference (10.1%) this mean that museums need more efforts in sustainability, smart, and technical solutions in Riyadh museums. shown in Table 4. All the museum results are below the average and need more efforts to apply sustainability solutions.

		Sustainable Urban indicator	Reenable Energy	Water recycling	Material solid waste recycling	TELECOM	Open spaces/m2	Accessibility
Riyadh Prosperity	City Index	42.2%	1.2 %	62 %	30 %	47.9%	81.6%	21.8%
Sustainabil museums (Khogali, 2022) Table	lity in H., e 2	31%	32%	28.5%	32%	30.5%	30.5%	31.5%

## Table 4. Case study report to validate the results

Source: (UNHABITAT, 2019) and (UNHABITAT, 2016) and (Khogali, H., 2022)



Figure 37. To validate the results compare between the average results and Riyadh city indicators

The validity: The results are valid by comparing with (UNHABITAT, 2019) and (UNHABITAT, 2016) Saudi City Report it showed the sustainable urban development measurement indicators for Riyadh city and the measurement indicator was 42.2% compared by this study the sustainability indicator is 31.5% which near to UNHABITAT report is 42.2% the difference (10.1%) and the research shows moderate results this mean that museums need more efforts in sustainability, smart, and technical solutions in Riyadh museums. shown in Table 4. All the museum results are below the average and need more efforts to apply sustainability solutions Figure 3

The stability: the survey was distributed twice in April/2021 and on Sep/2021 to different groups

The overall results for the first group were 3.8/5, and the overall result for the second group was 3.9/5 so the results and response to survey question was stable and the readings 3.8/5 + or - (0.1).

## 4. The Discussion

The discussion will focus on the result of the investigation of the four main pillars of the sustainable solutions research including accessibility, material, energy, water; smart solutions; techno-cultural solutions; and health procedures post-COVID-19. The survey was distributed from March to April 2021. The target number was 100 samples. The total number of respondents was 66%. There was some limitation in collecting samples due to COVID-19 and the lockdown of the museums during 2020 and 2021. In Figure 23 and it was recorded that visitor numbers from 2013 to 2019. After that, the museums were closed during the lockdown from 2020 to 2021. This period has a gap of no visitors and no services in the museums. They are expected to open again in the latest 2021.



Figure 38. Statistical data (number of visitors in private, natural, and site museums in Saudi Arabia, 2013–2019) reflecting 2021 and 2022 [32]

**Regarding Hypothesis 1:** Riyadh National Museum (RNM) and Al Masmak Fort Museum are applying sustainable solutions in the accessibility and the site, the energy, the water, and the materials.

## Sustainability

The researchers agreed with [7], who discussed in her book how we can bring sustainable water solutions to heritage sites, especially in the landscape. We agreed with this research and our research applied more water solutions such as recycling of gray water and the use of smart devices in toilets to safe water usage. In addition, the research agreed with [8] who discussed building life cycle. We applied more material solutions such as using local and recycled building materials. Additionally, most of the research discussed the energy efficiency in heritage buildings. We agreed with them and applied more energy solutions such as using economic lighting such as LED lights. In general, we found no research that discussed the sustainability value and solutions in museums.

According to the analysis, the respondents agreed that both RNM and MFM applied sustainability in accessibility, material, water, and energy.

Regarding accessibility, RNM had a more comfortable, clear access to the main entrance, and closer public transportation access than MFM as shown in Figure 2. In front of the MFM main entrance (Figure 14) there are some stones that discouraged access. Both museums are near public transportation, especially the new subway in Riyadh city.

Regarding the green space in the outdoor environment, the respondents indicated that RNM had more green space than MFM (as shown in Figure 12); the green outdoor space encourages people to come and visit the museum. Regarding the services, the respondents agreed that RNM offered more services to the public such as a mosque, café, and library; on the other hand, MFM had only a mosque and temporary gallery. The more services the museum provides to the public the more visitors the museum will have in the future. Regarding the material, the

respondents agreed that both RNM and MFM used local building material such as Riyadh stones, gravel, sand, and clay to represent the local environment, as shown in Figures 13–14). Regarding the water, the respondents agreed that both RNM and MFM used smart devices to reduce water usage in the toilets, and they recycled water for the green areas in the outdoor environment. Figure 2 shows the outdoor water well (Figure 20) to represent the historical background of water usage in MFM. Regarding the energy, the respondents agreed that both museums used economic lighting such as LED light because it offers long-term usage and sustainability.

## Smart solutions

Regarding Hypothesis 2: RNM and MFM are applying the smart solutions

The research agreed with [10,13, 26] in applying smart solutions. We suggested more advanced smart solutions, as shown in Figures 6,7,18. Regarding smart solutions, the respondents agreed that both museums were using smart LED lighting, smart solutions, laser cleaning of the exhibits, artificial intelligence, virtual reality, and virtual tours. RNM has a website that offers the virtual tour, shown in Figure 12; RNM also uses the smart screen in Prophet Mohamed Hall to display the history of Prophet Mohamed, as shown in Figures 6 and 7. On the other hand, limited smart solutions were found in MFM; it is using the smart screen to display the history of Riyadh, as shown in Figure 18, but there is no virtual tour in MFM. Both museums display the work of the Noor Initiative to present the heritage in the main elevation by using lighting techniques (Figure 21). Other approaches can be used in the smart solutions, such as the interactive kinetic screen between the halls where the children can stand and take photos as they are moving from one hall to another (Figure 39). Additionally, the museum can offer to take photos of visitors wearing their heritage clothes (Figure 40). In addition, the museum can use virtual reality online, especially nowadays because of COVID-19 and the lockdown (Figure 41). Both RNM and MFM need to apply smart solutions such as a virtual tour on their websites. (Figure 42) uses of the virtual tour on the website during COVID-19 in RNM.



Figure 39. Use of the kinetic energy screen to take photos in Londom



Figure 41. Use of virtual reality during the COVID-19 lockdown



Figure 40. Visitors can try on the clothes and take photos in MFM



Figure 42. Use of the virtual tour on the website during COVID-19 in RNM

Figures 39. Use of the kinetic energy screen to take photos in Londom, Figure 40. Visitors can try on the clothes and take photos in MFM, Figure 41. Use of virtual reality during the COVID-19 lockdown., Figure 42 Use of the virtual tour on the website during COVID-19 in RNM

#### Techno-Cultural solutions

Regarding Hypothesis 3: RNM and MFM are applying the techno-cultural solutions post-COVID-19

COVID-19 has brought to the surface the importance of applying techno-cultural solutions. Our research agreed with [20] in applying cultural value to the museums, but we applied more techno-cultural solutions in this research. Regarding the techno-cultural solutions, the respondents were asked to choose from multiple options in Question 13 (use of lighting effects, use of sound effects, use of new technology–smart trains, use of the outdoor plaza for cultural activities, provide online conferences, narrated online virtual tours, and art by members of the Noor Initiative). Both respondent groups agreed that RNM and MFM use techno-cultural solutions. Both museums use LED economic lighting techniques in different halls, soft spotlighting with sound effects. Sound effects are used in all halls, especially in the Prophet Mohamed Bridge in RNM, and there is an LCDL screen hall in MFM. Other new technologies could be used in the museums, such as the audio-visual hall shown in Figure 554, the seminar room in Figure 28, the virtual lecture and virtual conference in Figure 30 showing the researcher webinar with King Faisal Centre for Research and Islamic Studies during COVID-19 2021., the outdoor plaza celebration of National Heritage Day with the Noor Initiative using lighting techniques on the main elevation, as shown in Figure 21. More interactive solutions could be added to the museums such as drawing arts, especially for kids and teens, 3D models and handicraft work, which will be very interesting to the women. The techno-cultural solutions shown in Figure 43 to Figure 46.



Figure 43. An audio-visual room



Figure 44. Seminar discussion room



Figure 45. Use of virtual lectures and forums post-COVID-19



Figure 46. Use of the outdoor plaza in celebration of the National Heritage Day, with special lighting

effects on the main elevation

Figure 43. An audio-visual room, Figure 44. Seminar discussion room, Figure 45. Use of virtual lectures and forums post-COVID-19.and Figure 46. Use of the outdoor plaza in celebration of the National Heritage Day, with special lighting effects on the main elevation

## Heath procedures

Regarding Hypothesis 4: RNM and MFM are applying the health procedures post COVID-19

Regarding the health procedures, the research result agreed with [19] in applying the health proceedures in all public spaces during 2020–2021. Both respondents (RNM and MFM) agreed that RNM and MFM apply the health procedures. At this time both museums are closed by the government because of COVID-19, and only the administrative staff are working. Without visitors, health procedures such as wearing a mask, testing the temperature with a smart device, using the Tawakkalna app at the front door, and practicing social distancing are

applied to the administrative staff shown in Figure 32 to Figure 35.



Figure 47. Apply the health procedure at the main entrance in MFM



Figure 49. Wearing the Mask in all spaces following his highness prince Mohammed bin Salman in

applying the health proceadures in the Kingdom

Figure 48. Apply the health procedure at the main entrance in RNM



Figure 50. Open Tawakkalna before entering indoor spaces

Figure 47. Apply the health procedure at the main entrance in MFM, Figure 48. Apply the health procedure at the main entrance in RNM. Figure 49. wearing the Mask in all spaces following his highness prince Mohammed bin Salman in applying the health procedures in the Kingdom. Figure 50. wearing the Mask in all spaces following his highness prince Mohammed bin Salman in applying the health procedures in the Kingdom.

## Future research should focus on:

- Studying the urban context of the museums in Riyadh city.
- Providing interactive activities to the museums in Riyadh City.



Figure 51. The proposed interactive 3D model to evaluate museum performance before COVID-19 in applying solutions in the museums such as lighting effect, sound effect, smart screen. During COVID-19 applying solutions such as online webinars, online conferences, online tour. and post-COVID-19 apply solutions such as both online and face to face when the museums open in sustainability, smart, and techno-cultural solutions

Figure 51 shows the solutions applied in the museum before COVID-19 such as face to face webinars, virtual tour, use of sound effect, lighting effect on the products. Also, solutions during COVID-19 such as online webinar, online conferences, virtual tour and solutions post COVID-19 such as combined with the solutions face to face if the museum is opened and online solutions if the museum is closed.

#### 5. Conclusion

The research was conducted to assess museums' post-COVID-19 performance. The result was obtained through a survey distributed from March to April 2021. The conclusions were as follows: Access should be clearer, comfortable, directly to the main entrance, and near public transportation access, especially the new subway in Rivadh city, to encourage people to visit the museums. There should be green space in front of the museum, and a large park should be provided to encourage people to visit the museum. In addition, the museum should provide more public services, such as a mosque, café, library, temporary gallery, lecture rooms, conference halls, and seminar rooms. Museums should use local building materials such as Riyadh stone, gravel, sand, and clay to represent the local environment. Economic light sources such as LED lighting should be used for durability and sustainable usage. Besides that, museums should apply water efficiency solutions such as smart devices in toilets and recycling gray water for irrigation of the green space in the outdoor environment. Museums should also apply smart solutions, such as the use of a laser to clean the products, artificial intelligence, virtual reality, and virtual tours on the museum website. Museums must apply techno-cultural solutions such as lighting and sound effects, new technology-smart trains, the outdoor plaza for cultural activities, online conferences, display of art by the Noor Initiative, audio-visual hall, seminar rooms. Finally, to prevent the spread of coronavirus after the lockdown, the museums must place health restrictions on the administrators, technical personnel, and visitors, such as wearing a mask, taking the temperature with a smart device, using the Tawakkalna app (launched by the Saudi Ministry of Health to help prevent the spread of coronavirus) near the front door, and practicing social distancing. Figure 50: shows the proposed interactive 3D model to evaluate museum performance before, during and post COVID-19 and find solutions for the future.

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#### References

- [1] UNESCO. (2021). What is meant by "cultural heritage"? Retrieved from http://www.unesco.org/new/en/culture/themes/illicit-trafficking-of-cultural-
- [2] Berg, F. (2018). Life cycle assessment and historic buildings: energy-efficiency refurbishment versus new construction in Norway. *Journal of Architectural Conservation*, 152-167.
- [3] Kalliopi Fouseki, D. N. K. S. M. C. S. N. (2020). Atmosphere, p. 604.
- [4] Tadeu, S. F. (2015). Energy Retrofit of an Historic Building in a UNESCO World Heritage Site: an integrated Cost Optimality and Environmental Assessment. Madrid, Spain, University of Coimbra.
- [5] Fernando, S. (2014). Energy Retrofit of an Historic Building in a UNESCO World Heritage Site: an integrated Cost Optimality and Environmental Assessment. Madrid, Department of Civil Engineering, FCTUC, University of Coimbra.
- [6] Stefano, P. (2014). *Macroseismic Method for Vunerability Assessment for Rationalist Architecture Heritage*. UK, Science Direct.
- [7] Hein, C. (2020). Introduction: Connecting Water and Heritage for the Future. UK: Springer.
- [8] Fuglseth, F. B. (2018). Life cycle assessment and historic buildings: energy-efficiency refurbishment versus new construction in Norway. *Journal of Architectural Conservation*, 152-167.
- [9] Elborombaly, H. (2020). *Smart Green Maintenance for Buildings*. Riyadh City, Arabian Operation and Maintenance Center (OMAINTEC).
- [10] Khan, M. A. (2011). Assessment of R-Value Effective of Building Envelope Using High Definition Thermal Image Technique. Dahran, Saudi Arabia: King Fahad University. Retrieved from https://eprints.kfupm.edu.sa/id/eprint/138440
- [11] SEMTECH. (2019). Capgemni Delivers Smart Building Transformation, UK: Semtech.com. Retrieved from https://www.semtech.com/uploads/technology/LoRa/SmartBuildingsTransformed-WhitePape-final.pdf
- [12] Amrutha. (2020). Imagining the COVID-19 pandemic through the minds of 9-11 years. *Public Health*. https://doi.org/10.1016/j.puhe.2021.01.007
- [13] Tan, M. K. B. (2021). Curating wellness during a pandemic in Singapore: COVID-19, museums, and digital imagination. *Public Health.* https://doi.org/10.1016/j.puhe.2021.01.006
- [14] Biraglia, A. (2020). Corporate sponsorship for museums in times of crisis. Annals of Tourism Research. https://doi.org/10.1016/j.annals.2020.103056
- [15] Dewi, R. (2016). *The Rapid Assessment of Heritage Area Method for Kemasan Heritage Area*. Indonisia, Science Direct.
- [16] Solution, E. D. (2020). Post COVID-19 Workplace Strategies. Vasant Vihar, New Delhi: Environmental Design Solution Pvt Ltd. Retrieved from https://www.indiamart.com/environmental-design-solutions-pvt-ltd/
- [17] WHO. (2020). Word Health Organization. Retrieved from https://en.unesco.org/cultnatlaws
- [18] Control-2, S. C. (2020). Booklet orientation Against COVID-19 in workplace. Saudi Center of DeseasePrevensionandControl.Retrievedhttps://www.cdc.gov/globalhealth/countries/saudi\_arabia/default.htm
- [19] Khogali, H. (2020). The Effect of COVID-19 on Sustainable Teaching and learning. Canada: Modern Applied Science. https://doi.org/10.5539/mas.v14n8p44
- [20] MEED. (2020). COVID-19 Sparks Contract Issues. UK: MEED Business Municipility. Retrieved from https://www.alriyadh.gov.sa/en/riyadh/DiscoverRiyadh/Pages/details.aspx?cat=Museums&cat2=%D8%A7 %D9%84%D9%85%D8%AA%D8%A7%D8%AD%D9%81
- [21] Sameh, S. (2020). *The Influence of COVID-19 and QUARANTINE on our Life Style and Home Design*. Jedda: s.n.

- [22] Agostino, D. (2020). Italian state museums during the COVID-19 crisis: from onsite closure to online openness. *Museum Management and Curatorship*, 35(4), 362-372.
- [23] Feliu-Torruella, M. (2021). Building Relationships between Museums and Schools: Reggio Emilia as a Bridge to Educate Children about Heritage. Sustainability, Heritage. Sustainability. *MDPI*, 13, 3713. https://doi.org/10.3390/su13073713
- [24] Pennisih, E. (2020). Shuttered natural history museums fight for surviva, USA. Science, 368(6495), 1042-1043.
- [25] Kahn, R. (2020). Locked down not locked out Assessing the digital response of museums to COVID-19. Retrieved from https://blogs.lse.ac.uk/impactofsocialsciences/2020/05/08/locked-down-not-locked-outassessing-the-digital-response-of-museums-to-covid-19/
- [26] Samaroudi, M. (2020). Heritage in lockdown: digital provision of memory institutions in the UK and US of America during the COVID-19 pandemic. *Museum Management and Curatorship, Routledge, 35*(4), 337-361. https://doi.org/10.1080/09647775.2020.1810483
- [27] Burini, F. (2020). From Crisis to Recovery Tourism Facing a Pandemic. The University of Bergamo.
- [28] Sukanya Krishnamurthy. (2020). State-of-the-practice: Assessing community participation within Chinese cultural World Heritage properties. *Habitat International, 96.* https://doi.org/10.1016/j.habitatint.2019.102107.
- [29] Agostino, D. (2021). New development: COVID-19 as an accelerator of digital transformation in public service delivery. *Public Money & Management, Routledge, 41*(1), 69–72. https://doi.org/10.1080/09540962.2020.1764206.
- [30] LEED. (2021). *Green Museums*. Retrieved from https://www.getty.edu/conservation/publications\_resources/newsletters/29\_2/green\_museums.html
- [31] Khogali, H. (2016). Comparison of Four Global Sustainable Building Rating Systems Carried out with Focus on Hot and Dry Climate. *Journal of Sustainable Development*, 9, 1-26. http://dx.doi.org/10.5539/jsd.v9n2p1
- [32] Heritage, S. C. f. T. a. N. (2021). *Al Masmak total number of Vistors during 2019*. Riyadh City: Saudi Commission for Tourism and National Heritage.
- [33] UNHABITAT. (2019). Saudi Cities Report. Riyadh City: UNHABITAT. Retrieved from https://saudiarabia.un.org/sites/default/files/2020-04/English%20Saudi%20City%20Report.11.03.2020 0.pdf
- [34] UNHABITAT. (2016). *Future City Report*. UNHABITAT. Retrieved from https://unhabitat.org/sites/default/files/2020/04/tqryr\_halt\_azdhar\_almdn\_-\_alryad\_2019.pdf
- [35] Islamic Art, D. (2020). 2020: Ayear without Public Space Under the COVID-19 Pandemic. Doha: Ali Alrouf.

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