Architecture Image Studies
AIS Scientific Journal

Vol.6, Issue 4, pp.45-57, 2025
DOI: https://doi.org/10.62754/ais.v6i4.363

https://journals.ap2.pt/index.php/ais/index

Green Buildings as a Cornerstone of Green Cities: A Comparative Analytical Study of (Msheireb, Masdar, and NEOM)

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Abstract

This study presents a comparative analysis of three pioneering sustainable urban developments in the Gulf region: Msheireb in Qatar, Masdar City in the UAE, and NEOM in Saudi Arabia. Employing a qualitative evaluation framework based on the LEED assessment categories, the research explores how each city integrates environmental standards, technological innovation, and regional cultural identity. Msheireb emphasizes heritage preservation, dense urban fabric, and pedestrian-friendly design, utilizing traditional materials and passive cooling strategies. Masdar prioritizes a low-carbon footprint through renewable energy reliance, smart water management, and ecological compatibility, serving as a model for climate-adaptive urban planning. NEOM stands out with its futuristic vision, integrating AI, green technologies, and large-scale environmental protection, although its practical implementation remains under evaluation. The study underscores that regional context, cultural heritage, and technological maturity shape each city's sustainability approach, highlighting the importance of tailored urban solutions. These insights contribute to understanding sustainable city planning in arid regions, emphasizing the need for balancing innovation with regional appropriateness to achieve long-term environmental and social resilience.

Keywords: *Sustainable urbanism, green cities, water and energy efficiency, smart technology.*

Introduction

Green building (also known as green building or sustainable building) refers to the development and implementation of environmentally responsible and resource-efficient processes throughout a building's life cycle, from planning to design, construction, operation, sustainability, restoration, and demolition. With rising environmental pressures, green buildings have emerged as a response to environmental issues by lowering energy usage, prices, and providing people with comfort. (U. Nations,2019) The urban trend toward green building has become a source of concern for planners and designers since it is one of the most significant components of green cities, which strive to provide a low-emission environment while also improving inhabitants' public health.

Theoretical Definition 1-1 Green city concept

"Green cities" In urban research refer to an environmentally friendly concept for urban planning and development. This concept covers different topics of planning and design, and includes several stages. The fundamental work for the success of sustainable urban development is to ensure the careful management of environmental cities at every level. Equally important is the necessity for all components of urban design to work interactively and inseparably. (Lehmann, 2011, p:108) With the increasing recognition of the environmental crisis in the 1970s and climate change in the 1990s, environmental awareness and the concepts of sustainable cities, healthy cities, compact cities, and ecological cities gradually evolved, leading to the emergence of the concept of the green city, revealing a new beginning in urban design theory. Planning and designing the green cities are one of the solutions to Climate challenges such as rising temperatures, global warming and heating land. (Wikantiyoso et al, 2013, p.4-18).

An urban area created and planned to lessen its environmental impact while fostering sustainability and ecological balance is referred to as a "green city" in another sense. The phrase "green city" refers

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to a collection of policies and programs designed to lower the carbon footprint of the city, protect its natural resources, and enhance the standard of living for its citizens. Among the main features of a green city are the following (R.I. McDonald,2023, P 84):

"Green spaces, Eco-friendly transportation, Sustainable infrastructure, Waste management, Green surfaces and walls, Water conservation, Community participation and environmental awareness. In this article, we study green buildings as one of the most important features of green cities.

Green building concept

Green buildings integrate measures that are environmentally friendly and resource-efficient throughout the building's lifespan. The green building idea seeks to decrease a building's negative impact while increasing its beneficial influence on the natural environment and its occupants. (L. Li,2021, p4).

Green buildings successfully maximize the natural efficiencies of a building site and integrate them with renewable and low-carbon technologies to support the building's energy needs while also creating a healthy built environment. Green buildings prioritize the effective use of energy, water, and other resources, the quality of the inside environment, and the influence on the natural environment. (A. De Bock &B. Belmans, 2023, p 2)

The basic principles of green building

Construction and building operations utilize excessive natural resources and generate massive volumes of garbage, despite the fact that some of this waste can be recycled, albeit at a low rate in comparison to the volume of waste generated by construction work. As these environmental challenges worsened, the concept of green buildings gained traction. (Lin, Y.,2016, P 26)

There must be main principles on which this concept is based to achieve the intended purpose, but these principles may differ from one building to another as they cannot be considered fixed and a comprehensive design cannot be achieved for all buildings, regardless of the conditions and locations of their construction, even if all studies in this field agree on a main principle for green buildings, which is to reduce the negative impact on the environment and occupants. (M. Aboramadan et al. 2021, P 16) designer must choose the principles that are consistent with the project budget and project objectives in a manner that does not conflict with environmental standards, as they are indicators and trends that contain renewed ideas to achieve the concept of green buildings and cannot be considered fixed in terms of design. Through the studies prepared in the field of green buildings, the common basic principles of green buildings that must be realized and adopted to achieve a sustainable environment can be limited to:

- Energy protection and natural resources
- Recycling and manufacturing
- Reliance on renewable energy sources

The concept of energy and its protection is embodied in all types of energy that we need to manufacture the product or the energy needed to convert raw materials into products or process raw materials and invest and manufacture them. As these amounts of energy cannot be underestimated or their impact reduced, as nearly 5% of the total energy consumed in Britain is spent for the purpose of producing and distributing materials needed for construction and building. (Kibert, C, 2013)

The international standard for sustainable green building LEED

It is a system followed and approved in the United States of America and is known as the leadership system, meaning leadership in energy and environmental design to achieve sustainable buildings in green cities. The meaning of the abbreviation (LEED) was established by the US Green Building Council (USGBC) in 1998 AD, which is an abbreviation for (The Leadership in Energy and Environmental Design) meaning (Leadership in the field of energy and environmental design) (Colombo et al., 2013, P 56)

This standard was established to provide a set of goals that achieve sustainability and environmental preservation, as the goal of the LEED standard is to create buildings in green cities that achieve the highest degrees of environmental suitability, with lower economic performance and costs, as planners and specialists are provided with a list of points for a set of requirements that this standard achieves as follows: (Leong et al., 2014, P 17).

1- The energy consumption process for buildings in green cities is given 17 points

2- Water use efficiency assessment is given 5 points

3- Indoor environmental safety and air quality is given 15 points

In addition, there are additional points that achieve sustainability for the building, such as renewable energy sources, and monitoring carbon dioxide CO2, and the points are calculated as a total of points that reflect the LEED standard assessment, for example, a green building in green cities that has a total of 39 points gets the highest rating in terms of sustainability, and this rating means that the building reduces environmental impacts by at least (50%) compared to traditional buildings in other traditional cities, while a building that has a total of 52 points means that the building achieves a reduction in environmental impacts by at least (70%) compared to other similar traditional buildings. (U.S. Green Building Council, 2010, P16)

Practical study

The practical aspect of this research relies on a comparative analytical approach, which is used to analyze and evaluate sustainable planning practices in three Arab cities that represent different models for applying green city principles: Msheireb in Qatar, Masdar in the UAE, and NEOM in Saudi Arabia. These cities were chosen because of their innovative efforts to combine local identity, technology, and environmental norms in a sustainable urban planning framework.

Land Use in Msheireb City, Qatar

A mixed-use urban redevelopment project, Msheireb Downtown Doha includes retail, business, residential, and cultural areas. Its goal is to reinvigorate the city's historic center by fusing modern design with traditional Qatari architecture.

Planning for Transportation

Three self-powered, single-deck trams that run without overhead wires make up the district's sustainable tram system, which improves mobility in the neighborhood.

Specifications for the Building

Traditional materials and contemporary construction methods are used in the energy-efficient and sustainable buildings in Msheireb Downtown Doha. The development's dedication to green building standards has earned it LEED certifications.

Smart Management Technologies

The district employs advanced smart city solutions, including a building management system, smart meters for utilities, and high-speed connectivity. These technologies contribute to efficient resource management and enhanced quality of life for residents.

(Law, R., and K. Underwood. 2012.) See location in Fig (1)

Figure (1) shows location of site Area

Author based on: https://www.arrus-intl.com/projects/msheireb-downtown-doha/ review on 04-02-2025

Fig (2) Shows Land use map of Msheireb City

Author based on master plane last review on 05-02-2025 https://www.msheirebproperties.com/locations/

The city of Msheireb includes more than 100 buildings with diverse activities and uses, but they share the same architectural designs that reflect the local culture and take into account the climate and nature of the region in the design principles, as shown in the land uses within the city's basic design plan.

Figure (3) Shows the urban architecture and sustainable transportation within Msheireb City.

Author based on https://www.msheirebproperties.com/msheireb-downtown-doha/about-msheireb-downtown-doha/character-areas/ review on 06-02-2025

Masdar City – UAE

Land Use

A planned urban development, Masdar City is intended to serve as a center for clean-tech businesses. It consists of business buildings, residential areas, and research facilities, all of which were constructed with sustainability in mind.

Planning for Transportation

In order to reduce carbon emissions, the city emphasizes pedestrian-friendly design and has electric cars, a Personal Rapid Transit (PRT) system, and other environmentally friendly transportation choices.

Specifications for the Building

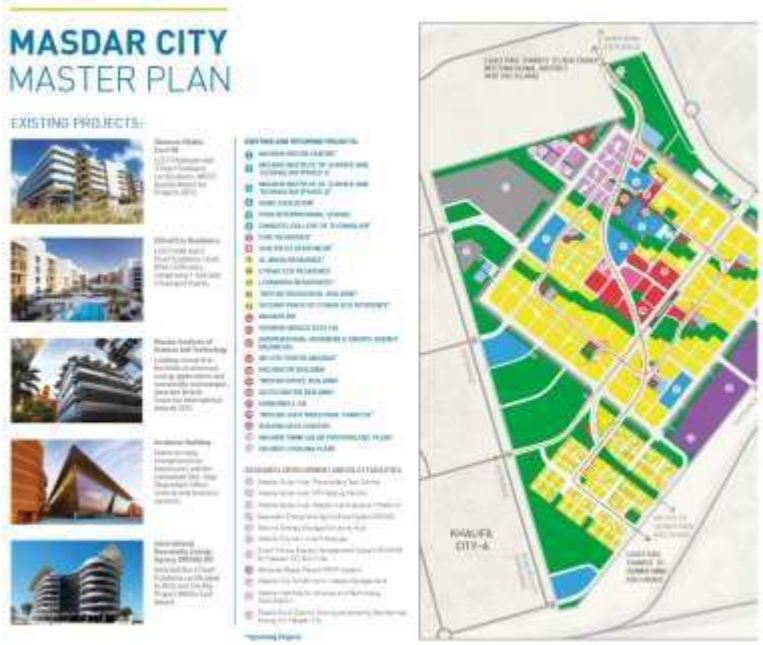
Many of Masdar City's buildings have received ratings under the Estidama Pearl Building Rating System, demonstrating that they are built to strict sustainability requirements. Passive design techniques are used in the architecture to lower energy usage.

Technologies for Intelligent Management

To maximize energy utilization and help achieve its aim of being a carbon-neutral society, the city combines energy-efficient systems, smart grid technologies, and real-time monitoring. (Nikhil Manghnani, 2014, P:4)

Figure (4) Shows location of site Area Masder City.

Author based on https://masdarcity.ae/docs/default-source/pdf-to-download/masterplan_21-12_english_v2.pdf?sfvrsn=a6dd270e_3 review on 07-02-2025



Author based on master plane

Fig (2) Shows Land use map of Masder City https://masdarcity.ae/docs/default-source/pdf-to-download/masterplan_21-12_english_v2.pdf?sfvrsn=a6dd270e_3 last review on 07-02-2025

NEOM City - Saudi Arabia Land Use

NEOM is a projected cross-border city located in northwest Saudi Arabia's Tabuk Province. It seeks to serve as a tourism destination and integrate smart city technologies. The project encompasses a number of zones, including commercial, residential, and industrial regions.

Planning for Transportation

To effectively connect its several regions, NEOM intends to put in place a multi-modal transportation infrastructure that includes high-speed transit and driverless electric vehicles.

Specifications for the Building

With plans for buildings that use state-of-the-art building techniques and materials to reduce their negative effects on the environment, the city's design places a strong emphasis on sustainability and innovation.

Technologies for Intelligent Management

In order to improve the quality of life for its residents, NEOM is intended to be a "cognitive city," employing artificial intelligence and sophisticated analytics to proactively manage services and infrastructure. (Alsharif, M., & Ghabban, A. ,2021, P: 6)

Figure (4) Shows location of site Area NEOM City.

Author based on https://controltap.com/article/neom-projects-saudi-arabia/ review on 07-02-2025

Figure (4) Shows List of NEOM City's Visionary Projects in Saudi Arabia.

Author based on https://controltap.com/article/neom-projects-saudi-arabia/ review on 07-02-2025

Planning Overview

In the context of rapid urban transformation in the Gulf region, innovative urban models such as Msheireb (Qatar), Masdar (UAE), and NEOM (Saudi Arabia) illustrate distinct approaches to sustainable urbanism and smart city planning. These projects reflect a diverse range of priorities, from heritage revitalization and environmental design to digital urban planning, with each project responding to national development visions and global sustainability requirements. The following comparative analysis explores the distinctive planning and environmental features that shape each city's structure, along with their functions and future aspirations. See table (1)

Table 1 : A brief description of the planning and environmental characteristics of each city		
city	**Planning characteristics**	**Environmental characteristics**

Msheireb City - Qatar	1. Based on the urban renewal model in the heart of the capital, Doha, it aims to revitalize the historic commercial center with a modern approach. 2. The design features an integrated mix of land uses (residential, commercial, and cultural) within a high-density urban fabric. 3. It preserves the traditional Qatari architectural identity by integrating traditional architectural elements with modern technologies.	1. It relies on smart energy and water management systems and uses environmentally friendly building materials. 2. It employs an urban design that reduces reliance on cars by promoting pedestrian and public transportation. 3. Many of its buildings have achieved LEED (Leadership in Energy and Environmental Design) certification.
Masdar City - UAE	1. It is a global model for sustainable planning and is being built as a low-carbon urban community on the outskirts of Abu Dhabi. 2. It adopts a compact grid design that encourages walking and limits uncontrolled urban sprawl. 3. It aims to be vehicle-free and rely on smart electric transportation.	1. It is powered almost entirely by renewable energy sources, particularly solar power. 2. It adopts traditional climate architecture principles (wind towers, shading, and natural ventilation). 3. It aims to minimize its carbon footprint and is one of the first cities planned for net-zero emissions.
NEOM City - Saudi Arabia	1. A massive urban project planned to be a model for future cities based on artificial intelligence, robotics, and smart infrastructure. 2. One of its most prominent projects is "The Line," a 170-kilometer linear city with no cars and no roads. 3. It focuses on digital integration and provides access to services within just a five-minute walk.	1. It is planned to be a zero-emission city, free of carbon and waste. 2. 95% of NEOM's area will be protected for nature, preventing environmentally harmful horizontal expansion. 3. It will rely on clean energy and fully recycle water and waste.
Source : Researcher based on (Ali Abdul Samea Hameed, 2021) (T. Mezher , G. Dawelbait , I, Tsai , N. Al- Mariam I. Al-Hammadi , 2022) Hosany , 2016) (		

The comparison between Msheireb, Masdar, and NEOM reflects the contrasting approaches to urban planning, based on cultural contexts, environmental goals, and technological ambitions. While Msheireb prioritizes heritage preservation and improving quality of life, Masdar focuses on environmental sustainability, while NEOM aspires to create a future-oriented urban model powered by artificial intelligence technologies. Taken together, these cities offer valuable insights into how planning strategies can shape new paradigms for urban development in the Arab world and beyond.

Table 2 : General Comparison (Schematic View)

City	Nature of the project	Urban Planning	Energy and Environment
Msheireb City	Inner Urban Regeneration	Dense and Mixed-Use	Smart Resource Management
Masdar City	Sustainable Smart City	Compact and Walkable	Solar Energy/Low Carbon Footprint
NEOM City	Large-scale future city	Linear/Smart/Zero-car	Zero emissions, maximum environmental protection

Source : The researcher relied on previous sources..

Evaluation Model: LEED System

The LEED system, the globally recognized system for measuring the environmental efficiency performance of buildings and cities, was adopted as a standard framework for evaluating the sustainability elements of the three cities. It is used here as an analytical tool to compare each city's commitment to urban sustainability, using the category.

The analysis consists of six main axes:

- Location and planning.
- Water efficiency.
- Energy and atmosphere.
- Materials and resources.
- Indoor environmental quality.
- Innovation and regional priority.

Comparative analysis tool

A standard analytical matrix was developed to compare the three cities according to estimated scores for each LEED axis, based on available qualitative and quantitative information, with a contextual interpretation of each score within the local environment and community of each case.

5 = Excellent fit (complete and fulfilled implementation) 4 = Very good fit (most of the criteria are met)

3 = Good fit (clear partial implementation)

2 = Limited fit (initial or incomplete attempts) 1 = Poor fit (absent or weak implementation)

Each project is evaluated using a 5-star rating system to reflect performance in each category. This assessment highlights the relative strengths and areas for improvement in each development, providing insights into best practices in sustainable urban design in the MENA region. See table (3)

Table 3 : Comparative LEED-Based Evaluation

LEED Evaluation Category	Msheireb (Qatar)	NEOM (Saudi Arabia)	Masdar (UAE)
Location and Planning	5	4	5
Water Efficiency	4	4	5
Energy & Atmosphere	4	5	5
Materials & Resources	4	4	4
Indoor Environmental Quality	4	4	4
Innovation & Regional Priority	4	5	5

Source : The researcher relied on previous sources.

Comparison of results between the three cities within the clustering matrix.

A comprehensive comparison analysis of three sustainable urban developments is presented with four LEED assessment categories: Msheireb (Qatar), NEOM (Saudi Arabia) and Masdar City (UAE). How Each Project compares to Critical Sustainability Measures The matrix summarizes the strengths that are evident in each project at this stage of the RFP in tackling the critical sustainability measures: Location and Planning, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality and Innovation & Regional Priority. See table (4)

Table 4: Synthesis Matrix: Comparative Summary

LEED Evaluation Category	Msheireb	NEOM	Masdar

Location and Planning	Central location, traditional compact urban form, high transit accessibility	Futuristic planning, AI-driven smart mobility (in progress)	Walkable, integrated layout, excellent access to services and transit
Water Efficiency	Advanced water management, limited reuse	Full reuse systems, smart controls	Greywater recycling, smart irrigation, efficient management
Energy & Atmosphere	Solar energy usage, smart grid integration	Fully renewable-based, green hydrogen	100% solar-powered, smart grid, energy storage
Materials & Resources	High-efficiency traditional materials, local sourcing	Futuristic sustainable materials, high recyclability	Local sourcing, recycling, low carbon footprint
Indoor Environmental Quality	Natural ventilation, low emissions, good insulation	Smart environment systems, open comfortable microclimate	Healthy indoor air, daylighting, advanced controls
Innovation & Regional Priority	Fusion of heritage and modern design, climate-sensitive solutions	High-tech innovation, human-machine interface	Climate-adapted design, resilient urban planning
Source : Researcher based on (Ali Abdul Samea Hameed, 2021) (T. Mezher , G. Dawelbait , I, Tsai , N. Al- Hosany , 2016) (Mariam I. Al-Hammadi , 2022)			

Critical Discussion: Differences and Regional Appropriateness

Comparison of Msheireb, Saudi Arabia's NEOM and Masdar City demonstrates how sustainable urban development can take on distinct forms in response to varying geographic, cultural and technological opportunities. So here is a comparative overview of the major differences and how they apply locally:

Location and Planning

- Msheireb prioritizes classic, descending urbanism that matches the cultural visuals of Doha and the consideration of efficient land use for a small, dense city center. Its transit- oriented design fits in well with the region's urban development.
- NEOM, on the other hand, is a futuristic greenfield project -- a monument to future planning and a future that will be defined by AI and autonomous driving. Novelty, however, its complete match with the regional context remains to be seen as it is at its early stage.
- Masdar provides an ideal as a balanced model, a walkable car free urban design that responds to environmental resources of the city of Abu Dhabi and encourages less carbon mobility with a tried and regionally adaptable structure.

Water Efficiency

- Conservation and reuse of water is a necessity, given the arid nature of the Gulf. NEOM's high-tech reuse systems and smart controls offer the most technologically advanced response, but these are not yet widely operational.
- Masdar's greywater recycling and intelligent irrigation are proven techniques suited to a Middle East water scarce ecosystem.
- Msheireb demonstrates rather moderate efficiency, and a relatively low reuse capacity could raise medium to long-term sustainability issues in water-scarce environments.

Energy and Atmosphere

- Masdar's 100%-solar-powered, renewable energy storage solution is a grown-up, location-appropriate reaction to a fierce solar resource.
- The green hydrogen and 100% renewable energy system of NEOM, are ambitious but unproven in harsh desert environments.

- The partial solar integration of Msheireb and the way it uses the smart grid represents an incremental yet down-to-earth approach that can potentially be retrofitted into existing urban grid.

Materials and Resources

- Msheireb demonstrates cultural and environmental consciousness by utilizing traditional locally sourced construction materials. Local looks are preserved while the embodied carbon is eliminated.
- If it fits geography and lifespan-wise (See above), NEOM's focus on futuristic, recyclable technologies is a focus on sustainability with an eye towards the future
- The low carbon, resource-efficient approach of MASDAR, however, functions as an intermediary between the technical and the natural environment.

Indoor Environmental Quality

- Masdar leads in promoting healthy indoor environments, leveraging daylighting and advanced environmental controls to combat the region's harsh climate.
- Msheireb integrates natural ventilation and passive cooling, aligning with vernacular design traditions.
- NEOM's smart environmental systems are promising but remain largely theoretical until implementation can be assessed.

Innovation & Regional Priority

- NEOM is the most wide-ranging in terms of innovation, ploughing ahead with AI integration and post-human urban design, but is yet to discover its local relevance.
- Msheireb is a pioneering development that seamlessly integrates heritage with green and climate-sensitive architecture and will become a replicable model for the region's historic downtowns.
- Masdar provides robust climate-resilient planning with proven technologies that not only shows works; but is scaleable across the ME.

Both projects have unique strengths based on their regional forebears, stage of development, and approach to design. NEOM is a concept that outlines a whole new vision for future cities and has yet to be seen if it is viable on the ground. There is a technologically sophisticated and ecologically responsive model at Masdar City and a culturally rooted story of sustainability in 9a dense urban habitat at Msheireb. These differences remind us that innovation needs to be adapted more closely to the characteristics of the region, it school, cultural identity or environmental limits in order to ensure its sustainability over the long term.

Conclusions

1. **Regional Differentiation in Varied Approaches:** Msheireb, Masdar, and NEOM: differentiate but contextually-specific comparison: The circumstance of the place-led and cultural-led and technology-led (inclusive place and culture and technology) circumstance based/related with the technology, culture, and geography so for the Msheireb, Masdar and NEOM (issues in designs for sustainable futures analogy. Masdar emphasizes ecology and renewable technologies, Msheireb focuses on history and high-density urbanism, and NEOM aspires to pioneer AI-led urbanization.
2. **Importance of Cultural and Environmental Compatibility:** A sustainable urbanism approach is effective when technological systems are in accordance with the environmental conditions and cultural characteristics of the region. Msheireb is simply traditional materials and passive cooling, but is an example interpreting the culture; Masdar is simply solar panels suited to the climate.
3. **Applicability and Technology Readiness:** Masdar City serves as a living example of ecologically viable and technically feasible urban planning with a template for sustainable urban development in desert regions. While NEOM, on the other hand, underlines the need for gradual deployment and verification even if mostly speculative in its goal..

4. **Striking the Balance between Innovation and Regional Appropriateness:** Innovation is crucial but needs to be locally attuned if it is to be sustainable and socially acceptable. The wisdom of NEOM's high-tech vision needs serious scrutiny, and if it is to be effective, it must be tailored to meet local needs.

5. **Implication for Future Urban Planning:** his study insists that a systemic approach involving ecological resilience, resource efficiency, technological innovation and heritage conservation is essential for sustainable urban development in desert areas. These examples are rich lessons in how to make resilient, ecologically responsible and culturally meaningful cities.

In general, the projects Msheireb, Masdar, and NEOM all serve as examples of the way region-based local priorities shape sustainability strategies. To achieve long-term sustainability and resilience, regional context, cultural heritage, and technological advances have to be incorporated into an overarching scalable urban planning frameworks that are flexible, pragmatic, and holistic.

Recommendations

1. **Enhance Contextual Adaptation of Technologies:** Technology that are adaptable to the local environments and social contexts should be readily implemented as a part of future sustainable urban projects. For enhanced viability and receptivity, for instance, passive cooling, and conventional building materials should have preference over leading edge technologies.

2. **Promote Phased Implementation and Validation:** The viability of futuristic concepts such as obligatory AI integration and green hydrogen energy can only be seen in practical work; to this end, new models like NEOM should be tried on a small scale first to guarantee that they work before being scaled up.

3. **Integrate Cultural Heritage with Sustainability:** To promote societal acceptability and maintain regional character while accomplishing environmental goals, urban design initiatives should keep incorporating local cultural identities, as demonstrated in Msheireb.

4. **Invest in Regional Infrastructure and Policy** Frameworks: To increase the efficacy of sustainable cities, governments should create infrastructure and supportive regulations that enable sustainable practices, such as eco-friendly urban planning, renewable energy, and intelligent water management.

5. **Give Priority to Stakeholder Participation and Community Engagement**: Involving local communities, stakeholders, and experts in urban planning procedures will guarantee that development initiatives are economically viable, environmentally responsible, and socially inclusive.

6. **Encourage Knowledge Sharing and Regional Cooperation:** Regional collaboration should be fostered to share best practices, technologies, and innovations among Middle Eastern cities. This cooperation can accelerate the adoption of contextually suitable sustainable urban strategies.

7. **Invest in Monitoring and Continuous Improvement:** Implement comprehensive monitoring systems to evaluate the performance of sustainability practices over time. Data-driven assessments will support continuous improvements and adaptive management strategies.

8. **Balance Innovation with Cost-Effectiveness:** While cutting-edge technologies are vital, sustainable projects should also consider economic feasibility to ensure long-term maintenance and scalability, especially in resource-constrained environments.

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