Implementing Building Information Modeling (BIM) in Sustainable Urban Design

(A comparative study between Masdar City and Marotta City)

Sali Haidar[1], Mohammad shaban[2]

[1] Building Information Modeling Management Master Student, Syrian Virtual University

[2] Lecturer Professor at Syrian Virtual University, Damascus, Syria

Emails: sallyhedar1@gmail.com; mhdshaban@yahoo.com

Abstract

This thesis explores the utilization of Building Information Modeling (BIM) technology in the design of sustainable cities. It provides a comprehensive definition of BIM, with a focus on its various dimensions. The concept of sustainable cities and green buildings is examined as a foundation for achieving sustainable development goals. The thesis also addresses sustainable project phases and how BIM can be integrated into these stages. The thesis emphasizes the role of BIM in enhancing the design of sustainable cities by improving energy consumption and elevating air and environmental quality. The research also delves into how BIM can be used to enhance interaction and collaboration among stakeholders during the design phases. Practical aspects of the research are illustrated through an analytical comparative study between the cities of Masdar and Marotta, with a specific focus on the results derived from the application of BIM in these projects. The research presents practical recommendations that enhance the integration between BIM and the design of sustainable cities. The thesis concludes by summarizing the comprehensive results and recommendations, reaffirming the crucial importance of applying BIM to enhance sustainability in urban design.

Keywords: Building Information Modeling (BIM) technology; Sustainable cities; green buildings; Energy consumption; Air quality and environment.

1. Introduction:

In the past, architecture used to evolve based on scientific discoveries related to materials and construction methods. However, in our modern era, architecture undergoes transformations and advancements driven by electronic technology, the information revolution, modern technology, and sophisticated systems utilized in buildings. This evolution has extended to the proper and optimal utilization of technology under the influence of environmental conditions, aiming to achieve human comfort and minimize harm to the surrounding environment. The goal is to harness technology appropriately while integrating it with the environment to create sustainable cities, preserving advanced technology and promoting the fusion of technology with the surroundings. [1]

In recent times, modern and advanced technologies have emerged in project management, representing a crucial phase for transitioning towards a more prosperous future in the construction industry. One of the most significant advancements is Building Information Modeling (BIM) technology, which constitutes a revolutionary shift in the field of engineering projects. [2]
Smart sustainable cities rely on the latest technologies and apply recent knowledge like Information and Communication Technologies (ICT), BIM, and lean construction to expand people's eminence of

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

life, smooth urban maneuvers and facilities more competent, and develop their competitiveness while confirming that they achieve the economic, social, environmental, and cultural demands of current and forthcoming generations. [3]

The research paper defines Building Information Modeling (BIM), links its tools to architecture, and explores its impact on sustainable urban design. The research reaches a strategy and methodology for application that supports the achievement of sustainable green cities by documenting and highlighting the role of modern applications in the computing field.

2. Research Methodology:

The descriptive-analytical research method was employed, utilizing a case study approach (a comparative study between the cities of Masdar and Marotta) in our research. This involved studying and analyzing Building Information Modeling (BIM) systems and the concept of sustainable cities to achieve integration between them. Books, articles, scientific papers, and the internet were used as research tools.

3. Research problem:

The absence of a comprehensive application of Building Information Modeling (BIM) technology in the design of sustainable cities, leading to the failure to achieve desired objectives, highlights that the research problem lies in finding ways to implement BIM technology. Based on this research problem, several questions arise:

1) What is the significance of implementing Building Information Modeling (BIM) technology in the design of sustainable cities?
2) What are the obstacles facing the application of Building Information Modeling (BIM) technology in the design of sustainable cities?
3) What role do renewable energies play in achieving sustainable development?
4) How can Building Information Modeling (BIM) be used to design cities that reduce energy consumption and improve air quality?
5) How can interaction and collaboration between stakeholders in the design of sustainable cities be enhanced using Building Information Modeling (BIM)?

4. Building Information Modelling (BIM):

As specified in PAS 1192-2:2013 by the British Standards Institution, Building Information Modelling is “the process of designing, constructing or operating a building or infrastructure asset using electronic object-oriented information” [4].

This methodology and process manage the information and data of a building digitally throughout its entire lifecycle. This methodology has already begun to impact the workflow of designers, consultants, and contractors. The Building Information Model (BIM) mimics the construction process in a virtual environment, encompassing three-dimensional models of all project elements and their relationships with all design-related information. Through the use of a suite of software, it can indicate the building's feasibility for actual implementation and allow for modifications in the project before it becomes a reality.[5]

5. Building Information Modelling (BIM) dimensions:

5.1 The Third Dimension (3D BIM):

Refers to data associated with the model, such as material specifications, components, and cost. These data can be utilized to enhance the design, construction, and maintenance of buildings and infrastructure. [6].

The three dimensions refer to the graphical representation of the X, Y, and Z axes. These are the height, width, and depth of an object, in this case, the model. [7].

5.2 The Fourth Dimension (4D BIM):

It is a 3D model + time. Building Information Modeling (BIM) has facilitated the ability to create schedules for various design projects that align with both the design and execution processes. Previously, achieving this was reliant on traditional and separate methods, which increased the time required to complete the task.[8]

5.3 The Fifth Dimension (5D BIM):

It is a 3D model + cost. The use of Building Information Modeling allows for the development of a mechanism that assists in quantity take-offs based on design specifications, including standard material specifications and installation methods. This results in the direct determination of pricing schedules during both the design and execution phases.[9]

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

5.4 The Sixth Dimension (6D BIM):
This dimension adds environmental and sustainability information to the model, such as energy consumption and the project's environmental impact. It can be used to assess the sustainability of the project. The sixth dimension involves providing environmental and energy-efficient solutions for both design and the entire building. The design model is used to achieve environmental sustainability standards and to control execution processes in accordance with various environmental sustainability standards. This includes the ability to make precise and rapid modifications to the base model.[10]
5.5 The Seventh Dimension (7D BIM):
This dimension has significantly contributed to the quality of operational and maintenance aspects of the building lifecycle. Emphasis has been placed on the projects utilizing Building Information Modeling, showcasing a substantial reduction in time, from the issuance of work orders to repairs, the technical team's on-site operational time, execution of work, and the realization of other services and gains.[11]
5.6 The eighth dimension (8D BIM):
8D is essential for safety planning during construction by including safety information in the model from the design stage. This BIM technology can be used in combination with other advanced technologies such as VR (Virtual Reality) to view a typical site and visualize any potential site threats.[12]

6. Importance of BIM:

The traditional systems deal with each project phase and its teams separately, the main feature of BIM is the integration of the different project phases (project management life cycle) and its teams. [13]
BIM proved its capability to enhance the cooperation between all project parties [14], where BIM is deemed as an environment that effectively combines all liabilities and endeavors from all project stakeholders through diverse project phases to deliver a functional sophisticated and innovative product replying to all parties and project objectives [15, 16, 17]
Using BIM with partnering agreements reduces disputes, eliminates conflict of interest, and allows sharing of knowledge, healthy interaction between project stakeholders, and improving problem-solving techniques. [18]
BIM can be applied to several topics. Using BIM in the transportation industry through real way construction projects [19]
Furthermore, BIM technology can be applied to achieve sustainability and improve the energy efficiency and the life cycle of the building through the application of the skylight system and the Trombe wall as a passive design strategy [20- 21].
The importance of using BIM technology in studying the lighting performance in buildings to develop the best design solutions and upgrade to obtain optimal performance, whether in the design stage or the evaluation stage of an existing building through the use of environmental analysis programs such as Ecotect- Desktop Radiance [22]
The most significant barriers against BIM adoption are lack of expertise, standardization, and protocols. And, most influential drivers as the Availability of trained professionals to handle the tools, Proof of cost savings by its adoption, BIM Software affordability, and awareness of the technology among the industry stakeholders [23]

7. BIM in Syria:

Recently, studies have developed that are concerned with applying BIM, as many companies have begun to realize the importance of technological tools that are able to apply an integrated methodology that helps in managing construction projects in the various stages of the project.
Obstacles and challenges that hinder BIM implementation are classified in economic, technical, regulatory and legal challenges human kind, and the risks associated with using a new technology, and they agreed on:

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

- Introducing BIM into university curricula will introduce a new generation of BIM experts from Syrian engineers.
- Support from the Syrian government is the main driver for BIM adoption.
- Designers play an important role in embracing and convincing other project parties of the benefits of BIM at all stages of the project life cycle.
- Preparing a time plan for training unqualified employees.
- provide standard Dealing with principles and techniques BIM. [24]

8. Sustainable Cities:

It is a city designed with environmental requirements and standards, and the first to record the formulation of the term (eco-cities) in a book was Richard Berkeley in 1987, Eco-Cities: Building Cities for a Healthy Future. Experts generally agree that sustainable development must meet the needs of the present without sacrificing the ability of future generations to meet their own needs.[25]
Green Building (also known as sustainable construction) refers to a structure and usage process that adopts an environmentally friendly and resource-efficient configuration throughout the building's life cycle: from site selection, design, and construction, to operation, maintenance, renewal, and even demolition. This necessitates close collaboration between the design team, engineers, and the client at all project stages. The practice of green building expands and complements classic design considerations for buildings in terms of economy, utility, durability, and comfort. [26]

9. Green buildings:

These are buildings that provide a better quality of life for humans, considering environmental standards at every stage of construction, design, implementation, operation, and maintenance. As a result, they reduce the harmful environmental impact of the building on society and the planet as a whole.[27]
Green Building (also known as sustainable construction) refers to a structure and usage process that adopts an environmentally friendly and resource-efficient configuration throughout the building's life cycle: from site selection, design, and construction, to operation, maintenance, renewal, and even demolition. This necessitates close collaboration between the design team, engineers, and the client at all project stages. The practice of green building expands and complements classic design considerations for buildings in terms of economy, utility, durability, and comfort. [28]

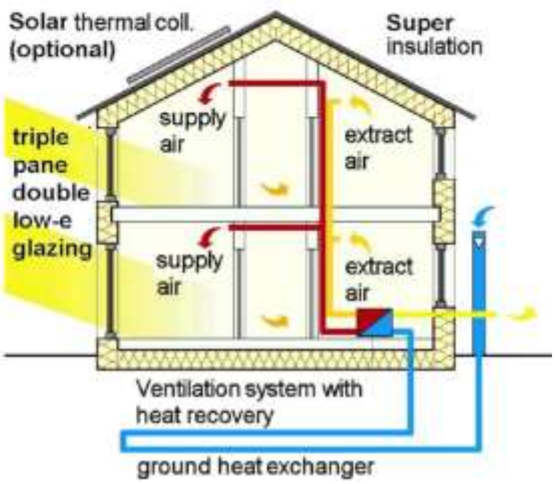

Figure 1: Green building model

10. Sustainable project Phases:

10.1 Pre-design Phase (Planning):

It relies on the overall vision set by the project owner, which mandates that the final product meets the requirements of green buildings.[29]
The consulting team and the client must discuss specific sustainable goals for the project, such as energy efficiency or carbon emission reduction.

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

10.2 Design Phase:
To achieve sustainable architecture, the principles of sustainability must be integrated into the design process, guiding architects towards a sustainable design approach. This is accomplished through the following elements:
• Site analysis
• Environmental impact assessment
• Integration of design environment and process support
Energy modeling for cities is carried out during the design phase and relies on computer programs to represent all electrical loads, lighting devices, air conditioning, heating, and other aspects. The model is adjusted to achieve optimal design.
10.3 Construction Phase:
It is essential to consider sustainable implementation to achieve sustainable design. There is no point in designing a building that reduces energy, fuel, and water usage and provides a healthy environment for occupants during the operation and maintenance phase if, at the same time, environmentally polluting emissions resulting from the production, transportation, and construction processes exceed those of their counterparts in traditionally designed facilities that lack sustainable foundations.[30]
Sustainability in the construction sector refers to all practices during project implementation that ensure the facility is environmentally friendly, economically viable, and has a positive impact on the health and comfort of users.
10.4 Performance Testing and Monitoring:
This part of the project process includes various activities such as measuring environmental performance, monitoring air and water quality, waste impact assessment, maintenance continuity, data collection, and reporting. Building Information Modeling (BIM) allows for the simulation of specific system performances, such as HVAC or lighting systems, providing a comprehensive assessment of their efficiency. BIM can be used for quality control by comparing real-world data with the construction model, facilitating the detection of any discrepancies or variations.
10.5 Maintenance and Management:
The maintenance and management phase is a vital part of the sustainable project life cycle, aiming to achieve long-term sustainability by preserving its environmental and economic performance.
10.6 Education and Awareness:
This stage aims to disseminate awareness and knowledge about sustainability concepts and how to achieve them through directing residents and users, workshops, training, promoting community participation, and educational workshops.
10.7 Demolition Phase:
In this stage, buildings or structures are dismantled and removed properly and efficiently to conserve resources and reduce environmental impact.

11. The role of building information modeling in designing sustainable cities:
Building Information Modeling (BIM) contributes to the analysis of building performance and its surroundings by enabling simulations that compare various design options and provide clearer insights into the analysis results. This allows for a more detailed examination of building and environmental performance.[31]
Building Information Modeling (BIM) is a crucial tool for designing sustainable cities for several reasons, including:

- Improving design efficiency
- Enhancing collaboration
- improving sustainability

BIM has the capability to compare and simulate multiple options rapidly, aiming to select the best option based on various aspects such as time required for implementation, cost, materials and resources used, user comfort and well-being, sustainability, energy consumption, and more. [32]

12. Optimizing energy consumption using building information modeling:
The decrease in the cost of renewable energy is considered one of the incentives driving the world towards the adoption of renewable energy and replacing traditional energy sources. In the initial years of interest, costs initially rose but soon experienced a decline. The reduction in costs can be attributed to advancements in production technologies, which will require several more years of effort to reach maturity, a process similar to the early stages of development for conventional energy technologies.[33]
Energy efficiency is one of the key factors in the design of green buildings, and achieving such efficiency relies on the following factors:

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

- Energy Modeling
- Passive Design Principles
- Utilization of Renewable Energy
- Use of Load Management and Control Devices

Building Information Modeling (BIM) can assist in enhancing energy consumption through various methods, including:

- Improving energy efficiency for buildings
- Enhancing energy efficiency for infrastructure
- Improving energy efficiency for cities
- Enhancing building insulation
- Integrated energy design.

13. Improving air quality and the environment using building information modeling:

Among the first strategies implemented in the field of air quality management are engineering control strategies, which have had an impact and effectiveness in reducing air pollutants emissions and achieving air quality standards. However, these strategies have proven insufficient in finding a solution that reconciles the increasing population density, economic activities, and the limited capacity of air quality. They must be complemented by a set of important strategies, including land planning strategies, transportation planning strategies, and energy management.[34-35-36-37]

Air and environmental quality can be enhanced through the use of Building Information Modeling (BIM) by:

- Improving energy efficiency.
- Waste management.
- Sustainable transportation.
- Sustainable design.

14. Using Building Information Modeling (BIM) to enhance interaction and collaboration in designing sustainable cities:

The interaction and collaboration among stakeholders in the design of sustainable cities can be enhanced through the use of Building Information Modeling (BIM) by relying on several methods and tools [35-36], including:

- Creating a shared BIM model.
- Defining roles and responsibilities of teams.
- Providing training and education.
- Documenting and sharing information.
- Utilizing digital tools for communication.
- Holding meetings and workshops.
- Real-time interaction.
- Using BIM models to showcase results.

15. Comparison study between Masdar City and Marotta City:

Masdar City - Abu Dhabi, UAE	**Marotta City - Damascus, Syria**	**Theoretical design foundations and principles**

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

Building the world through more sustainable cities for a bright future. It can accommodate 90,000 people on an area of 6 km2 (70 people/acre)	The initial step in the journey of prosperity and urban development for the capital, Damascus, contributes to the resurgence of the city on an international scale. The new commercial center in Damascus, with its towering high-rise towers (Landmark), encompasses a variety of buildings including luxurious residences, stores, hotels, serviced apartments, restaurants, cafes, financial and banking institutions, specialized healthcare facilities, cultural services, distinguished and upscale educational institutions that embrace green architecture.	**Vision**
Activate cost-effective natural techniques including: • Alignment by adjusting the city's orientation in relation to the sun and wind to reduce building heat absorption and facilitate natural ventilation flow. • Natural conditioning of streets and spaces through narrow streets and human-scale urban spaces shaded and naturally or artificially roofed, equipped with parks, fountains, and recycled lakes to mitigate the climate. • Proximity between housing, work, and services.	• Consideration of wind and sun directions, utilizing solar breakers and plants. • Dedicated spacious areas, quiet pathways, and extensive gardens with large water lakes and musical fountains that inspire and provide a serene environment for family strolls and enjoyment.	**Planning**
Reviving the Emirati urban heritage in a new city that blends traditional Emirati characteristics with modernity in its architecture and urban structure within the framework of sustaining the urban heritage.	----------	**History**
30% Of the city's total residential area 24% For the business and research area 13% For commercial projects and light industries. 6% For Masdar Institute of Science and Technology 19% For services and road network. 8% For civil and cultural events.	3% Administrative activities 6% Public buildings 9% Investment areas 18% Residential areas 29% Roads 35% Green areas	**Land Uses**
Providing the city with an efficient transportation system to replace private cars, including: • Clean electric buses • Implementing the use of electric cars • Light rail and metro lines • Establishing terminal parking lots for private cars at the city's peripheries.	315,000 m2 walkways and sidewalks 28,000 m2 bicycle path 45,000 m2 parking	**Transport**

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

• The city utilizes photovoltaic panels installed on the ground and building rooftops to harness solar energy. The city houses the largest concentrated solar power station in the Middle East with a capacity of 10 megawatts. • Outside the city's limits, wind farms have been established capable of producing 20 megawatts. • The city also aims to harness thermal energy and hosts the world's largest facility for hydrogen energy generation.	• Using technologies that save electricity and water. • Using clean and renewable energies.	**Renewable energy**
• Reducing carbon footprint in the construction environment by developing a method for material assessment and monitoring its supply chain. • Using sustainably sourced timber from responsibly managed forests. • Utilizing 90% recycled aluminum in interior facades. • Using environmentally friendly concrete instead of cement to reduce carbon emissions. • Employing water-based paints that do not contain any volatile organic compounds or harmful chemicals to human health. • Using support bars made entirely from recycled steel.	Renewable and rapidly renewable materials are not specifically used as is known in the most sophisticated and advanced buildings. The materials used in various construction operations are mostly locally manufactured materials (such as cement, blocks, gravel, sand...) and some are imported (such as iron), and this in turn leads to an increase in energy consumption in its various forms. During all stages of construction, this is mainly due to not relying on natural alternatives to materials.	**Sustainable Building Materials**
• Efficiently using water consumption reduction systems. • Reducing the amount of water used for irrigation by 60% per square meter, achieved through an efficient sprinkler irrigation system. • Collecting rainwater through channels for recycling and effective drainage.	• 10 Water treatment stations. • Irrigating crops with water supplied by the management from centralized treatment stations, preventing the use of drinking water for irrigation.	**Water Use Management**

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

Reusing or recycling was implemented during the city's construction phase, where: • 96% of waste from construction operations, suitable for reuse, is separated and sent to nearby recycling facilities. • Cement residues are crushed and reused in filling building structures. • Composite waste is used to feed natural plants in the city. • Information dissemination campaigns were launched to reduce waste and increase the rate of delivering this waste to designated recycling locations.	Waste management was not implemented during the construction phase, but the principle of recycling was applied. Residents of the buildings were obligated to follow waste sorting principles according to the required standards. They dispose of their waste through the secured opening in the waste room on each floor, ensuring proper sorting. The waste is then transported to the main waste room in the basement, where waste collection vehicles gather it from inside the building and transport it out of the area. This approach helps maintain a clean environment and streets, free from containers and garbage accumulation areas.	**Waste and Residue Management**
Building information modeling was used.	Building information modeling was used.	**Use of Building Information Modeling**

Table 1: Comparison study between Masdar City and Marotta City

In summary, the sustainability of Masdar City and Marotta City was compared based on several important criteria. The measurements were conducted using various standards. The results indicate that Masdar City stands out due to the use of multiple types of renewable energy (solar, wind, and hydrogen), while Marotta City is characterized by a single type of renewable energy, which is solar energy, in addition to the presence of water treatment stations. It is essential to note that Masdar City and Marotta City adopt different strategies for achieving sustainability, and their differences are based on the needs and priorities of their residents. Therefore, achieving sustainability relies on the collective efforts of the community, as well as the public and private sectors, for continuous improvement and finding a balance between the environmental, economic, and social dimensions in both cities. Improving sustainability requires integrated efforts and dedicated work to enhance aspects facing challenges, contributing to the creation of more sustainable cities in the long-term.

16. Results:

1) Providing effective communication among various engineering teams leads to improving project integration and achieving sustainable development.
2) Enhancing planning is achieved through providing accurate three-dimensional models for infrastructure projects.
3) The lack of investment in Building Information Modeling (BIM) technology can restrict projects from benefiting from sustainable design advantages.
4) Companies need to re-engineer their processes and understand the full benefits of Building Information Modeling (BIM) technology to overcome challenges.
5) Encouraging the adoption of renewable energy technology contributes to improving energy consumption efficiency and reducing reliance on traditional energy sources.
6) Employing renewable energy can contribute to carbon emission reduction.
7) Building Information Modeling (BIM) can be used to enhance air quality in sustainable cities by improving architectural designs and ventilation.
8) Integrating Building Information Modeling (BIM) technology in planning, design, and execution processes promotes continuous interaction and reduces the likelihood of discrepancies and conflicts.

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

17. Recommendations:

1) Promoting a broad understanding of the benefits of Building Information Modeling (BIM) technology in sustainable city design among professionals and the construction industry is crucial.
2) There is a need to provide financial incentives for companies and projects that adopt Building Information Modeling (BIM) technology in sustainable design projects.
3) Specialized training courses for professionals in the field of Building Information Modeling (BIM) should be offered to increase efficiency and knowledge levels.
4) It is essential to implement policies that encourage the use of renewable energy and provide facilitations for the implementation of alternative energy projects.
5) The necessity of adopting international standards for the application of Building Information Modeling (BIM) that can be compatible with various engineering systems.
6) The incorporation of sustainable management principles into the policies and procedures of companies and governments is essential.
7) Conducting professional training and development for specialists and engineers on how to effectively use Building Information Modeling (BIM) in the design of sustainable cities.
8) In light of the foregoing, we can recommend some suggestions that can be implemented in Marotta City to enhance its position in the field of sustainability and compete with Masdar City:
   - The necessity to enhance public transportation, Marotta City can improve its public transportation system by introducing efficient and clean means of transport, such as electric buses, to reduce reliance on private cars.
   - The necessity to promote the use of sustainable building materials This involves using sustainable materials, such as sustainable wood, and transitioning towards building materials that reduce carbon emissions and support recycling.
   - The necessity to improve water and waste management Marotta City should focus on enhancing water and waste management, promoting recycling, and utilizing waste in construction processes.
   - The necessity to focus on urban heritage Emphasizing urban heritage can be beneficial. Marotta City can leverage Masdar's experience in revitalizing urban heritage and seamlessly integrate it with modern urbanization.
   - The necessity to increase investment in renewable energy projects This includes investing in projects like wind energy stations and hydrogen energy to promote sustainable energy sources.
   - The necessity to engage with the community It is essential to interact with the community to raise awareness of sustainability principles and encourage active participation in sustainable initiatives.
   - The necessity to launch awareness campaigns Initiatives should be taken to educate the community about the importance of sustainability and how to actively contribute to environmental conservation.

18. Conclusion:

At the conclusion of this thesis, we realize that the application of Building Information Modeling (BIM) technology as a fundamental tool in the design of sustainable cities is a crucial step towards building a more sustainable and efficient future. Through the concerted efforts to integrate this innovative technology into urban design processes, we witness a transformation towards interactive communities, renewable infrastructures, and buildings that rely on resource utilization efficiently.

BIM technology provides the digital foundation that enables engineers, designers, and planners to analyze environmental, social, and economic impacts in the early stages of urban development projects. This approach assists in making informed decisions, improving resource efficiency, and reducing waste. Despite the challenges that may confront us in adopting and effectively integrating this technology into the construction and urban planning industry, the significant benefits offered by BIM in achieving sustainable cities justify the investment in learning and adopting it.

Effecting change towards more sustainable cities requires continuous efforts and comprehensive collaboration across various sectors. However, by fully leveraging BIM technology and adopting it comprehensively, we can attain sustainable cities that reflect innovation and sustainable development, achieving environmental, social, and economic sustainability for both current and future generations.

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

References

[1] Al-Shafi'i, Islam, Khalifa, Henar, Hussein, Hisham: **Sustainability of smart buildings, the role of applications of sustainability principles to reach a balance between technology and the environment to reach sustainable cities**, article, Journal Of Al Azhar University Ngineering Sector, vol (13),2018, P1,2

[2] Saudi, Mohammed, Al-Shimi, Hisham, Mahdi, Mohammed, Ashour, Shaima: **Strategies for designing sustainable cities using BIM technology**, article, P3.

[3] Saleh, Fawaz, Elhendawi, Ashraf, Darwish, Abdul Salam, Farrel, Peter: **An ICT-based Framework for Innovative Integration between BIM and Lean Practices Obtaining Smart Sustainable Cities**, Article, International Journal of BIM and Engineering Science (IJBES), vol 14, p68

[4] PAS 1192-2. (2013). Specification for information management for the capital/delivery phase of construction projects using building information modelling. UK: British Standards Institution.

[5] Kymmell, W. **Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations**. USA: McGraw Hill, Inc., 2008.

[6] Mehmet F. Hergunsel: **Benefits of building information modeling for construction managers and BIM scheduling**, A Thesis Submitted to the Faulty of WORCESTER POLYTECHNIC INSTITUTE, Civil Engineering May 2011, P5.

[7] Saada, Michel, Aslan, Hala: **The effectiveness of applying BIM in increasing the accuracy of estimating quantities for public facilities rehabilitation projects in Syria after the war**, Article, International Journal of BIM and Engineering Science (IJBES), Vol. 05, PP10

[8] Mustafa Youssef, Reda Bahy El-Din, Surkn, Eman Ibrahim Badr: **A holistic vision to achieve sustainability standards using building information modeling technology**, Journal of engineering, art and humanities 2023 .P623

[9] Mustafa Youssef, Reda Bahy El-Din, Surkn, Eman Ibrahim Badr: **A holistic vision to achieve sustainability standards using building information modeling technology**, Journal of engineering, art and humanities 2023 P624

[10] VINCI Facilities, **BIM for Facility Management Handbook and technical specifications for the digital model**, Les Cahiers Experts supplement published and distributed by Groupe Monitor in April 2016. P4 .

[11] Mustafa Youssef, Reda Bahy El-Din, Surkn, Eman Ibrahim Badr: **A holistic vision to achieve sustainability standards using building information modeling technology**, Journal of engineering, art and humanities P624, (2023).

[12] Saada, Michel, Aslan, Hala: **The effectiveness of applying BIM in increasing the accuracy of estimating quantities for public facilities rehabilitation projects in Syria after the war**, report, International Journal of BIM and Engineering Science (IJBES), vol (5), 2022, p10.

[13] Shaban, M., & Elhendawi, A. (2018). **Building Information Modeling in Syria: Obstacles and Requirements for Implementation**. International Journal of BIM and Engineering Science, 1(1), pp. 42-64.

[14] Ahmed, S., Dlask, P., Selim, O., & Elhendawi, A. (2018). **BIM Performance Improvement Framework for Syrian AEC Companies**. International Journal of BIM and Engineering Science, 1(1), 21-41.

[15] Elhendawi, A., Omar, H., Elbeltagi, E., & Smith, A. (2019). **Practical approach for paving the way to motivate BIM non-users to adopt BIM**. International Journal of BIM and Engineering Science, 2(2), 1-22.

[16] Elhendawi, A., Smith, A., & Elbeltagi, E. (2019). **Methodology for BIM implementation in the Kingdom of Saudi Arabia**. International Journal of BIM and Engineering Science, 2(1), 1-21

[17] Taher Salamah, Abdussalam Shibani, Kheder Alothman. (2023). Improving AEC Project Performance in Syria Through the Integration of Earned Value Management System and Building Information Modelling: A Case Study. International Journal of BIM and Engineering Science, 6 (1), 74-95.

[18] Evans, M., Farrell, P., Elbeltagi, E., Mashali, A. and Elhendawi, A. **Influence of partnering agreements associated with BIM adoption on stakeholder's behaviour in construction mega-projects.** International Journal of BIM and Engineering Science, 3(1), pp.1-20

[19] Abd Alnoor, B. (2022). **BIM model for railway intermediate station: transportation perspective.** International Journal of BIM and Engineering Science, 4(2), pp. 33-48.

[20] Ghedas, H. (2021). **Skylight as a passive design strategy in Tunisian dwelling using BIM technology**. International Journal of BIM and Engineering Science, 4(1), pp. 18-25.

[21] Ghedas, H. (2021). Trombe wall as a passive design strategy in Tunisian dwelling using BIM technology. International Journal of BIM and Engineering Science, 4(2), pp. 79-89.

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023

[22] Younes, M. (2022). Achieving optimal lighting to improve the functional performance of the museum using computer simulation case study: Lattakia Museum in Syria. International Journal of BIM and Engineering Science, 5(2), 19-37.

[23] Hamma-adama, M., Kouider, T., & Salman, H. (2020). Analysis of barriers and drivers for BIM adoption. International journal of BIMa and engineering science, 3(1), 18-41.

[24] Lepkova, N., Maya, R., Ahmed, S. & Šarka, V., 2019. BIM Implementation Maturity Level and Proposed Approach for the Upgrade in Lithuania. International Journal of BIM and Engineering Science, 2(1), pp. 22-38.

[25] Saudi, Muhammad, Al-Shimi, Hisham, Mahdi, Muhammad, Ashour, Shaima: **Strategies for designing sustainable cities using BIM technology**, article, p. 3.

[26] vyas, supriya, ahmed, seemi, parashar, arshi: **BEE (Bureau of Energy Efficiency) and Green Building**, article, international journal of Research, vol (1), issue (3),2014, p24.

[27] Zakaria Al-Abd, Riad: **Green Buildings, US Green Building Council, LEED rating system**, article, Bim Arabia Magazine, Issue (16), 2017, p. 34.

[28] vyas, supriya, ahmed, seemi, parashar, arshi: **BEE (Bureau of Energy Efficiency) and Green Building**, article, international journal of Research, vol (1), issue (3),2014, p24.

[29] Tahan, Hassan, Bastoun, Haider: **Sustainable Construction Project Management**, Thesis, 2018, p. 22.

[30] Tahan, Hassan, Bastoun, Haider: **Sustainable Construction Project Management**, Thesis, 2018, p. 31.

[31] Saudi, Muhammad, Al-Shimi, Hisham, Mahdi, Muhammad, Ashour, Shaima: **Strategies for designing sustainable cities using BIM technology**, article, p. 6.

[32] Abu Al-Saud, Yasser: **Sustainability using Building Information Modeling (BIM) techniques: Evaluation of building performance analysis software**, article, BIM Arabia, Issue 10, (2016), p. 13.

[33] Bouachir, Maryam: **The role and importance of renewable energies in achieving sustainable development**, Master's thesis, 2011, pp. 153,154.

[34] Bouachir, Maryam: **The role and importance of renewable energies in achieving sustainable development**, Master's thesis, 2011, p. 75.

[35] Elhendawi, A.I.N., 2018. Methodology for BIM Implementation in KSA in AEC Industry. *Master of Science MSc in Construction Project Management), Edinburgh Napier University, UK*

[36] Fawaz Saleh, Ashraf Elhendawi, Abdul Salam Darwish, Peter Farrell. (2024). A Framework for Leveraging the Incorporation of AI, BIM, and IoT to Achieve Smart Sustainable Cities. *Journal of Journal of Intelligent Systems and Internet of Things*, 11 (2), 75-84 (**Doi:** https://doi.org/10.54216/JISIoT.110207)

[37] Ahmed Fahim Elgendi, Ashraf Elhendawi, Waleed Mahfouz M. A. Youssef, Abdul Salam Darwish. (2021). The Vulnerability of the Construction Ergonomics to Covid-19 and Its Probability Impact in Combating the Virus. Journal of *International Journal of BIM and Engineering Science*, 4 (1), 01-17 (**Doi :** https://doi.org/10.54216/IJBES.040101)

Doi : https://doi.org/10.54216/IJBES.070205
Received: March 23, 2023 Revised: August 16, 2023 Accepted: October 29, 2023