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Public Buildings Post COVID-19: Bahraini Architects' Perspective

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Abstract The year 2020 has been an exceptional one worldwide; it has imposed new norms on the ways of living and business as usual practices. With the outbreak of COVID-19 in December 2019, a sudden shift was witnessed in many sectors such as education, transportation, tourism, construction, health and business. Health and safety measures enforced either the abandonment of some buildings such as schools, theaters, malls, and other public buildings, or the stay-at-home option in many nations. Residential buildings, therefore, became places to rest, study, work, and entertain, and public buildings witnessed alternating occupancy based on the health protocols. This research investigates how COVID-19 has altered and impacted the use of buildings in cases of crisis and lockdown. It then investigates the future of buildings post COVID-19, referring to sustainable and smart buildings as the way ahead. Features of sustainable and smart buildings are compared to the requirements of buildings post COVID-19 based on the literature review. Finally, this paper also provides an insight into Bahraini architects' vision of public buildings post COVID-19. A survey was used to obtain how designers and architects in Bahrain envision buildings post COVID-19. The survey also measures if any changes have already been applied to buildings during this period. The survey results indicate that around 60% percent of architects believe that the future of the building stock in Bahrain will change to incorporate smart and sustainable buildings.

Keywords Post COVID-19, Smart Buildings, Sustainable Buildings, Built Environment

1. Introduction

The spread of COVID-19 has called for a sudden shift in many practices worldwide. Each country has addressed health and safety measures against the spread of the disease differently. However, most of the protocols adopted included the closure of borders, social distancing, and lockdown [1]. Some researchers predict that the world is prone to witness similar outbreaks in the future, as a result of urban sprawl and the imbalance created due to human development and changes to different ecosystems [2]. Since December 2019, many countries worldwide have undergone a series of lockdowns, where people were forced to stay at home and avoid gatherings at work, schools, universities, shopping centers, gyms, and public buildings. This has been accompanied by a vast number of studies that further investigated the impacts of the pandemic on different sectors such as education, tourism, business, health, transportation, and the built environment [3,4,5,6,7]. In terms of the built environment, many studies have concluded that during lockdown buildings' requirements needed to be re-studied to ensure better living conditions for people during the crisis. The focus was mainly on the quality of life and how could health and well-being be sustained in buildings during lockdown [2,4]. Humans are social by nature, and, although lockdown has changed many of our ways of thinking and living styles, people are bound to socialize and meet in public buildings post COVID-19. Many papers have examined the requirements of residential buildings due to lockdown procedures and due to the various roles that the buildings had to play during lockdown; being a place to work, study, rest, entertain, and even socialize virtually [8]. This study,

therefore, addresses the need to re-think the design of public buildings post COVID-19. As the world is still experiencing the impacts of COVID-19 and with the different variants of the virus, there might be other waves to come. Furthermore, as researchers and scientists predict the possibility of other similar viruses in the future, preparation for such incidents is essential [2]. This paper, therefore, focuses on the design of public buildings post COVID-19. The first section presents the impacts of COVID-19 on the built environment, whilst the second section illustrates the features of smart and sustainable buildings. The third section compares between the requirements of buildings post COVID-19 and smart and sustainable buildings and summarizes the requirements for public buildings post COVID-19. The fourth section investigates the vision of Bahraini designers and architects in relation to the future of public buildings in Bahrain post COVID-19. An online survey was conducted where around 30 responses were collected from a number of architectural firms in Bahrain. The aim of this survey was to obtain an insight into how Bahraini architects perceived the challenges of operating public buildings during the pandemic. The fifth section showcases the main findings of the paper through the discussion and conclusion section.

2. COVID-19 and Its Impact on the Built Environment

Studies have shown that COVID-19 has impacted the lives of individuals in multiple ways; with people spending more time indoors, mainly in residential buildings, several changes in the built environment were required. A number of studies have pointed out changes in energy use patterns during the lockdown. As homes became occupied by family members for more hours than usual, energy use was altered based on the change in the consumption hours; some researchers indicated an increased rate in energy bills [9,10]. Other researchers highlighted the importance of acoustic measures in buildings during the pandemic and measured their impacts on occupant comfort levels [11,12]. Other studies assessed safety and well-being measures in multiple buildings, with results confirming that people who had access to well-lit and ventilated spaces were more satisfied during the lockdown and stay-at-home regimes [5]. Other studies indicated the importance of introducing green spaces in buildings, through the inclusion of a private green space or providing views overlooking a green space [2]. Researchers also focused on privacy issues in residential buildings as, with all household members being at home at the same time, working or studying, providing a private space for each member was found to be challenging [13].

The introduction of flexible spaces was studied by a number of researchers, and with the need to use homes for multiple functions, it was essential to utilize the spaces to their maximum potential or benefit [4]. During the pandemic, the use of temporary structures was also found to be a solution that was favored by some countries. Such structures were used as quarantine facilities or even as temporary health facilities [14]. In another study, researchers pointed out the importance of touchless technologies in reducing the spread of the virus [2]. Buildings equipped with such technologies could adhere to the health and safety levels required during the pandemic.

In terms of the indoor environment, the quality of the internal environment has been investigated by researchers. Studies indicated that special attention should be given to the use of internal materials to ensure a better internal indoor environment quality and to enable more effective cleaning of surfaces [8]. Management of waste was an issue that was reported as a result of the pandemic; waste had become an issue whether it was a medical waste, water waste, or other types of waste [3]. Finally, some researchers suggested applying changes to the layout of buildings, through the provision of wider entries, and corridors, the provision of an isolation room in residential buildings, and the use of modular designs and plan layouts [13,14].

3. Smart and Sustainable Building Features/Requirements

The terminology of smart buildings originated in the 1980s when new technologies started to emerge. A smart building can be defined as a building that employs technology and is energy efficient and sustainable [15]. It is also defined as a nearly zero energy building that uses renewable energy sources, enables control over energy flows, and provides comfort, health, and safety to its occupants [16]. Another definition includes the communication aspects; in addition to the above-mentioned, the building has the ability to communicate and share data with other buildings, creating a whole network of smart buildings, and on a larger scale forming a smart city [17].

According to Al Dakheel et al., smart buildings are characterized by the following: (a) automated; can perform with the use of automatic devices, (b) multi-functional; capable of hosting different functions, (c) adaptable; responsive to the external environment and adjust to meet the occupants' needs, (d) interactive; through the ability to allow interaction with the users, (e) efficient; provides energy savings and is energy efficient [16]. Ghorbanzadeh and Nezami define smart buildings as, "a design that responds to a changing environment in an efficient way with low cost." They have identified the four components of a smart building: its structure, services, systems, and management, and the interaction between them. The authors also mentioned sustainable architecture as designs that provide health and convenience for the present and future generations [15].

Berardi listed the broad definitions of suitability in an

attempt to clarify the interpretations of sustainability. His study included various definitions of suitability encompassing its environmental, economic, and social impacts. He points out that the environmental pillar of sustainability has mainly been addressed in most of the interpretations and assessments of sustainable building, in comparison to the social pillar, which has gained less weight. His interpretation of a sustainable building, however, addresses all three pillars. According to him, a sustainable building, therefore, is a building that has reduced environmental impacts, and promotes social equity, culture, heritage, and social interaction. It is a building that provides a healthy and safe environment for its occupants, taking into account their physical and mental health [18]. Table 1 summarizes the features of smart and sustainable buildings [15,16,17,18].

Finally, an aspect that is strongly connected with sustainable and smart buildings is the smart city. For the success of sustainable and smart buildings, the whole building stock, outdoor areas, streets, transportation, and urban areas need to be connected through a network that allows access to real-time data. By achieving such a connection, the true smart city visualization could be realized. Most recently, the concept of digital twins and digital shadows, in addition to other technologies, has started to be associated with the smart built environment. These technologies are not the focus of this paper; however, it is worth mentioning that such technologies bring the smart city to another level, where the data that is collected is used for planning, development, and energy saving [19].

Table 1. Characteristics of smart and sustainable buildings

1.	Low impact on the environment throughout their life cycle
2.	Saves cost and energy
3.	Utilizes renewable energy
4.	Provides comfortable and healthy internal environments
5.	Flexible and adaptable buildings
6.	Responds to the external environment
7.	Promote social equality and social well being
8.	Promotes culture and traditions
9.	Incorporates the use of smart technologies and services and equipment
10.	Uses sensors and actuators
11.	Real-time monitored and supervised
12.	Connected through a network or smart grid with other buildings

4. Public Buildings Post-COVID 19

As demonstrated in the previous sections, there is a strong correlation between the features of sustainable buildings and the impact of COVID-19 on buildings. Many researchers have pointed out this similarity. Kakderi et al. in their paper focus on mobility and the need to revise its sustainable aspect to meet any future crisis. They argue that cities need to incorporate advanced solutions to address the design of open public spaces and urban settings to enable a better future for buildings and cities. They also express concerns about people returning to routines that might disturb the environmental benefits that have been achieved during the pandemic. They conclude their study by stating that the pandemic is an opportunity to change toward sustainability, and to promote better practices [20].

Tokazhanov et al. examine the sustainability of residential buildings post COVID-19. The authors examine the effects of COVID-19 in buildings worldwide, and suggest possible changes to sustainable requirements of residential buildings, separating these into three main categories: health and safety, environment, and comfort. The suggested alterations to sustainable rating systems for residential buildings mainly focus on giving more attention to social and health aspects in comparison to environmental aspects. The authors also specify certain features that could improve the health and safety aspects of buildings such as the use of technology, the inclusion of green spaces, and the development of technologies that would enforce further savings in energy and water. In their conclusion, the authors propose that sustainable codes could be developed to ensure these changes [2]. Pinheiro and Luís discuss how COVID-19 could leverage a sustainable built environment. The authors discuss how previous infections such as plague, cholera, tuberculosis, and the ‘Spanish flu impacted how cities, buildings, and services were designed. Their research details multiple improvements to the sustainable built environment requirements to accommodate impacts resulting from COVID-19, including the structure, shell, interiors, services, equipment and furniture, building division, external spaces, and landscape. They conclude their paper by emphasizing the changes that should be addressed to face future outbreaks, which are derived from sustainable practices [8].

With scientists and researchers’ prediction of future outbreaks, it is essential that sustainable and smart building enforcement becomes the norm in the coming period. Furthermore, planners and decision-makers should start to implement retrofits to the existing building stock to enable a full approach to a sustainable and smart environment. Another aspect, according to some researchers, that has been overlooked as a result of the pandemic is climate change, which is a major concern that is pushing forward the sustainable agenda through implementing sustainable and smart practices in the future.

Botzen et al. in their research highlight that, due to the pandemic, less attention has been directed to measures that address climate change. The authors similarly point out that the pandemic could be an opportunity to enforce sustainable measures in the built environment to both address the crises caused by the spread of infectious

diseases and at the same time tackle the impacts of climate change. Most recently, climate change impacts have started to hit the world with wildfires spreading in many regions [21]. In some regions, this has led to the evacuation of nearby residential buildings; in such an event, it can be argued that public buildings could be converted into areas of refuge for people, enforcing the idea of designing public buildings to meet future needs.

Through the above-mentioned research, there seems to be a strong relationship between the requirements of sustainability and the future of buildings. Public buildings have been abandoned during the pandemic, but, with the enforcement of sustainable and smart measures, the neglect of these buildings could be avoided. This is true for the spread of diseases and also for any future crisis resulting from the impacts of climate change or any other event.

5. Bahraini Architects and Designers' Vision

An online survey was conducted during the summer of 2020 [22] and was repeated in the summer of 2021 to measure the level of awareness of Bahraini architects and designers in relation to the future of public buildings. Around thirty responses were received mainly from the private sector, i.e. architectural consultant offices in Bahrain. The survey highlighted the changes that could be applicable to buildings post COVID-19, and if any changes have been applied to the design approaches in public buildings during 2020, since the beginning of the pandemic. The survey also explored the vision of architects in relation to sustainable and smart buildings as the future of buildings in Bahrain. Based on the responses received, two consultant firms had started to apply changes to the design of public buildings in Bahrain; the changes included the design of larger spaces to accommodate social distancing and provide areas for people to wait in during busy hours. The second change applied with the pandemic in mind is the design of flexible spaces that could be easily converted to other facilities in case of emergency efficiently and effectively. Other responses included future changes that architects and designers thought should be applied to public buildings in Bahrain.

After analyzing the responses, it was found that these could be separated into four categories: Design, Materials, Systems, and Technology (Figure 1).

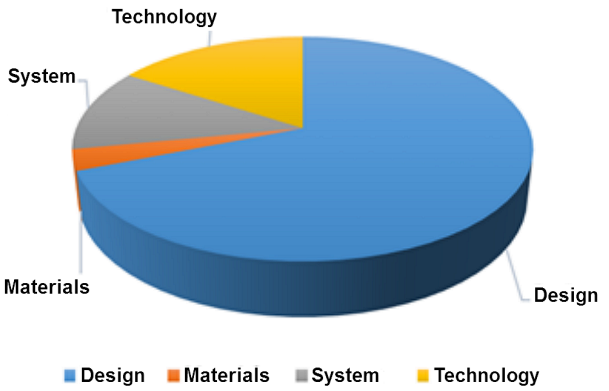

Figure 1. Changes to public buildings based on responses by categories

Sixty-nine percent of responses related to design; the majority focused on applying larger spaces in the future to accommodate any social distancing protocols. Other design changes included the consideration of building flexibility, either to allow interconnection between outdoor and indoor spaces, or the conversion of public buildings into other types of facilities as needed. Another design-related response suggested the inclusion of large entry lobbies and the provision of essential facilities such as restrooms, testing rooms, clinics, isolation rooms, lockers, etc., near entrance areas. A few responses highlighted the importance of sustainable design in the future and called for the application of sustainable codes and regulations. One response was related to giving more attention to the design of outdoor spaces. Three percent of the future action in public buildings was related to material selection; the responses were mainly related to the selection of internal building finishes which could be easily cleaned to maintain a high level of hygiene in buildings easily.

Twelve percent of the responses were system-related solutions, with the focus on using efficient ventilation and cooling systems in buildings. Sixteen percent were technology related, most of which included the use of touchless technologies, sensors, standalone systems, and monitors in buildings to enable hygiene practices and have overall efficient control and monitoring of individuals entering public buildings. Table 2 illustrates the responses of Bahraini architects indicating measures that should be applied to public buildings post COVID-19 based on the four categories mentioned.

Table 2. Measures to be applied in public buildings post COVID-19 by category based on the survey

Category	Measure
Design	Increase in size of gathering spaces
	Include isolation room
	Design facilities with multiple entries
	Introduce access to buildings through specific zones
	Design buildings to be flexible
	Increase connection with outdoor spaces
	Focus on the design of entrance areas and waiting areas
	Provision of service areas such as restrooms, lockers, and clinic ramp access near the main entrance
	Design spaces with social distancing in mind
	Furniture such as seating areas to be increased
	Introduce separate circulation for different users
	Improve the quality of outdoor spaces
	Incorporate sustainable design solutions
Materials	To improve hygiene in buildings through material selection
	Design internal elements and materials to support social distancing
	Self-cleaning materials
Systems	New air-conditioning systems
	Improved ventilation systems
	Increase the number of vertical circulation systems such as lifts
	Utilize treated fresh air for a better ventilation system
Technology	Automatic doors in all buildings
	Sensors, monitors
	Standalone systems
	card readers
	User-friendly technology in buildings
	Use technology to reduce human contact

Additionally, Bahraini architects and designers indicated that buildings in Bahrain in the future are likely to change and that the change could be toward sustainable and smart buildings. More than half the responses were in favor of sustainable and smart buildings: 60% of the participants indicated that sustainable and smart buildings could represent the building stock of the future, whereas the remaining responses showed uncertainty on how the design of buildings would be in the future (Figure 2).

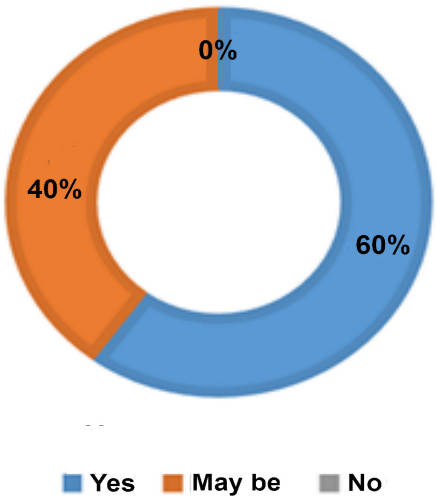

Figure 2. Percentage of responses indicating a shift in the design of public buildings in the future

6. Discussion and Conclusion

COVID-19 has imposed new ways of thinking in many sectors, one of which is the buildings sector. As a result of the pandemic, many people had to change their daily routine and ways of using buildings, either by staying at home or by experiencing restrictions on entering public buildings. Many studies have examined the impacts of the pandemic on the design of buildings. Sustainable and smart buildings were highlighted as providing the blueprint for future buildings. As demonstrated in the previous sections, researchers have also pointed out the need to apply sustainable and smart measures in the design of buildings and cities to overcome any future outbreaks. Additionally, with the current alarming climate change impacts, there are further challenges that might face humanity in the future. Sustainable and smart buildings will offer a level of flexibility, and efficiency in energy and waste management, in addition to providing occupants with a safe and healthy monitored environment.

Humans by nature are social; therefore, protocols that restrict people's movement and gathering are bound to be temporary. Many countries have now eased a number of restrictions, allowing people to gradually return to work and school, and have re-opened public buildings. Policy and decision-makers have to implement the changes to the buildings stock to follow smart and sustainable designs in the future, ensuring a resilient future ahead. Furthermore, retrofits to existing buildings should also be considered to achieve a holistic smart and sustainable city. In Bahrain, there was no full closure of public buildings; however, entry restrictions were applied. Users of public buildings had to have been vaccinated and have their temperature taken, to ensure health and safety, in addition to other measures such as wearing face masks and adhering to social distancing protocols.

Although responses received from Bahraini designers indicated a high level of awareness among this group, there are a number of constraints that may hinder the process of implementing smart and sustainable measures, one of which is the lack of regulations and laws obligating developers to enforce such measures. Such laws are currently under development in Bahrain. In addition to that, this should be accompanied by enforcement regulations to ensure that developers do not fail to follow this path. Another challenge is to obtain a network that connects buildings, urban areas, streets, etc. This would require upgrading the infrastructure of the whole country to achieve sustainable and smart cities.

A number of studies examined in this paper highlighted areas of change and how sustainable and smart measures could be upgraded to possibly address future crises. Lessons from the pandemic should not be overlooked; stringent measures that have been implemented during this hard time could be eased if in the future adequate measures were in place, such as applying sustainable and smart measures. After this pandemic, if a similar infectious disease spreads across the world, less disruption may occur in people's lives, building use, businesses, and cities as they have been designed to be healthy and safe environments that allow the exchange and flow of information. With the high rate of development that the world is witnessing, cities and urban developments are replacing habitats of different ecosystems. This imbalance that is created may cause future animal-borne diseases that may affect humans. Additionally, climate change might be another reason for changes on our planet which may also lead to future crises. Therefore, we have to work today to ensure a brighter future for the next generations; this is the core definition of sustainable development: "*a development that meets the need of the present without compromising the ability of the future generations to meet their own."* [23]

In this paper, a comparison between the impact of COVID-19 on buildings and the requirements of smart and sustainable buildings has been presented. A number of studies have been examined that similarly highlight this correlation; many papers have been published that concludes that suitability is the path to overcoming future crises. Suggestions of changes applicable to buildings in the future were listed with reference to studies conducted by researchers worldwide. A survey was conducted among Bahraini architects to measure their awareness and to identify the changes that should be applied to the public building stock in Bahrain. The importance of addressing the issue of public buildings arises from the lack of literature in this area and as a result of the abandonment of these buildings due to social distancing protocols. Sustainable and smart measures would enable better use of public buildings in the future. The designs of public buildings should accommodate safety and security measures, in addition to social distancing requirements. Future public buildings should be flexible, efficient, and smart. Sensors and actuators will provide data collection about the quality of the internal environment, the users of the buildings, the occupancy levels, energy and waste management, and much more information. Buildings should be designed in such a way as to enable conversion to other facilities if needed. Public buildings should be designed with attached outdoor spaces, enabling open-air events. Energy-efficient cooling, heating, and ventilating systems should be installed in future buildings, enabling savings in energy, achieving a high-quality internal environment, and aligning with the sustainable requirements of buildings.

One of the limitations of this study is that it only focused on review papers and therefore there might be other resources that may have been overlooked during the study. Additionally, the survey only presented the views of around thirty consulting companies. Further research could examine more papers in different databases and the survey could be extended to include different stakeholders such as public building users, owners, and developers.

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