



Eco-towns, Sustainable Development and Challenges Facing a Green Future in West Asia: A Case Study of Masdar City in the UAE

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ABSTRACT

Since the 1970s, the development of urban environments designed to support sustainable lifestyles—integrating urban planning, ecology, and civic participation—has emerged as a primary global solution to environmental degradation. The West Asia region, characterized by rapid urbanization, population growth, diverse environmental pollutants, and acute water scarcity, faces a unique set of challenges. Furthermore, regional nation-states have implemented long-term development programs that necessitate rigorous environmental considerations. This article presents a case study of Masdar City in the UAE, reviewing the national policies adopted to attain and ensure sustainable development. Employing a descriptive case study methodology, this research examines the challenges the government faces in meeting the ecological standards established in the original project design and advocated by eco-city theorists. The author argues that while the UAE's initiative to develop an eco-city is fundamentally sound—driven by both environmental imperatives and tourism objectives—some green ambitions remain unfulfilled due to the state's tendency to prioritize commercial interests over the holistic goals of ecological urbanism. Additional challenges include the fragility of societal infrastructures and inequitable access to urban facilities, which disproportionately favour affluent segments of the population.

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Introduction

The publication of the Brundtland Report, *Our Common Future*, by the World Commission on Environment and Development in 1987, laid the foundations for the concept of sustainable development. The report defined this concept as: “humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations Brundtland Commission, 1987: 24). Concurrently, urban theorists began to conceptualise the ‘sustainable city’ as a primary approach to achieving sustainable development. Sustainable urban development can be defined as “a process of synergetic integration and coevolution among the great subsystems making up a city (economic, social, physical and environmental), which guarantees the local population a non-decreasing level of well-being in the long term, without compromising the possibilities of development of surrounding areas and contributing by this towards reducing the harmful effects of development on the biosphere” (Camagni, 1998). At the core of this concept lies the understanding of the city as an ecosystem, the sustainability of which is indispensable to human life. Indeed, human sustainability is fundamentally dependent upon the ecological sustainability of urban centres (Barati, 2022; Wong & Yuen, 2011: 3). The idea of building eco-cities emerged as a solution to two important global challenges: expanding urbanization and climate change (Joss et al., 2013, p. 55). According to UN-Habitat (2008, in Suzuki et al., 2010: 14), “world’s population living in cities is expected to grow to almost 5 billion by 2030” and “over 90 percent of the urban growth is taking place in developing countries”. Suzuki et al. (2010: 16) regard “unprecedented consumption and loss of natural resources” as two inevitable consequences of urbanization at this rate. As shown in Figure 1 the world population distribution by size and class of settlement and region from 2018 to 2030 published by the United Nations Environment Programme and United Nations Human Settlements Programme in 2021

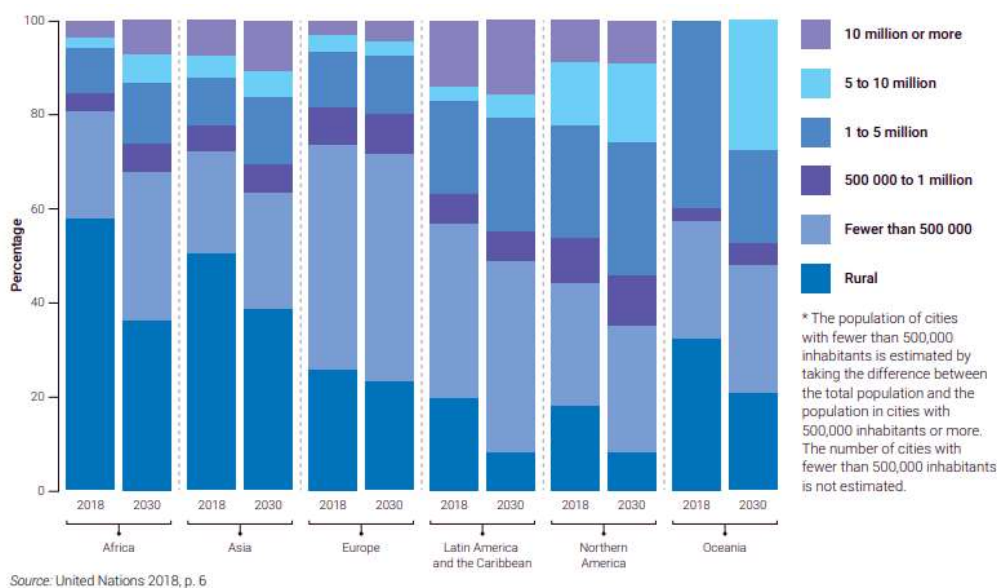


Figure 1. The world population distribution by size and class of settlement and region from 2018 to 2030.
Source: (United Nations, 2018: 6, in United Nations Environment Programme and United Nations Human Settlements Programme, 2021: 23).

As Figure 1 shows, across all five continents, the rural population is decreasing, and urbanization increases from 2018 to 2030, meaning that more and more people are going to live in cities in the near future; a fact that in turn highlights the significance of urban areas. Seto et al. (2012: 44) mention ‘city’ as “a nexus of connections in time and space”, noting that “an important feature of urban areas is that they continuously exchange people, goods, resources and information with other places”. The ideal long-term perspective of eco-city building is to create balance between economic development, ecological sustainability and social justice. Cities are regarded as having a defining role in strategic sustainable development, as to be mentioned in the United Nations 2030 Agenda as a target to be made more sustainable, resilient, inclusive, and safe (Bibri, 2020: 2).

According to British Columbia Institute of Technology (2025), an eco-city is a human settlement modelled on the self-sustaining resilient structure and function of natural ecosystems:

- It provides healthy abundance to its inhabitants without consuming more renewable resources than it produces.
- It functions without producing more waste than it can assimilate or recycle for new uses, or than nature can dilute and absorb harmlessly, and without being toxic to itself or neighbouring ecosystems.
- The impacts of residents’ lifestyles are in balance with the Earth’s ecology carrying capacity; its social order reflects fundamental principles of fairness, justice, reasonable equity and consensus, and allow for high levels of happiness.

Wong and Yuen (2011: 3) state that an eco-city “suggests an ecological approach to urban design, management and towards a new way of lifestyle” where “the advocacy is for the city to function in harmony with the natural environment”. Joss (2011: 269) recognizes three phases as for the historical development of the notion of eco-cities:

- Phase I: 1980s to early 1990s; grassroots movement/visions. At this phase, the term ‘eco-city’ was first coined in the context of the rising environmental movement, notably by Richard Register and a series of international eco-city conferences were held. But eco-city was mainly a normatively prescriptive concept with few practical examples
- Phase II: 1992 to early 2000s; local and national experimentation. The United Nations ‘Earth Summit’ in Rio de Janeiro (1992) and the resulting sustainable development programme (‘Agenda 21’) formed the background against which eco-city concepts were increasingly translated into practice. In this period, practical efforts were made to model eco-city examples such as: Curitiba (Brazil), Waitakere (New Zealand) and Schwabach, (Germany).
- Phase III: 2000s to present; global expansion/policy mainstreaming. Thus, eco-city initiatives are visible in numerous geographies around the globe; and several high profile policy initiatives at national and international levels have begun to promote eco-city innovation, such as the Clinton Climate Initiative, the European Commission’s Eco-City Project, and the World Economic Forum’s SlimCity knowledge exchange initiative.

The implementation of eco-city projects began in East Asian nations, such as China and Japan, in the late 1990s, before garnering significant attention across West Asia by the mid-2000s. The last two decades have witnessed a surge in ambitions among Arab governments to promote eco-city developments, including The Line and NEOM in Saudi Arabia, Msheireb Downtown Doha and Lusail City in Qatar, the Masdar project in the United Arab Emirates, Yiti and the Blue City in Oman, XZERO City in Kuwait, and Eco-city Bahrain, to name but a few. A critical question arises: how effectively can these projects operate in response to the region's requirements for adapting to current and future global environmental challenges?

This article presents a descriptive case study of Masdar City in the UAE, reviewing how an Arab state of the Persian Gulf seeks to attain and ensure sustainable development, thereby creating a balance between the social, economic, and environmental dimensions of progress. The objective is to examine the challenges the UAE government faces in meeting the ecological standards provisioned in the original project design and promised by eco-city theorists.

Materials and Methods

The theoretical foundations of eco-city development can be traced to urban planning literature, which dates back to the late nineteenth century. Gaffron et al. (2005: 14) assert that various historical and contemporary concepts of urban planning have played an instrumental role in shaping the vision of the eco-city. These concepts encompass several facets relevant to the eco-city model, including: "the interdependence of urban and transport planning, the relationship between rural and urban tissue, urban density, the territorial context of cities, the city as a social stage, and the preservation of material and energy resources". Gaffron et al. (2005: 14–15) characterise these ideas as having evolved from the 1860s to the 1970s.

In the twentieth century, the term 'eco-city' was popularised by Richard Register in his 1987 book, *Ecocity Berkeley: Building Cities for a Healthy Future*. Register proposed "building the city like a living system with a land-use pattern that supports the healthy anatomy of the whole city, enhances biodiversity, and makes the city's functions resonate with the patterns of evolution and sustainability" (Wong & Yuen, 2011: 3). He identified fifteen characteristics for his ideal eco-city, namely: "proximity-based access, clean air, healthy soil, clean and safe water, responsible resources and materials, clean and renewable energy, safe and accessible food, healthy culture, building healthy social capacities and participation, healthy and equitable economy, lifelong learning, quality of life, healthy biodiversity, land carrying capacity, and ecological integrity" (Barati, 2022: 78).

Other theorists of the field, Mark Roseland (1997; 2012), Philine Gaffron (2005), Paul Downton (2008), Zhifeng Yang (2012), Ken Yeang (2009), Rodney R. White (2002; 2004) and Elias Bibri & John Krogsti (2020) each have developed theoretical basis with specific features of their ideal eco-cities.

In general, the approaches to building eco-cities can be categorized on the basis of the following measures: 1. Renewable energy use, 2. Carbon neutral, zero carbon or low carbon features, 3. Garden city, 4. Resource efficiency, 5. self-sufficiency, 6. Distribution and decentralization, 7. Smartness. Table 1 below shows a typology of approaches to eco-city building objectives, features and examples.

Table 1. Typology of approaches to eco-city building objectives and features

Model	Description	Case Example
Renewable energy city	The city's energy, from buildings to districts and the entire city, is supplied by renewable sources at different scales. Depending on local conditions, sources such as biofuels, sunlight, wind or geothermal energy can be used. Cities are required to rebuild their infrastructure (such as power generation and buildings) and institutions in a way that allows for the penetration of renewable energies	Masdar City in the United Arab Emirates, the solar city of Dezhou in China and Vauban on the outskirts of Freiburg in Germany
Carbon neutral city, zero carbon city, low carbon city	The city aims to become carbon neutral by improving energy efficiency and replacing fossil fuels with renewable energy sources. There are several initiatives to achieve zero carbon emissions on a small scale, such as within buildings or at the district level. Reducing greenhouse gas emissions is an integral part of many eco-city projects.	The UK government's requirement to reduce carbon emissions in all public sector urban developments by 2016 and the China Low Carbon Cities Project
Garden city	This city uses intensive green space as part of the urban environment. Green spaces can be located in low-density areas of the city, such as suburbs, or they can be integrated into man-made environments, such as green roofs. Urban green spaces can also be used for urban agriculture, planting renewable energy devices, and greening densely populated areas of cities.	The Honeybee Project 1 is considered as a model of "Satoyama" in the Ginza district of Tokyo's business district (Japan).
Resource efficient city	The city relies on both upstream and downstream waste management systems. The city encourages the use of sustainable resources in production and consumption patterns, while also equipping it with city-wide infrastructure designed to maximize 3R2 (reduce, reuse, recycle) habits, waste-to-energy technology, and sustainable composting.	Many cities in Japan, industrial coexistence in the UK, circular economy in China and industrial eco-parks in South Korea
Self-sufficient city	Environmental efficiency is achieved through local and self-sufficient production and consumption. The city can save on the economic and environmental costs of importing as well as exporting products and services by making maximum use of the city's resources.	The concept of self-sufficiency economy in Thailand and Yusohara in Japan.
Distributed city	By relying on small-scale, neighborhood-based water and energy systems, the city can save on the costs of the centralized system transition process.	Small-scale community sewage system in Hyland, New South Wales, Australia. Hybrid photovoltaic-diesel systems to power 64 schools in Borneo, Malaysia.
Smart city	The city uses information technology as part of improving environmental sustainability. For example, a city can provide real-time information through its transportation network and enable interactive data management in green building, energy, water, and waste systems.	Smart City Project in Yokohama Japan.

Source: Newman et al., 2009, in Nourani Jodaghia & Farnam, 2024: 9-10

Generally speaking, a three-dimensional set of objectives is assumed for eco-city development based on the three areas in which the basic idea of sustainability emerged. Figure 2 shows the sustainable objectives behind eco-city building.

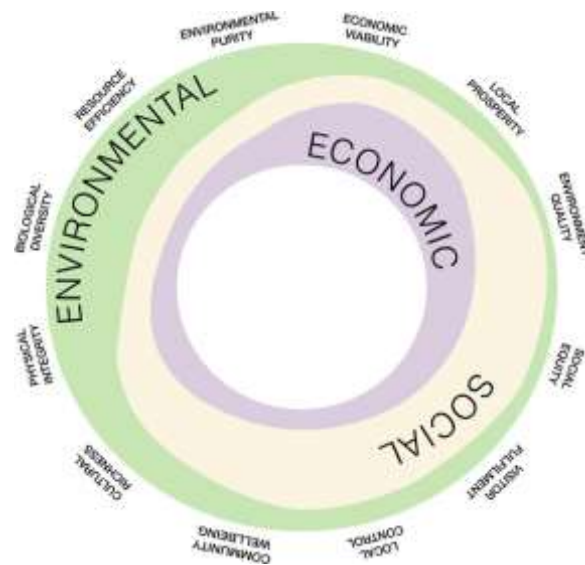


Figure 2. UNWTO sustainable objectives.

Source. United Nations World Tourism Organization, in Dunn and Jamieson, 2011: 96

As this article seeks to review the features of Masdar City, it relies on the provisions and objectives established for the project to analyse its characteristics, status, and challenges—specifically its renewable energy and zero-carbon mandates—within the framework of a case study. Creswell et al. (2007: 245) describe a case study as “a qualitative approach in which the investigator explores a bounded system (a case) ... over time through detailed, in-depth data collection ... and reports a case description and case-based themes”. They divide case studies into several categories, including descriptive, explanatory, exploratory, illustrative, cumulative, and critical instance.

This paper employs a descriptive design to explore how Masdar City and its specific features can be scrutinised as an instance of efforts to harmonise environmental concerns, economic aspirations, and social justice within the city as an ecosystem in West Asia. Descriptive research is used “to describe characteristics of certain phenomena, and does not address questions about how, why, or when the characteristics occurred—no causal relationships” (Bibri, 2020: 4).

In this study, data were collected from primary and secondary sources. Official statements from the UAE government concerning the facts and features of the project are utilised as authoritative sources regarding Masdar’s status at various stages of development. These sources include official documents, reports, and interviews with key stakeholders. Furthermore, the discussion section references the work of subject matter experts, drawn from academic manuscripts and media articles. In the following sections, a comprehensive overview of the Masdar City project is provided, examining both its design and objectives, including a detailed description of the city’s specific characteristics. Masdar is contextualised as the original initiative designed to meet dual objectives: zero-carbon and zero-waste status. Subsequently, the reality of the project as it proceeded is scrutinised, and the current situation is analysed to determine whether and how these objectives have been achieved across the three focal areas of sustainability. The challenges to the project’s implementation are discussed in the concluding section.

Results and Discussion

Masdar City is the UAE project was launched with strong political backing in 2006 with the ambition to become the first zero carbon city in the world and a model for the future eco-city building. Assuming that sustainability is “a fundamental philosophy that governs every aspect of our design, development, operations, and business strategy” (Masdar City, 2024), the original objectives of the city included:

- optimisation of solar energy through maximising efficiency gains
- integration of all aspects of city life by providing minimal use of transportation
- limiting height of construction and buildings
- providing high quality of life in an efficient ecosystem and environmentally smart way (UAE Government, 2025).

In the interim, Table 2 shows other basic information about the city:

Table 2. Masdar City basic information

Location	desert/ 17 kilometers east-south-east of the city of Abu Dhabi, beside Abu Dhabi International Airport, UAE
Surface Area	6 km ²
Population capacity	50,000 people
Start year	2006
Initial investment	\$22 billion

Masdar City was expected to house 50,000 people as residents and support a floating population of additional 40,000 people. The city's primary objective was to carbon management under the United Nation's (UN) clean development mechanism (CDM) framework, setting up Renewable Energy-based power plants and running the Masdar Institute, a university being developed in collaboration with the Massachusetts Institute of Technology (MIT) with focus on the science and engineering of advanced RE (Premalatha et al., 2013: 664).

The project is owned by the Mubadala Development Company, a government-owned investment body responsible for economic development projects across the country. Administrative affairs were assigned to the Masdar enterprise, which comprises five integrated units: Masdar City, Masdar Carbon, Masdar Capital, Masdar Power, and the Masdar Institute of Science and Technology. Masdar City was planned as a special economic zone offering 100% foreign ownership and tax exemptions to incentivise international investment in the region.

International collaboration began during the design and construction phase. The design of the city, the formulation of sustainability standards, and the development of the Masdar Institute campus were entrusted to London-based Foster + Partners. Other international partnerships included: Adrian Smith + Gordon Gill Architecture (Chicago) for the design of the Masdar Headquarters; LAVA Architects (German/Australian) for the Masdar City Centre and the cooling towers; Atkins for infrastructure; Mott MacDonald for infrastructure consulting; CH2M Hill for programme management; the Al Jaber Group for infrastructure construction management; Siemens for the innovative power grid and advanced building technologies; General Electric for peak power demand reduction strategies; Al Falah Ready Mix for the manufacturing of low-carbon concrete; and BASF for construction materials and system

solutions (Alusi, 2011, p. 8). Additionally, on 21 June 2009, the Abu Dhabi Future Energy Company (representing the Masdar City Project) signed a cooperation agreement with the Fraunhofer-Gesellschaft, a prominent European applied research institution, to partner on sustainable urban development and building planning, including solar climatisation and solar-thermal process heating (European Commission, 2009).

The city's original master plan consisted of six phases, expected to be fully completed by 2016. The first phase included the construction of the Masdar Headquarters, the Masdar Institute, and the initial residential, office, and community infrastructure. The city was designed as a carbon-neutral, zero-waste settlement incorporating Arabian design principles and striking architectural elements. The developers stated their commitment to "not only... building one of the most sustainable cities in the world, and one that is an attractive place to live, but also to achieving this in a commercially viable manner" (Manghnani & Bajaj, 2014, p. 39). The city's project partnership network is illustrated in Figure 3.

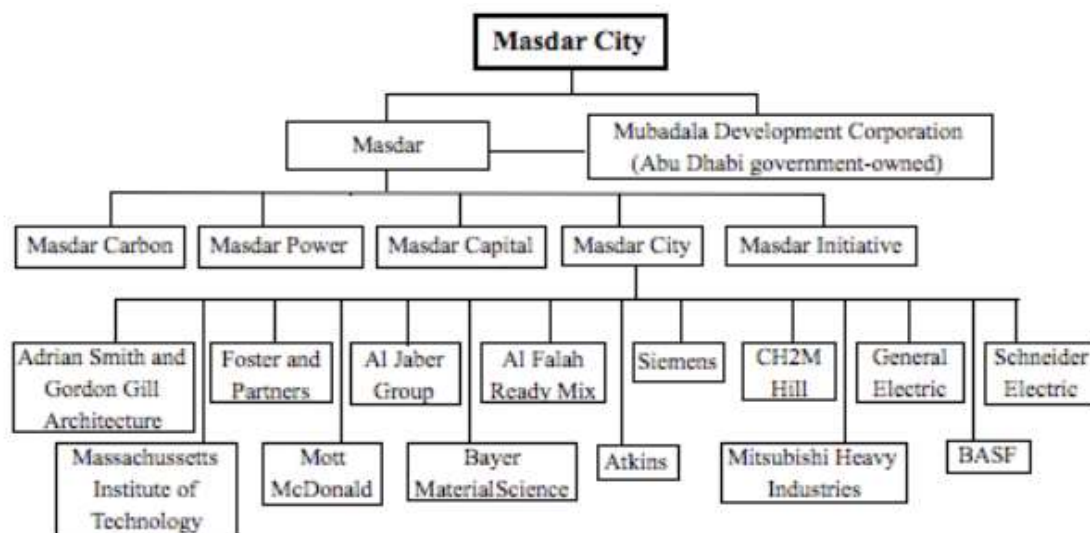


Figure 3. Masdar City Project Partnership Network

Source. Alusi et al., 2011, p. 22

Masdar City is designed to be a hub for clean-tech companies with environmentally sustainable features and smart technologies. It hosts the International Renewable Energy Agency (IRENA)'s Global Head Quarter (HQ) with an area of 32,000 square meters of commercial office space (IRENA, 2015). Both large global corporations/MNCs and small and medium enterprises can have offices in the building which is environmentally sustainable (designed to conserve water, promote biodiversity and create thermally comfortable outdoor spaces (Madakam & Ramaswamy, 2016, p. 5)) and deploys Internet of Things (IOT) technologies.

The architectural design was meant to maintain traditional Arabian features rooted in indigenous wisdom and post-modern elements of intelligent buildings that seeks to minimize energy and material use. Since the city was being built in desert, maintaining temperature was a big challenge. One way to solve the problem was to make shades on the windows angled to avoid direct sunlight, providing light without heat. The shading system works with a technology that automatically opens and closes its shades in response to air pressure changes resulting from

temperature variation (ARUP, 2022). The buildings' positions are designed so as to shade each other from desert sunlight. The use of sunlight reflectors and heat insulators on the building walls was meant to avoid desert hot weather passing into the buildings. Walls are designed to have vents to let the hot air escape and support wind movement that would have a cooling effect (Premalatha et al., 2013: 664). While the lattice work protects inhabitants from direct sunlight, the curves provide an angled view that prevents the inhabitants from seeing into the windows of other buildings to meet "Middle Eastern norms for personal privacy" (Lau, 2023: 78). The pedestrians are also shaded so that the city feels 5 to 10 degrees Celsius cooler than the surrounding area (PWC, 2023). Figure 4 shows the architectural features of Masdar residential buildings.



Figure 4. Masdar City sample architecture.
Source. The Executive Center, 2025

A primary priority for the city was to reduce energy consumption by "deploying the best commercially available international energy-efficient techniques such as insulation, low-energy lighting specifications, the percentage of glazing (i.e. windows), optimising natural light, and installing smart appliances and smart building management systems" (Manghnani & Bajaj, 2014: 39). The rationale behind these provisions was to implement strict controls over energy usage to ensure that the city required only one-quarter of the energy supply of a conventional city with the same population (Fortson, 2009, in Lau, 2023: 77).

The zero-carbon mandate implied that the city was intended to function entirely without the use of fossil fuels. Energy was to be generated through renewable sources, including solar thermal, photovoltaic, and wind power (Crampise, 2008; Bullis, 2009; Palca, 2008, all in Premalatha et al., 2013: 664). Furthermore, the city's energy generation plan incorporated the utilisation of geothermal and hydrogen energy. Solar panels were also intended to contribute significantly to the city's electricity generation.

An important method for generating energy from sunlight in Masdar City was the 'Beam Down Project', regarded as "a step forward in concentrated solar power (CSP)" (Jabreili, 2013). The Masdar Institute of Science and Technology, Japan's Cosmo Oil Company, and the Tokyo

Institute of Technology collaborated to utilise ‘beam-down’ technology, which possesses the potential to convert solar irradiation into electricity. This process inverts conventional solar tower technologies by using mirrors (heliostats) to reflect sunlight towards a central tower to heat a transfer fluid and generate steam. The sunlight is then reflected from the tower down to a collection platform at the system’s base, a design believed to minimise energy losses within the process. Figure 5 illustrates the beam-down CSP system and provides a schematic of its operational mechanism.

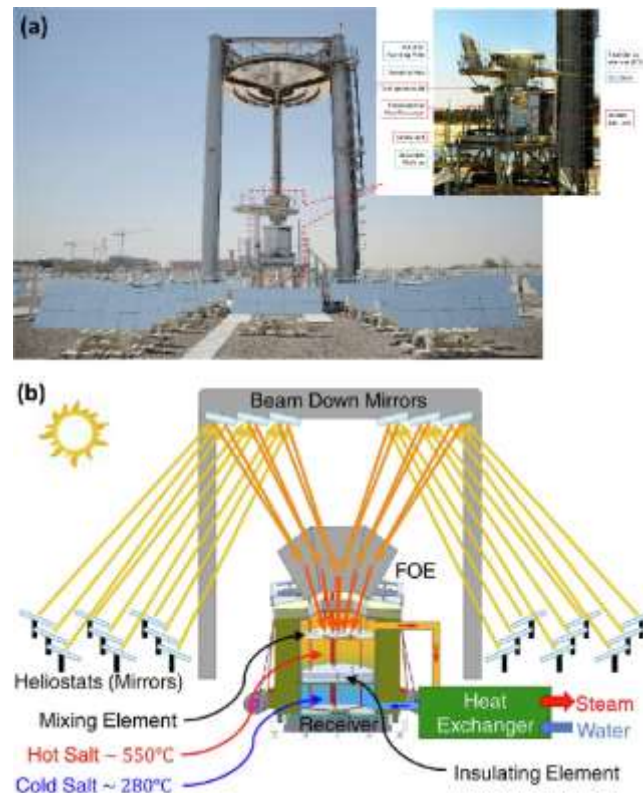


Figure 5. Beam down solar concentrator (a) Picture of beam-down CSP system at the Masdar Institute of Science and Technology, UAE. (b) schematic of working of beam-down system.

Source: Adapted from: AlQaydi et al., 2017; Calvet et al., 2021; Diago et al., 2018; Hamer et al., 2017, in Imran Khan et al. (2023: 206)

The original master plan for Masdar City envisioned a closed-loop system where all water used would be fully recycled, while residents would be encouraged to minimise their overall water consumption. Water-use reduction technologies include “high-efficiency appliances, low-flow showers, highly efficient laundry systems, a water tariff that promotes water efficiency, incentives, real-time monitoring, smart water meters that inform consumers of their consumption, reducing leakage ultimately to 1%, treated wastewater recycling, and high-efficiency irrigation and low-water use landscaping, particularly through use of indigenous desert flora” (Manghnani & Bajaj, 2014, p. 40). This reduction strategy was further integrated into the city’s landscaping through the selection of drought-tolerant plant species and the utilisation of treated wastewater for irrigation.

In addition to consumption reduction, the implementation of Membrane Bioreactor (MBR) technology was provisioned for Masdar City’s wastewater treatment. Wastewater Treatment

(WWT) is increasingly regarded as a global necessity for environmental preservation and the management of water scarcity. Among the various available technologies—namely Conventional Activated Sludge Systems (CAS), Conventional Activated Sludge Systems with Filtration Treatment (CAS-TF), immersed Membrane Bioreactor (MBR), and external MBR (Ortiz et al., 2007, in Pirani et al., 2012)—Masdar City planners selected MBR. This method utilises microfiltration or ultrafiltration “for the separation of sludge produced by biological treatments instead of using a clarifier for gravity settling as in conventional biological treatments” (Ur Rahman, 2023: 181). Now widely employed in municipal and industrial wastewater treatment plants, this advanced technology separates solids from liquids more efficiently than traditional clarifier-based gravity settling.

The zero-waste objective was assumed to be achieved first by encouraging reusable bags and containers and waste chutes. More importantly, the city was planned to have a vacuum waste system, transporting garbage to a Material Recycling Center. The garbage would be sorted and recycled there. What could not be recycled, was to be converted to energy using new technologies (Masdar, 2019).

The initial plan of the city provisioned a “car-free, fully pedestrianised public realm” (Elgendy, 2024). So, gasoline powered vehicles were not to be allowed to be used in Masdar. The city was planned to be built seven meters above ground to leave room for the Personal Rapid Transit (PRT), an underground transportation system consisting of small electric vehicles passing automatically without stop on rails. The passengers of these cars would choose the destination and the vehicle, controlled by computers, were expected to go the right direction and stop if it sensed another vehicle on its way. To ensure access to wider metropolitan areas, Abu Dhabi’s metro line was planned to pass through Masdar City. Figure 6 is a picture of the PRT vehicles.



Figure 6. A PRT vehicle used in Masdar City.
Source. Masdar City, 2024b

Analysis of Implementation Challenges

The Masdar City project can be analysed through the practical challenges encountered during its implementation, the most significant of which were economic. At the project’s inception, the global economy was stable; however, the onset of the 2008 global financial crisis rendered

Masdar's ambitious targets seemingly unattainable or prohibitively expensive in terms of both construction costs and deadlines. Due to the crisis, economic uncertainty deterred many potential investors, and the West Asian property market was subsequently weakened. Consequently, officials transitioned toward what Jensen (2025) describes as a 'pragmatic phase', in which "every aspect of the original vision had to be carefully re-examined and tested against more cautious feasibility studies". Project managers were forced to recalibrate their strategies to balance environmental goals with economic and social considerations (Elgendy, 2024). These adjustments included moderating ambitions from a 'zero-carbon, zero-waste city' to targets focused on reducing overall energy demand by 50%, embodied carbon by 30%, and operational carbon by 50%—relative to the 'business as usual' baseline in Abu Dhabi—as well as reducing water and landfill waste by 30% and 50%, respectively (Alusi et al., 2011: 7). Furthermore, project timelines were scaled back repeatedly; the completion date for full construction was pushed from 2016 to 2021–2025, and subsequently to 2025–2030. The initial 22 billion investment was also reduced to 18 billion due to these financial constraints (Cugurullo, 2013: 29).

However, the challenges were not merely economic, but also technical. As the project progressed, the concept of a 'zero-carbon' and 'zero-waste' city—encompassing both the construction phase and long-term operation—appeared increasingly impractical. Technological limitations made such goals economically unfeasible, leading the zero-carbon objective to be moderated to 'carbon-neutral'. As Cugurullo (2013: 28–29) notes, a Masdar representative admitted that "buzzwords such as 'zero-carbon' and 'zero-waste' were unrealistic" and "it simply was not working". Premalatha et al. (2013: 664) argue that a fundamental flaw in the Masdar City design was "the sheer impracticality of attaining 'zero carbon-zero waste' existence" due to the Second Law of Thermodynamics. They maintain that "there can never be any machine that can utilise all the energy given to run it, nor can there be any process that can operate without wasting some material or energy" (Premalatha et al., 2013: 665). While recycling and reuse are possible, these processes themselves require energy consumption; thus, they merely prolong an item's life cycle rather than achieving a true zero-waste state. In technical terms, "not all heat can be converted into work in a cyclic process" (Rao, 1997: 158; Reichl, 1980: 9). In Masdar City, these theoretical limitations manifested in practice. For instance, when the photovoltaic (PV) power plant became operational, desert dust accumulation on the solar panels reduced generation efficiency. Additionally, solar heating of the panels' dark surfaces led to thermal energy loss. Consequently, managers were forced to utilise water and manual labour for cleaning, while importing electricity (often from non-renewable sources) from the Abu Dhabi grid (Premalatha et al., 2013: 666). Furthermore, achieving these green goals requires dramatic shifts in resident lifestyles. Even if low-carbon objectives were met, citizens may lack the economic incentive to maintain a green lifestyle if it is no less expensive than a traditional, fossil-fuel-driven consumerist one.

Another critical dimension of urban environmentalism is social justice. The concept of the eco-city inherently incorporates social justice, perceiving the city as a context for human dignity

and welfare. Brand and Thomas (2005: 46) state that the social agenda of urban environmentalism emerged in the 1990s to address the need for credible data regarding citizens' welfare and quality of life. Within this framework, 'equity'—rather than mere 'equality'—is the core concept. Brand and Thomas (2005: 46) argue that since both wealth (leading to over-consumption) and poverty (leading to under-consumption) contribute to environmental degradation, the reduction of inequality is an implicit objective of sustainable development. While some economic assessments suggest no direct correlation between poverty reduction and sustainability, it is widely held that inequality manifests spatially in urban environments. Thus, equity and social justice are often viewed as prerequisites for environmental sustainability. Conversely, scholars have criticised the approach of viewing the eco-city as a self-sufficient, technologically-driven geography (Hodson & Marvin, 2010). They argue that such models often translate consumerism into an exclusive enclave for the wealthy, failing to produce the equity and social justice envisioned by eco-city theorists.

In the case of Masdar City, the connection between social justice and environmentalism remains ambiguous. The management appears to have adopted a consumerist approach. While a '20 per cent policy' exists to reserve a small area for low-income workers, there is no clear definition of who qualifies as a 'low-income worker', nor is there a transparent implementation strategy. This suggests a preference for symbolic environmentalism over economic reality. A significant tension exists between the city's profitability and its capacity for inclusive sustainability (Kashef, 2015: 13). While Masdar City exemplifies technological and environmental advancement, it also highlights the neglect of the large population of low-wage migrant workers whose voices are absent from official narratives. This labour force is often unable to access the benefits of Masdar's sustainable objectives due to the high cost of services. Ultimately, the 20 per cent policy itself may reflect spatial segregation based on economic status, contradicting the societal dimension of sustainable development.

Notably, a primary driver behind the project has been commercial. Masdar City was designed as a showcase for sustainable technology—a 'living lab' to "test new technologies and see how they respond in a concrete urban context" (Cugurullo, 2013: 30). Cugurullo (2013: 29) describes the project as a "state-owned, commercially driven enterprise" where "attracting capital and making money are its main goals". The green technology sector is engaged through platforms such as 'The Future Build' (TFB) web portal. Furthermore, Masdar City hosts international events like the World Future Energy Summit (WFES) and the European Future Energy Forum (EFEF), serving as marketing venues for green products.

Beyond commerce, a city requires a resident population to function; without citizens and customers, capital circulation would cease, leaving the project as little more than infrastructure. Although the original capacity was set at 50,000, as of November 2023, only approximately 4,000 residents lived in Masdar City (PWC, 2023). Project managers have been criticised for creating a "technologically advanced yet socially exclusive enclave" (Kashef, 2025: 13). The city appears designed for specialists and the affluent, lacking the cultural diversity essential for socially sustainable urbanism. It remains uncertain whether Masdar can attract the population levels originally envisioned. While the city uses Key Performance Indicators (KPIs) to measure

social aspects, Cugurullo (2013: 32) argues that the definition of being ‘socially accepted’ is narrowly reduced to citizen ratings of green products and services on the TFB platform.

A summary of the Masdar City project indeed reveals a complex transition from ambitious environmental objectives to pragmatic, commercially-oriented outcomes. Figure 7 illustrates this progression from initial goals to current realities.

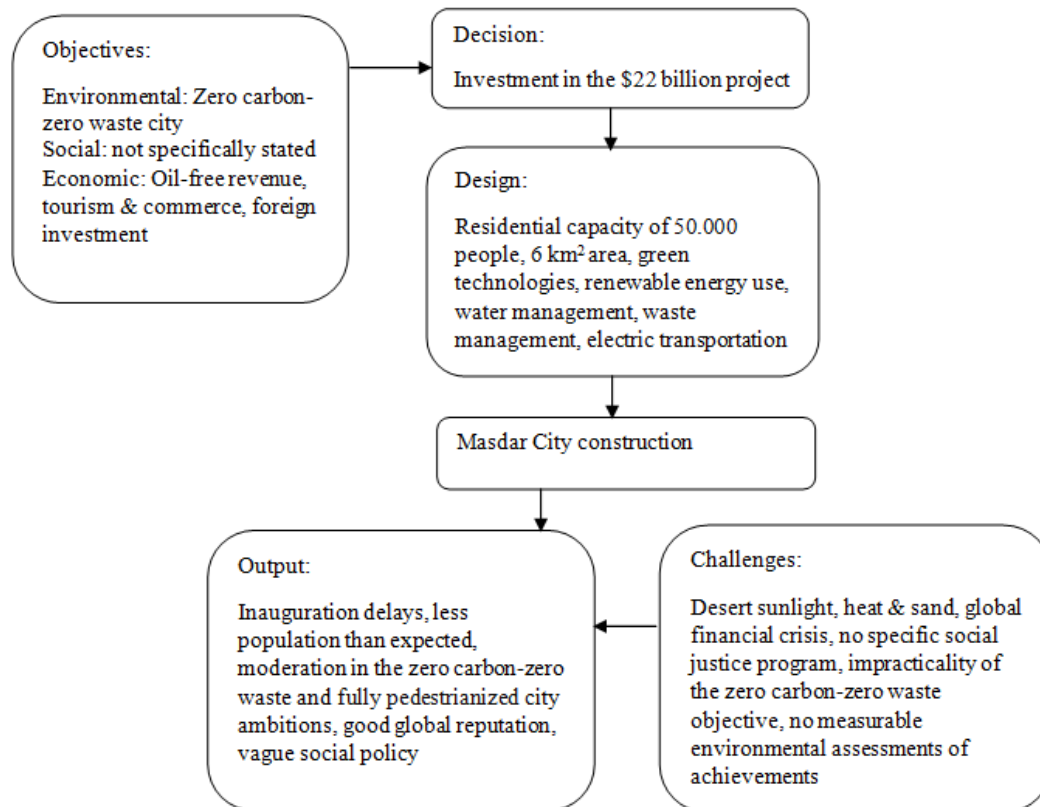


Figure 7. Masdar City Project Model.

Source. Author Findings

A critical avenue for an in-depth exploration of the Masdar City project entails a direct comparative evaluation between its stated objectives and its tangible outputs. As Figure 7 illustrates, the zero-carbon and zero-waste goals proved unattainable, and a clearly articulated social policy was absent at the project’s inception. Due to the inherent impracticality of the zero-carbon, zero-waste ideal, targets were subsequently moderated, while the lack of precise social benchmarks contributed to a significantly smaller resident population than originally projected. The impediments to achieving these objectives were both technical and managerial in nature. The harsh desert climate, the fallout from the global financial crisis, and the absence of a robust social justice framework collectively forced the recalibration of initial targets and the neglect of broader societal considerations. Conversely, the project yielded substantial dividends in other domains: it established the UAE’s international reputation as a forward-thinking state and a regional pioneer in ecological urbanism, catalysed massive capital investment into renewable energy, positioned the country as an exemplar of technological innovation and green-sector employment, and marked an initial shift away from oil dependency.

Regarding the overarching question of how effectively projects such as Masdar City can address West Asia's urgent need to adapt to current and future global environmental crises, several key observations emerge:

As the empirical findings of this study indicate, Masdar City was launched with sweeping promises and highly ambitious projections; however, practical implementation encountered severe setbacks driven by financial constraints and operational realities. While certain challenges—most notably the 2008–2009 global financial crisis—were largely unpredictable, others were foreseeable had the planners adequately accounted for regional environmental conditions, thermodynamic constraints, and societal dynamics.

Ultimately, whether such eco-developments can effectively address the region's long-term ecological vulnerabilities depends on the sustained commitment of political leadership to all three pillars of sustainable urbanism. As conceptualised in Figure 2, sustainable development mandates a balanced integration of economic, environmental, and social dimensions. Consequently, directing massive capital into green energy and constructing technologically sophisticated, high-prestige laboratories—while neglecting social justice and resident behavioural shifts—diverts the project from the holistic vision of urban sustainability. This distinction is especially pertinent given that adopting a sustainable lifestyle does not necessarily present an economic advantage over conventional, consumerist alternatives. Sustainable urban transformation cannot be realised unless technical interventions are embedded within comprehensive social justice initiatives, public environmental education programmes, and broader efforts to foster civic stewardship for future generations.

Conclusion

This study has presented a descriptive case analysis of Masdar City as an exemplar of West Asian governmental initiatives to cultivate eco-cities under the rubric of urban environmentalism. The article systematically examined the project's foundational objectives, empirical achievements, and multifaceted challenges across economic, environmental, and social dimensions. Following the establishment of a theoretical framework, the study detailed the design and construction phases of Masdar City to elucidate its original developmental trajectory and urban intent. Subsequently, the principal impediments confronting the project were analysed, most notably the absence of a comprehensive social justice framework and the pursuit of thermodynamically impractical environmental targets.

A comparative evaluation of initial aspirations against empirical outcomes reveals a significant divergence between Masdar City as conceptualised in promotional and scholarly literature and its operational reality on the ground. Because an idealized image of the city was institutionalised well prior to physical construction, global expectations expanded ahead of empirical testing and phased implementation. Consequently, although the development continues to be associated with the 'zero-carbon, zero-waste' moniker, empirical data have failed to substantiate these claims, and thermodynamic theory precludes their complete realisation.

Fundamentally, the UAE government's decision to commission Masdar City represented a pioneering commitment to sustainable urbanism in an oil-dependent economy. Nevertheless,

the enduring structural limitation of the project lies in the risk that core tenets of sustainability—particularly social equity and authentic ecological transformation—are compromised by a governance model that prioritises commercial viability and speculative capital accumulation over holistic ecological stewardship. To develop a more comprehensive understanding of sustainable transitions across West Asia, future research should critically examine complementary megaprojects across the region, most notably Saudi Arabia’s NEOM, to evaluate whether regional eco-urbanism can transcend symbolic modernism to deliver genuine systemic resilience.

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References

- Alusi, A.Y. et al. (2011). *Sustainable cities: oxymoron or the shape of the future?* (Working Paper 11-062). Harvard Business School. Available at: <https://www.hbs.edu/ris/Publication%20Files/11-062.pdf>
- ARUP. (2022). Raising the bar for sustainable city design. Available at: <https://www.arup.com/projects/masdar-city/>
- Barati, E. (2022). An analysis of theories of the eco-city approach. *Green Development Management Studies*, 1(2), 73-90. <https://doi.org/10.22077/jgmd.2023.5957.1013>
- Bibri, S. E. (2020). The eco-city and its core environmental dimension of sustainability: green energy technologies and their integration with data-driven smart solutions. *Energy Informatics*, 3(4), 1-26. <https://doi.org/10.1186/s42162-020-00107-7>
- Bibri, S. E. & Krogstie, J. (2020). Smart eco-city strategies and solutions for sustainability: the cases of Royal Seaport, Stockholm, and Western Harbor, Malmö, Sweden. *Urban Science*, 4(1), 11,1-42. <https://doi.org/10.3390/urbansci4010011>
- Brand, P., & Thomas, M. J. (2005). *Urban environmentalism, global change and the mediation of local conflict*. Routledge.
- British Columbia Institute of Technology (2025). What is an ecocity?. Available at: <https://www.bcit.ca/centre-for-ecocities/ecocity/>.
- Camagni, R. (1998). Sustainable urban development: definition and reasons for a research programme. *International Journal of Environment and Pollution*, 10(1), 6-27. <https://doi.org/10.1504/IJEP.1998.002228>.
- Creswell, J. W. et al. (2007). Qualitative research designs: selection and implementation. *Couns Psychol*, 35, 236–264.
- Cugurullo, F. (2013). How to build a sandcastle: An Analysis of the Genesis and Development of Masdar City. *Journal of Urban Technology*, 20(1), 23-37. <http://dx.doi.org/10.1080/10630732.2012.735105>.
- Downton, P., F. (2008). *Ecopolis: Architecture and cities for a changing climate*(Vol. 1). Springer Science & Business Media.
- Dunn, S. & Jamieson, W. (2011). The relationship of sustainable tourism and the eco-city concept. in t. ch. Wong & B. Yuen (Eds.), *Eco-city Planning: Policies, Practice and Design* (pp. 93-109). Springer. https://doi.org/10.1007/978-94-007-0383-4_5.
- Elgendy, K. (2024, Dec. 6). Masdar City: Where Sustainability Is Written in the Sand. Available at: <https://www.ribaj.com/buildings/masdar-city-sustainability-net-zero-carbon/>.
- European Commission. (2009, Jul. 7). Fraunhofer Know-how for the Ecological Model City Masdar. Available at: <https://cordis.europa.eu/article/id/113466-fraunhofer-knowhow-for-the-ecological-model-city-masdar#:~:text=It%20is%20designed%20to%20support,have%20significantly%20reduced%20water%20consumption.>
- Gaffron, P. et al. (2005). *Ecocity* (Book I). FacultasVerlags-und Buchhandels AG.
- Gaffron, Ph.; Huismans, G., & Skala, F. (2005). *Ecocity Book 1: A Better Place to Live*. European Commission, DG Research. Available at: https://www.oekostadt.at/root/img/pool/files/book_1.pdf.
- Harvey, D. (1996). *Justice, Nature and the Geography of Difference*. Blackwell

- Hodson, M. & Marvin, S. (2010). Urbanism in the anthropocene: ecological urbanism or premium ecological enclaves?. *Taylor & Francis Journals*, 14(3), 298-313. <http://doi.org/10.1080/13604813.2010.482277>.
- Imran Khan, M.; Asfand, F. & Al-Ghamdi, S. G. (2023). Progress in research and technological advancements of commercial concentrated solar thermal power plants. *Solar Energy*, 249, 183-226. <https://doi.org/10.1016/j.solener.2022.10.041>
- IRENA (International Renewable Energy Agency). (2015). Available at: <http://www.irena.org/FutureIrena/FutureIRENA.aspx>
- Jabreili, K. (2013). How it Works: Masdar's Beam Down Optical Tower. *Popular Science*. Available at: <https://www.popsci.com/science/article/2013-05/beam-down-optical-experiment/>. (Accessed on: 2013, May 30).
- Jensen, B. B. (2025). Masdar city: a critical retrospection. Available at: <https://urbannext.net/masdar-city-a-critical-retrospection/>. (Accessed on: 2025, Nov. 21).
- Joss, S.; Cowley, R. & Tomozeiu, D. (2013). Towards the 'ubiquitous eco-city': an analysis of the internationalisation of eco-city policy and practice. *Urban Research & Practice*, 6(1), 54-74. <https://doi.org/10.1080/17535069.2012.762216>.
- Joss, S. (2015). Eco-cities and sustainable urbanism. *International Encyclopedia of the Social and Behavioral Sciences* (2nd ed.). Vol. 6. 829-836. Available at: <https://www.scribd.com/document/823167514/b978-0-08-097086-8-74010-4-Cop>.
- Kashef, M. (2025). Rethinking Masdar and the Line megaprojects: the interplay of economic, social, political, and spatial dimensions. *Land*, 14(1358). <https://doi.org/10.3390/land14071358>.
- Lau, A. (2023). Masdar city: a model of urban environmental sustainability. Available at: https://ugc.futurelearn.com/uploads/files/a5/9f/a59f7a08-d066-4090-93b2-17d80312d5f2/Masdar_City.pdf
- Madakam, S., & Ramaswamy, R. (2016). Sustainable smart city: masdar (UAE) (A City: Ecologically Balanced). *Indian Journal of Science and Technology*, 9(6), 1-8. <https://doi.org/10.17485/ijst/2016/v9i6/87669>.
- Masdar. (2019, Jun. 9). Managing waste- a primer. Available at: <https://masdar.ae/en/news/newsroom/managing-waste-a-primer>.
- Masdar City. (2024a). Sustainability at Masdar City. <https://masdarcity.ae/sustainable-urban-development/Sustainability-at-masdar-city>.
- Masdar City. (2024b). Personal rapid transit (PRT) System [image]. <https://masdarcity.ae/tech-and-innovation/sustainable-mobility>.
- Manghnani, K. & Bajaj, N. (2014). Masdar City: A model of urban environmental sustainability. *Journal of Engineering Research and Applications*, 4(10), 38-42. https://www.ijera.com/papers/Vol4_issue10/Part%20-%204/H410043842.pdf
- Nourani Jodaghia, E., & Farnam, A. (2024). *Motale'e yetatbiqi-ye tajārob-e bum-šahr-hā: Āsib-šenāsi-ye šahr-hā-ye jaded-e bum-āvard* [i.e., Comparative analysis of eco-cities experiences: a pathology of new eco-cities]. Islamic Parliament Research Center. <https://rc.majlis.ir/fa/report/show/1812129> [In Persian].
- Pirani, S., Natarajan, L., Abbas, Z., & Arafat, H. (2012). Life cycle assessment of membrane bioreactor versus CAS wastewater treatment: Masdar City and beyond. The Sixth Jordan International Chemical Engineering Conference. Available at: <https://www.jeaconf.org/UploadedFiles/Document/2c4308bb-c65d-4e2d-b165-7572bee1adb5.pdf>.

- Premalatha, M., Tauseef, S. M., Abbasi, T., & Abbasi, S.A. (2013). The promise and the performance of the world's first two zero-carbon eco-cities. *Renewable and Sustainable Energy Reviews*, 25, 660-669. <http://dx.doi.org/10.1016/j.rser.2013.05.011>.
- PWC. (). Masdar City: The eco-oasis blueprint for sustainable cities. Available at: <https://www.pwc.com/gx/en/issues/business-model-reinvention/how-we-fuel-and-power/sustainable-energy-infrastructure/the-eco-oasis-blueprint-for-sustainable-cities.html>. (Accessed on: 2023, Nov. 10)
- Rao, Y. V. C. (1997). *Chemical Engineering Thermodynamics*. Universities Press.
- Reichl, L. (1980). *A Modern Course in Statistical Physics*. Edward Arnold.
- Roseland, M. (1997). Dimension of the eco city. *Cities*, 14(4), 197-202. [https://doi.org/10.1016/S0264-2751\(97\)00003-6](https://doi.org/10.1016/S0264-2751(97)00003-6)
- Roseland, M. (2012). *Toward sustainable communities: solutions for citizens and their governments*. New Society Publishers.
- Sustainability at Masdar City. (2024). Masdar City. Available at: <https://masdarcity.ae/sustainable-urban-development/Sustainability-at-masdar-city>
- Suzuki, H., Dastur, A., Moffatt, S., Yabuki, N., & Maruyama, H. (2010). *Eco2 cities: ecological cities as economic cities*. The World Bank. <https://documents1.worldbank.org/curated/en/634471468244553955/pdf/Eco2-cities-ecological-cities-as-economic-cities.pdf>
- The Executive Center. (2025, Sep. 26). A picture showing masdar city architecture [image]. Available at: <https://executivecentre.ae/masdar-city-abu-dhabi-a-guide>
- UAE Government. (2025, Nov. 6). Smart sustainable cities. Available at: <https://u.ae/en/about-the-uae/digital-uae/digital-cities/smart-sustainable-cities>
- United Nations Brundtland Commission. (1987). *Report of the world commission on environment and development: Our common future*. Available at: <http://www.un-documents.net/our-common-future.pdf>
- United Nations Environment Programme and United Nations Human Settlements Programme. (2021). *Global environment outlook for cities: geo for cities: towards green and just cities*. Available at: https://unhabitat.org/sites/default/files/2021/11/geocities_updated.pdf
- Ur Rahman, T., Roy, H., Islam, R., Tahmid, M., Fariha, A., Mazumder, A., Tasnim, N., Pervez, N., Cai, Y., Naddeo, V., & Islam, Sh. (2023). The advancement in membrane bioreactor (mbr) technology toward sustainable industrial wastewater management. *Membrane*, 13(2), 181. <https://doi.org/10.3390/membranes13020181>
- White, R. R. (2002). *Building the Ecological City*. Woodhead Publishers.
- White, R. R. (2004). Financial Incentives for Behavioral Change in the Ecological City. *Ekistics*, 71(424/425/426), 63-67. Available at: <https://www.jstor.org/stable/43623402>
- Wong, T. Ch., & Yuen, B. (2011). *Eco-city Planning: Policies, Practice and Design*. Springer. Available at: https://cus.ubt-uni.net/wp-content/uploads/2024/11/Eco-city-Planning_-Policies-Practice-and-Design-2011-Springer.pdf
- Yang, Z. (2012). *Eco-cities: A planning guide*. CRC Press.
- Yeang, K., & Woo, L. (2010). *Dictionary of ecodesign: An illustrated reference*. Routledge.
- Yeang, K. (2009). *Eco master planning*. John Wiley & Sons Ltd
- Renewable Energy Magazine. (2010, Jan. 22). Masdar launches solar “Beam Down” project. Available at: https://www.renewableenergymagazine.com/solar_thermal_electric/masdar-launches-solar-a-beam-down-a