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Climate Change and its Implications for Sustainable Urban Development in Egyptian Coastal Cities

Ahmad Rshwan Mahrous
Department of Architectural Engineering, University of Beni-Suef, Egypt.

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ABSTRACT

Climate change is one of the most pressing global challenges, with impacts such as global warming, sea-level rise, and flooding that threaten ecosystems, agricultural productivity, and urban settlements. Egypt's Mediterranean cities, particularly the Nile Delta, Alexandria, and the Suez Canal region, are among the most vulnerable areas. This study examines the implications of climate change for sustainable urban development, focusing on sea-level rise and its risks to coastal zones, with special attention to New Alamein City. An inductive review of climate change concepts was combined with a descriptive–analytical framework and comparative evaluation of three representative case studies: Vancouver (a global coastal model), Masdar City (a regional desert model near Abu Dhabi), and New Alamein (an Egyptian coastal model). The results indicate that while Vancouver provides a strong, integrated model linking environmental, social, and economic sustainability, Masdar and New Alamein show partial achievement, with emphasis on technological and economic priorities at the expense of ecological and social equity. The research derives a referential framework of urban, environmental, social, and economic criteria that can guide sustainable planning in Egyptian coastal cities. Recommendations highlight the need for climate-resilient infrastructure, renewable energy adoption, social inclusion, and ecosystem-based adaptation to ensure balanced and long-term urban resilience.

1. Introduction

Climate change has a significant impact on the urban planning process, particularly in cities most vulnerable to its effects, such as floods, droughts, and rising sea levels. Many Egyptian cities, especially those located along the Mediterranean coast, are expected to be affected by these challenges, which threaten both environmental stability and urban growth.

In response, this research explores how sustainable urban development can mitigate the effects of climate change on coastal regions, emphasizing the case of New Alamein City as a representative example of Egypt's emerging coastal development model. The study also includes a comparative analysis of Vancouver and Masdar City, representing global and regional approaches to sustainability and climate adaptation.

The paper employs an inductive and descriptive–analytical methodology, integrating theoretical frameworks with empirical observations to assess how cities can balance environmental, economic, urban, and social dimensions of sustainability within the context of climate adaptation.

* Corresponding author. Ahmad Rshwan, Assitant lecturer, Beni Suef University. Email: ahmad.rshwan_td3@eng.bsu.edu.eg

1.1. Research objectives

- To assess the implications of climate change on sustainable urban development in Egypt's coastal areas.
- To analyze how different urban models (Vancouver, Masdar, and New Alamein) integrate sustainability principles in response to climate change.
- To derive a framework that can guide climate-resilient planning in Egyptian coastal cities.

1.2. Research questions

- How does climate change influence urban sustainability in coastal contexts?
- What lessons can be learned from international and regional models to improve Egypt's coastal development strategies?
- To what extent do Egyptian new coastal cities, particularly New Alamein, incorporate environmental and social resilience measures?

2. Literature review

2.1. Climate Change & its concepts

Climate change is a global phenomenon with local effects, as it disproportionately impacts areas that are geographically and topographically vulnerable. Since October 1985, the scientific community has increasingly relied on advanced computer models to project global warming. These projections have been confirmed by long-term weather data collected over decades.

It has become clear that global temperatures are indeed rising. As shown in Fig.1 for the period 1980–2025, global mean surface temperatures have increased by approximately 1.0 °C since 198. This evidence confirms that the Earth has become noticeably warmer than in the past century. Climate research centers emphasize that the current warming trend is one of the clearest indicators of ongoing climate change [1].

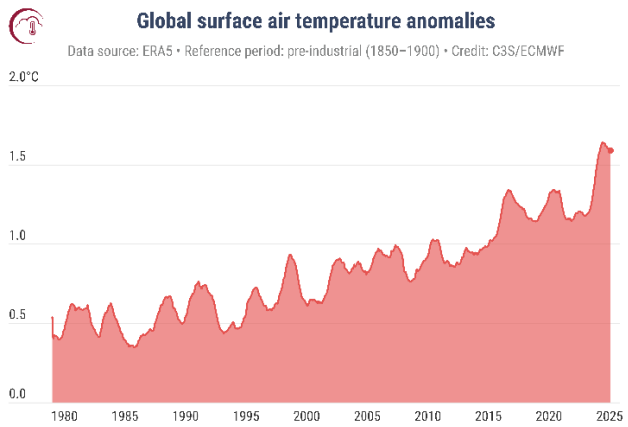

Fig. 1. Global surface air temperature anomalies from 1980 to 2025 based on the. Source: The Copernicus Climate Change Service (C3S) (2025).

Climate change: refers to alterations in climate conditions that result directly or indirectly from human activities which modify the composition of the global atmosphere. These human-driven changes occur in addition to the natural variations in climate that happen over similar time periods [2].

Greenhouse gases (GHG): are certain gases in the atmosphere that trap heat. They let sunlight pass through the atmosphere and warm the Earth's surface but block part of this heat from escaping back into space. Among the main greenhouse gases are carbon dioxide, water vapor, and methane. However, not all atmospheric gases fall into this category—oxygen and nitrogen, which together make up more than 95% of the atmosphere, are not greenhouse gases [3].

Sea-level rise: is the increase in the average level of the ocean, primarily driven by the thermal expansion of seawater as it warms and the addition of water from melting glaciers and ice sheets. The rise is not uniform globally but varies regionally due to factors such as vertical land movement, ocean dynamics, and gravitational, rotational, and deformational effects [4].

The World Meteorological Organization (WMO) report forecasts that the annually averaged global near-surface temperature for each year between 2025 and 2029 is predicted to be between 1.2°C and 1.9°C higher than the average over the years 1850-1900 [5].

2.2. Expected effects of climate change

The 2007 IPCC report highlighted multiple global and regional risks linked to climate change, including impacts on water, agriculture, health, forestry, energy, settlements, and cities. For the Intermountain West, projections indicate more frequent droughts, extreme weather, catastrophic wildfires, and major disruptions to ecosystems. Rising temperatures and altered precipitation patterns are expected

to reduce snowpack, shift peak snowmelt earlier in the season, and create longer dry periods; threatening water supplies, wildlife, and municipal systems [6].

Additionally, hotter and drier conditions are likely to increase severe storms, floods, and heat waves, placing particular strain on vulnerable populations. Wildfires are projected to worsen due to higher fuel loads, invasive grass, and longer fire seasons. Natural ecosystems will also face disruption, with species displacement, pest expansion, and potential loss of iconic plants such as the Joshua tree and saguaro cactus. Collectively, these changes may transform entire landscapes and pose major challenges for communities and resource managers [6].

Climate change has shown significant but uneven impacts on the four major staple crops worldwide: rice, wheat, maize, and soybeans.

- Rice: Average yields have slightly increased under global warming, but maximum potential yields have declined more strongly.
- Wheat: Average productivity benefited from warming, yet maximum yields were negatively affected.
- Maize: Mean yields improved modestly, while top yields decreased, widening the yield gap.
- Soybeans: Average yields increased with rising temperatures, whereas maximum yields dropped, leading to a narrower gap.

Overall, temperature rise played a much stronger role in yield changes than precipitation patterns during 1961–2021 [7].

Recent research shows that by 2050, rising seas could put three times more people at risk than previously estimated, with about 150 million people living on land projected to be below high tide. Key cities at risk include Ho Chi Minh City, Bangkok, Shanghai, Mumbai, Alexandria, and Basra. While seawalls and barriers can offer temporary protection, researchers emphasize that defensive measures have limits, and large-scale internal migration and security challenges may result [8].

2.3. Regions most affected by climate change

1. Africa: High vulnerability due to limited adaptive capacity, with increased risk of drought, reduced agricultural productivity, and water scarcity.
2. Asia: Populations in large deltas (e.g., Ganges, Mekong) face heightened risks from flooding, sea-level rise, and extreme weather.
3. Small Islands: Extremely vulnerable to sea-level rise, storm surges, and loss of coastal ecosystems.
4. Arctic: Rapid warming leading to melting sea ice, permafrost thaw, and severe impacts on indigenous communities and ecosystems.
5. Latin America: Decreased water availability, biodiversity loss in tropical forests, and reduced crop yields.
6. Polar Regions & Mountain Areas: Significant retreat of glaciers affecting water supplies and ecosystems downstream [9].

2.4. Sustainable development & its concepts

Sustainability refers to the capacity to ensure long-term well-being while taking ecological, economic, political, and cultural factors into account. The concept of sustainable development has been defined in various ways. According to Kersten et al., it is essential to develop approaches that highlight the synergies between economic growth and environmental enhancement [10].

Sustainable development is framed as an approach that secures the continuity of environmental, economic, and social aspects within both natural and human systems. Although it originated in forest management, the concept has expanded to integrate economic and social dimensions alongside the environmental ones. The IPCC adopts the Brundtland Commission's definition, which describes sustainable development as meeting present needs without limiting the capacity of future generations to meet theirs (WCED, 1987). In 2015, the United Nations introduced the Sustainable Development Goals (SDGs) as the successor to the Millennium Development Goals (MDGs), highlighting the importance of balancing three core pillars: economic growth, social inclusion, and environmental protection [11]. SDG 13 is the specific goal focused on climate action, which aims to take urgent action to combat climate change and its impacts.

Sustainable urban planning has emerged as a contemporary concept linked to sustainability. Cities serve as the primary arenas for applying and testing sustainability policies and standards. Since urban life mirrors the broader social system, achieving sustainable urban development relies heavily on effective urban planning. In this context, sustainable urban planning plays a vital role in maintaining sustainability [12].

2.5. Sustainable development dimensions

According to [13], in Africa, research on sustainable urban development represents about 12% of global studies, with the majority addressing environmental-ecological, socio-cultural, and economic dimensions. Rapid urbanization, where the urban population doubles every 20 years, has intensified challenges such as inadequate housing, poor infrastructure, and vulnerability to climate change impacts including floods, droughts, and heat waves.

Despite vast natural resources, Africa remains heavily affected by poverty, unemployment, and weak institutions, which exacerbate environmental degradation and social inequality. Addressing sustainability in the region thus requires integrated attention to environmental, social, and economic concerns, supported by governance reforms and significant investment in infrastructure to achieve long-term resilience and equitable development [13].

2.6. International, global and local climate change conventions

The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, establishes an international framework to stabilize greenhouse gas concentrations at levels that prevent dangerous human-induced interference with the climate system. It acknowledges the principle of common but differentiated responsibilities, emphasizing that developed countries should take the lead in reducing emissions, while considering the specific needs of developing countries. The Convention highlights the vulnerability of low-lying islands, arid and semi-arid regions, and economies dependent on fossil fuels, stressing that climate policies must be integrated with sustainable development and poverty eradication goals [2].

To The Convention sets out commitments for all Parties, including developing national inventories of greenhouse gas emissions, promoting sustainable management of sinks and reservoirs (e.g., forests, oceans), and cooperating on adaptation, research, and public awareness. Developed countries commit to providing financial resources, technology transfer, and capacity-building support to developing nations. The Convention also establishes the Conference of the Parties (COP) as its supreme decision-making body, alongside mechanisms for financial assistance, dispute settlement, and the development of future protocols (such as the Kyoto Protocol and Paris Agreement) [2].

The Kyoto Protocol (1997) was adopted as a legally binding agreement under the UNFCCC, requiring industrialized countries (Annex I Parties) to collectively reduce their greenhouse gas (GHG) emissions by at least 5% below 1990 levels during the first commitment period (2008–2012). It emphasized policies such as enhancing energy efficiency, promoting renewable energy, sustainable forestry, and reducing methane and other non-CO_2 gases. The Protocol also established mechanisms to support flexibility, including international emissions trading, Joint Implementation (JI), and the Clean Development Mechanism (CDM), which enabled Annex I countries to finance emission reduction projects in developing countries and count the reductions toward their own targets [14].

The Protocol recognized the principle of common but differentiated responsibilities, obligating developed nations to lead mitigation efforts while providing financial resources, technology transfer, and capacity-building support to developing nations. It also created reporting and review systems to ensure transparency and accountability. Although the Protocol marked a critical step in international climate governance, its impact was limited by the non-ratification of some major emitters and the withdrawal of others. Still, it paved the way for subsequent climate agreements, notably the 2015 Paris Agreement, which built on its framework [14].

The Paris Agreement, adopted in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC), represents a commitment to strengthen the response to climate change while supporting sustainable development and poverty eradication. Its central goals include limiting the rise in global average temperature to well below 2°C above pre-industrial levels, pursuing efforts to restrict it to 1.5°C, and enhancing resilience to climate impacts without undermining food security. The Agreement emphasizes equity and the principle of common but differentiated responsibilities, recognizing the different circumstances of developed and developing countries [15].

2.7. Comparative Overview of Climate Agreements: Objectives, Commitments, Notable Features

Table 1: Comparative Overview of Major International Climate Agreements. Source: the author

Agreement	Objectives	Commitments	Notable Features
UNFCCC (1992)	Establish global cooperation on climate change; recognize common but differentiated responsibilities.	Countries to report GHG emissions and develop national climate strategies.	Framework convention-no binding emission targets.
Kyoto Protocol (1997)	Legally binding targets for developed nations to reduce emissions.	Annex I countries to cut GHG emissions by 5% below 1990 levels (2008–2012).	Introduced the Clean Development Mechanism (CDM).
Copenhagen Accord (2009)	Global political commitment to limit warming below 2°C.	Voluntary pledges (not legally binding).	Recognized developing countries' right to growth.
Paris Agreement (2015)	Strengthen global response to climate change and keep temperature rise well below 2°C.	All parties to submit Nationally Determined Contributions (NDCs).	Universal participation; flexibility for developing countries.
Glasgow Climate Pact (2021)	Enhance ambition and accelerate climate finance and adaptation.	Updated NDCs; phase-down of coal; increased finance for adaptation.	Acknowledged loss and damage; call for net-zero by mid-century.
COP28 (2023)	Implementation and accountability for Paris Agreement commitments.	New global stocktake and stronger adaptation framework.	Focused on climate finance, resilience, and fossil fuel transition.

From the early UNFCCC negotiations in the 1990s to the ambitious commitments of the Paris Agreement and the ongoing efforts up to 2025, international climate change governance has evolved from establishing frameworks to fostering action and accountability. The coming years remain crucial for translating commitments into tangible outcomes to mitigate climate change impacts.

Implementation and Challenges (2016–2024):

2016-2020: Countries began submitting updated NDCs. Despite commitments, emissions continued to rise globally due to various economic and political factors.

2020–2021: The COVID-19 pandemic temporarily slowed emissions but also delayed climate negotiations. The U.S. rejoined the Paris Agreement in 2021 after a brief withdrawal.

2022–2024: Focus shifted toward implementation, climate finance, and adaptation. Countries announced net-zero targets for 2050, with intermediate goals for 2030. The 2023 COP28 emphasized actionable commitments and increased climate finance.

Progress Toward 2025:

2023–2024: Countries worked to strengthen commitments, with many updating NDCs to reflect increased ambition. There was a global push for renewable energy adoption, technological innovation, and climate resilience.

2025 – The State of Global Climate Action: As of 2025, the international community continues to strive for greater ambition in reducing emissions, with ongoing efforts to mobilize climate finance, support vulnerable nations, and implement sustainable policies. The success of these initiatives is critical to limiting global temperature rise to safe levels.

Key COPs in the 2000s and 2010s:

2001 – COP7 (Marrakesh): Adopted the Marrakesh Accords, detailing rules for implementing the Kyoto Protocol.

2005 – COP11/COP/MOP1 (Montreal): Launched the Clean Development Mechanism (CDM) to promote emission reductions in developing countries.

2009 – COP15 (Copenhagen): Aimed to create a successor to Kyoto; resulted in the Copenhagen Accord, which was non-binding but recognized the need to limit warming.

2013 – COP19 (Warsaw): Focused on climate finance and adaptation.

2015 – COP21 (Paris): Resulted in the Paris Agreement, where countries committed to limit global warming to well below 2°C, preferably 1.5°C, with nationally determined contributions (NDCs).

2018 – COP24 (Katowice): Adopted the rulebook for implementing the Paris Agreement, including transparency and reporting guidelines.

2021 – COP26 (Glasgow): Emphasized increased ambition, phasing out coal, and climate finance; many countries announced stronger NDCs.

2023 – COP28 (Dubai): Focused on implementation, climate finance, and adaptation efforts. Nations were urged to accelerate action to meet climate goals.

Progress Toward 2025:

2024–2025: Preparations for COP29 and COP30, with a focus on reviewing progress, increasing ambition, and mobilizing financial support for vulnerable nations.

2025 – The State of Global Climate Action: The international community continues to leverage COP agreements and commitments to accelerate efforts to limit global warming, adapt to impacts, and promote sustainable development.

To achieve these aims, all Parties must submit and update nationally determined contributions (NDCs) every five years, progressively enhancing ambition over time. The Agreement also stresses adaptation, transparency, financial support, technology transfer, and capacity-building, particularly for developing nations and vulnerable communities. By linking mitigation, adaptation, and sustainable development, the Paris Agreement establishes a framework for global cooperation and accountability in the long-term transition toward a low-carbon, climate-resilient future [15].

The Egypt National Climate Change Strategy 2050 (NCCS) serves as a comprehensive roadmap aligning with Egypt Vision 2030 to integrate climate action into national development. It prioritizes improving citizens' quality of life while achieving sustainable economic growth through a low-emission pathway. The strategy outlines five overarching goals: (1) sustainable economic growth and low-carbon development, (2) enhancing adaptive capacity and resilience, (3) strengthening climate governance, (4) expanding climate finance infrastructure, and (5) advancing scientific research, technology transfer, knowledge management, and awareness. Each goal includes measurable indicators and enabling policies, ranging from energy transition and efficient resource use to disaster risk reduction, gender-responsive adaptation, and green financing mechanisms [16].

Implementation of the NCCS relies on multi-sectoral collaboration involving government, civil society, and the private sector. It emphasizes mainstreaming climate change into planning, adopting green infrastructure, and capitalizing on renewable energy opportunities. The strategy also highlights Egypt's vulnerability to climate change, including risks to water, food security, health, and coastal areas, making resilience building a national priority. By mobilizing domestic and international finance, strengthening institutional frameworks, and raising public awareness, the NCCS aims to ensure sustainable development, safeguard ecosystems and resources, and enhance Egypt's regional and global leadership in climate action [16].

3. Referential Framework for Sustainable Urban Development with regards to Climate Change in Coastal Cities

3.1. The Elements of the Referential Framework and the percentage of its application

The referential framework used in this study was inductively derived from the theoretical foundations established in the literature review. Through cross-analysis of prior studies and conceptual debates on sustainability, climate adaptation, and coastal urban development, forty evaluation criteria were synthesized and organized into four main domains: urban/spatial, environmental, economic, and social. Each criterion was assigned an equal weight, as the goal of the research is comparative evaluation rather than predictive modeling.

The relative importance of each criterion thus emerges implicitly through its recurrence and degree of application across the case studies, highlighting which aspects of sustainability are most consistently addressed in practice. This inductive, evidence-based approach ensures internal coherence between the theoretical synthesis and the analytical evaluation, while maintaining transparency and replicability for future comparative studies.

To achieve sustainable urban development under the pressures of climate change, it is essential to define a clear framework of criteria that addresses the main dimensions of sustainability. These dimensions are commonly categorized into economic, social, urban/spatial, and environmental aspects. The following (Table.1) summarizes the key criteria under each dimension, providing a comprehensive basis for evaluating policies, projects, and planning approaches.

Table 2: Referential Framework for the elements of sustainable urban development under climate change pressures in coastal cities. Source: the author

Elements of the Referential Framework	The percentage of application
Urban/Spatial Standards:	
1- Developing climate-resilient infrastructure (transport, utilities, housing). 2- Integrating green building standards and energy-efficient designs. 3- Adopting compact city models to limit uncontrolled urban sprawl. 4- Implementing sustainable land-use planning and zoning regulations. 5- Managing coastal and flood-prone zones to protect urban areas. 6- Expanding sustainable public transport and reducing car dependency. 7- Promoting mixed-use development to optimize land and resources. 8- Preserving urban green spaces and integrating nature-based solutions. 9- Enhancing waste and water management systems within urban planning. 10- Strengthening disaster risk reduction measures in city design. 11- Encouraging smart city technologies to improve efficiency and resilience.	urban standards = 11/40 * 100 = 27.5% of the total percentage
Environmental Standards:	
1- Reducing greenhouse gas emissions through mitigation strategies.	Environmental standards =

Elements of the Referential Framework	The percentage of application
2- Promoting renewable energy adoption to cut carbon intensity. 3- Enhancing water management systems (efficiency, recycling, desalination). 4- Protecting ecosystems and biodiversity from urban expansion. 5- Conserving forests, wetlands, and coastal zones to act as natural carbon sinks. 6- Reducing air, water, and soil pollution via sustainable waste management. 7- Strengthening adaptation strategies for ecosystems (resilient crops, urban greening). 8- Addressing risks of sea-level rise with natural and engineered solutions. 9- Limiting land degradation and desertification through sustainable land-use practices. 10- Integrating ecosystem-based adaptation into urban planning. 11- Encouraging sustainable consumption patterns to minimize ecological footprint.	11/40 * 100 = 27.5% of the total percentage
Economic Standards:	
1- Promoting investments in renewable energy and low-carbon industries. 2- Enhancing energy efficiency to reduce long-term operational costs. 3- Diversifying local economies to reduce dependence on climate-sensitive sectors (e.g., agriculture, fisheries). 4-Creating green jobs in renewable energy, sustainable transport, and eco-tourism. 5- Reducing economic losses from climate-induced disasters through insurance and risk management tools. 6- Expanding sustainable financing mechanisms (green bonds, carbon markets, climate funds). 7- Encouraging technology transfer and innovation in green industries. 8- Stimulating eco-friendly infrastructure projects to attract investment. 9- Strengthening food and energy security as key components of economic resilience. 10- Reducing dependency on imported fossil fuels to improve trade balance. 11- Encouraging public–private partnerships for sustainable urban development financing.	Economic standards = 11/40 * 100 = 27.5% of the total percentage
Social Standards:	
1- Reducing poverty and protecting livelihoods affected by climate impacts. 2- Ensuring social equity and justice in access to resources and opportunities. 3- Enhancing access to affordable housing, clean water, and sanitation services. 4- Expanding healthcare systems to address climate-related health risks. 5- Promoting education and raising awareness about climate change adaptation. 6- Strengthening community participation in planning and decision-making. 7- Building social resilience in vulnerable groups (elderly, children, low-income).	Social standards = 7/40 * 100 = 17.5% of the total percentage

3.2. The analytical study of 3 cities

This study adopts an analytical comparative methodology based on qualitative assessment. The sample includes three representative cases selected to reflect different scales of sustainable urban development under climate change pressures: a local case (New Alamein City, Egypt), a national case (Masdar City, UAE), and a regional/global case (Vancouver, Canada).

Data were collected through documentary review and critical analysis of academic papers, policy documents, and official reports related to each case. The evaluation process relied on a personal analytical judgment guided by the established framework of 40 criteria. Each criterion was examined in relation to the evidence presented in the selected references for every case.

The data analysis was systematically applied to all cases to ensure consistency and comparability. The analytical process involved scoring the extent of application for each criterion using a unified scale (Strong, Medium, Poor, None) and calculating average application percentages for each sustainability dimension.

The analysis is conducted through the following steps:

1- Calculating the percentage of application for each criterion, based on the ratio of applied elements to the total number of elements under that criterion.
2- Determining the overall percentage of application for each group of standards by dividing the total achieved percentage by the number of related elements.
3- Classifying the level of application according to the following scale: Strong (≥ 70%), Medium (≥ 50 - < 70%), Poor (≥ 20 - < 50%), and None (< 20%).

4. Analytical Study of Vancouver city in Canada

Fig. 2. Aerial view of Vancouver City, 2025. Source: City of Vancouver, retrieved from: https://www.instagram.com/p/DJc7-10hgoi/

A. **Background:** Vancouver is a coastal city on Canada's Pacific Coast, bounded by the Fraser River and the Strait of Georgia, with mountain ranges behind it. Its ocean-tempered but rainy climate and complex topography make it highly exposed to flooding hazards. The city records ~1,189 mm of annual rain over ~161 rainy days and is vulnerable to fluvial, coastal, and pluvial floods. Notably, it still ranks among North America's top sustainable cities [17].

From the 1990s onward, Vancouver embedded sustainability into city planning, beginning with CityPlan (1994) and the conversion of post-industrial districts into mixed-use, higher-density communities (e.g., Yaletown). This trajectory culminated in the Greenest City 2020 Action Plan (GCAP), produced through an unusually broad public process and intended to drive a "strong local economy and vibrant and inclusive neighbourhoods." [18].

B. **Main Sustainability Practices:** mixed-use regeneration (e.g., Yaletown) and compact urban form first framed under CityPlan (1994), supporting walkability and efficient land use [18].

Rain City Strategy (RCS): transitions Vancouver toward a water-sensitive city via green rainwater infrastructure (GRI), permeable pavements, bioswales, rain gardens, and green roofs, to capture and treat stormwater at source and reduce load on grey networks. Target: manage volume/quality for 40% of impermeable areas by 2050 through new projects and retrofits [19].

GCAP explicitly ties sustainability to local economic strength, positioning green initiatives as engines for jobs and competitiveness [18].

Vancouver is widely cited for community-based participation and city-wide dialogue (CityPlan), with ~20,000 active participants across multi-step engagement. This reframed planners' roles toward facilitation and collective learning [20].

Vancouver has adopted the Climate Emergency Action Plan (CEAP) to cut carbon emissions by 50% by 2030 and reach carbon neutrality by 2050. Policies focus on compact, walkable neighbourhoods, shifting transport to active mobility and transit, and cutting building emissions by halving operational pollution and reducing embodied carbon by 40% in new construction. The city also embeds equity and climate justice, ensuring vulnerable communities benefit fairly from climate action [21].

C. **Challenges:** Multi-hazard flood risk under a wet, oceanic climate: Vancouver's exposure to fluvial, coastal, and pluvial flooding is structural (river/ocean interface, orography, and intense rain events). This requires sustained investment in drainage upgrades, dike/river defenses, and nature-based solutions beyond business-as-usual [17].

Keeping pace with climate adaptation at city scale: Vancouver's RCS sets a 2050 management target (40% of impermeable area). The ambition is clear, but meeting it demands long-term funding, cross-departmental coordination, and retrofitting in built-out neighborhoods [19].

The following table presents the evaluation of Vancouver's performance against the sustainability framework. The analysis highlights the extent to which urban, environmental, economic, and social standards have been applied in the city as a model of sustainable urban development.

Table 3: Analysis of Vancouver city according to the previous Framework. Source: the author

Framework of reference standards	application degree	
Urban standards	81%	Strong
Environmental standards	81%	Strong
Economic standards	72%	Strong
Social standards	71%	Strong
Overall application score	76%	Strong

The analysis indicates that Vancouver performs strongly across all four dimensions, with particularly high scores in urban and environmental standards (81%). Economic and social standards also demonstrate strong application, though slightly lower at 72% and 71% respectively. These results confirm Vancouver's position as a leading global model for sustainable urban development and climate adaptation.

5. Analytical Study of Masdar city in UAE

Fig. 3. Master plan of Masdar City, 2018. Source: https://masdarcity.ae/docs/default-source/pdf-to-download/masterplan_21-12_english_v2.pdf

D. **Background:** Masdar City, launched in 2006 in Abu Dhabi, UAE, was envisioned as one of the first purpose-built eco-cities in the world. Planned for about 40,000 residents and 50,000 commuters, the city was designed by Foster + Partners as a compact, car-free settlement relying on renewable energy, particularly solar power. It was positioned as a flagship project within the UAE's broader strategy of shifting from an oil-based economy toward knowledge and technology-driven sectors, especially clean energy and sustainable urbanism [22].

From the outset, Masdar was promoted internationally as a "zero-carbon, zero-waste" city, intended to serve both as a global showcase for sustainable design and as a hub for research, technology, and green investment in the Middle East. It attracted early partnerships with global institutions like the Masdar Institute of Science and Technology, Siemens, and the International Renewable Energy Agency (IRENA), reinforcing its role as both an experimental urban lab and a geopolitical symbol of the UAE's commitment to sustainability [23].

E. **Main Sustainability Practices:** Masdar City in Abu Dhabi was launched in 2006 as one of the world's most ambitious eco-city projects, positioned as a global model of low-carbon urban development. Its vision was to create a carbon-neutral, zero-waste settlement powered almost entirely by renewable energy (mainly solar). The project was led by the state-owned Masdar Initiative, supported by Foster + Partners' masterplan, and promoted internationally as a showcase of the UAE's commitment to sustainable development and diversification away from oil dependency [23].

In terms of policies, Masdar has been framed within the UAE's wider strategy of eco-modernisation, using urban sustainability projects not only to reduce emissions but also to foster economic diversification and global competitiveness in the clean-tech sector. The city is essentially a "living laboratory" for renewable energy, smart infrastructure, and sustainable architecture, aiming to attract international corporations and research institutions (e.g., Siemens HQ, Masdar Institute) [22].

However, these policies have been heavily market-driven, with sustainability often interpreted in economic and technological terms rather than ecological or social ones [23].

F. **Challenges:** Despite its ambitious vision, Masdar has faced major challenges since inception. One central issue has been fast urbanism: the city was planned and implemented at high speed to meet political and economic deadlines, which compromised its environmental and social depth. Rapid development led to heavy focus on technological showcase projects while neglecting community building and ecosystem preservation [23].

Another challenge lies in its policy orientation. Masdar reflects Abu Dhabi's top-down planning style, where sustainability is subordinated to economic diversification goals. This has created a city more suited to corporate and elite interests than to inclusive social development. Affordable housing, public accessibility, and integration with existing urban fabric remain weak points [22].

Environmentally, while Masdar pioneered solar technologies and green building design, it has struggled to maintain its original zero-carbon/zero-waste targets. Dependence on imported materials, energy-intensive cooling systems, and construction delays reduced its ecological performance. Socially, the city has been criticized as an "ecological enclave," accessible mainly to privileged groups, with limited space for low-income communities [23].

The following table presents the evaluation of Masdar City's performance against the sustainability framework. The analysis highlights the extent to which urban, environmental, economic, and social standards have been applied in the city as a model of sustainable urban development.

Table 4: Analysis of Masdar city according to the previous Framework. Source: the author

Framework of reference standards	application degree	
Urban standards	81%	Strong
Environmental standards	63%	Medium
Economic standards	81%	Strong
Social standards	28%	poor
Overall application score	63%	Medium

The results show that while Masdar City demonstrates strong application of urban and economic standards, and a medium performance in environmental aspects, its social dimension remains weak. This indicates an imbalance in the city's sustainability approach, with limited focus on social equity and community integration compared to technological and economic priorities.

6. Analytical Study of Al Alamein New City in Egypt

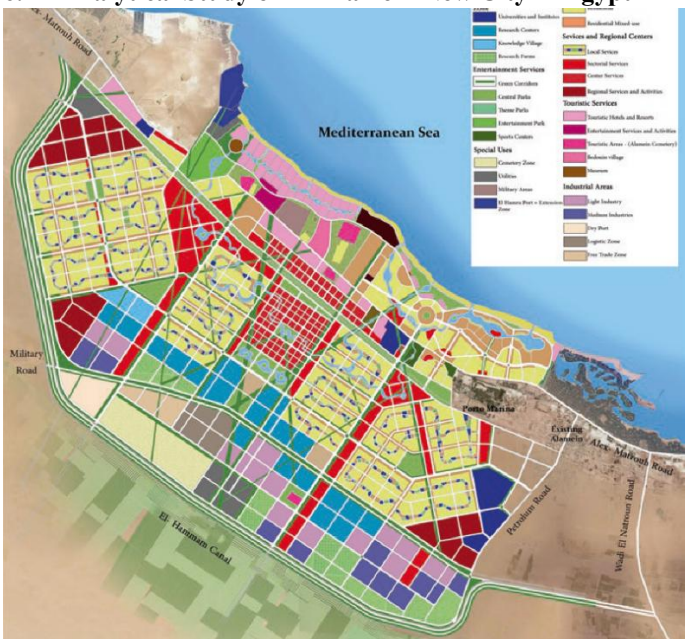

Fig. 4. Master plan of Al Alamein new city, 2017. Source: [24].

A. **Background:** Alamein New City (ANC) is a fourth-generation coastal city on Egypt's Mediterranean shore, planned to redistribute population away from the Nile Valley, catalyze regional development, and set a national benchmark for sustainable urbanism. The site has a 14-km public waterfront and a historically significant WWII landscape; the masterplan positions ANC as a resilient, inclusive city with strong identity, public spaces, and an international tourism/culture offer embedded in an integrated planning concept. The city's vision aligns with Egypt's national spatial strategy for the North-West Coast and emphasizes social inclusion, economic viability, environmental stewardship, and governance capacity [24].

Within Egypt's programme of New Urban Communities, ANC is framed as a testbed for linking spatial form to urban productivity—integrating mobility, connectivity, and value/supply-chain thinking so urban layout supports diversified economic drivers and jobs. [25].

B. **Main Sustainability Practices:** Strategic pathways and pillars. The city's Sustainable Development Strategy articulates five pathways: (i) social sustainability (equitable access, safe public realm, inclusion of women/children/elderly/people with disabilities); (ii) environmental sustainability (harmony with nature, pollution and waste reduction); (iii) economic sustainability (diversified base—eco-tourism, green industries, education/research); (iv) sustainable planning & urban design (livable, connected, mixed-use, balanced densities, efficient street network); and (v) enabling good governance and enforceable regulations as a fourth pillar alongside social–economic–environmental goals [24].

Guiding planning & infrastructure principles. Policy guidance prioritizes: compact, mixed-use neighborhoods; affordable and livable housing; walkability and transit as first principles; green links and public open space as connective tissue; and strong physical integration with Old Alamein. Infrastructure guidelines address groundwater protection, rainwater capture for irrigation, wastewater treatment, vegetation increase to reduce erosion, and upgrading storage and sanitation systems [24].

Linking planning and economy. At policy level, ANC adopts a productive urban development lens: spatial analysis is coupled with sectoral value-/supply-chain analysis to raise total factor productivity, cut logistics frictions, and leverage connectivity for investment and jobs. This reframes land-use, block size, network density, and regional linkages as economic enablers rather than purely physical form [25].

Policy direction on climate resilience. As a coastal city exposed to sea-related hazards, strategies include shoreline protection, ecosystem rehabilitation, and renewable-energy integration within city utilities—positioning ANC among Egypt's climate-safe urban initiatives [26].

C. **Challenges:** Governance and delivery capacity. Achieving sustainability hinges on robust institutions, transparent management, enforceable regulations, and continuous monitoring—historically a critical bottleneck in Egyptian new-towns and flagged as the most pressing challenge for ANC [24].

Balancing rapid coastal urbanization with ecology. Expanding a high-profile coastal city risks habitat degradation; sustained commitment is needed for dunes/wetlands restoration, shoreline protection, and maintenance of public waterfront accessibility. Water–energy nexus & operating costs. Desalination strengthens water security but raises energy intensity and lifecycle costs—requiring reliable renewables integration and efficiency gains to align with climate-safe goals. [26].

Linking spatial plans to real economy. Without deep coordination between land-use, mobility, logistics, and sector value chains, cities underperform in productivity and jobs; ANC's approach explicitly aims to close this gap, but it remains an execution risk. Social inclusion & year-round vitality. Branding and tourism can attract investment, yet policies must secure affordable housing, everyday services, and local employment so the city functions inclusively beyond seasonal peaks. [24, 25].

The following table presents the evaluation of ANC's performance against the sustainability framework. The analysis highlights the extent to which urban, environmental, economic, and social standards have been applied in the city as a model of sustainable urban development.

Table 5: Analysis of ANC according to the previous Framework. Source: the author

Framework of reference standards	application degree	
Urban standards	72%	Strong
Environmental standards	45%	Medium
Economic standards	54%	Medium
Social standards	28%	poor
Overall application score	49%	Medium

The results indicate that ANC demonstrates relative strength in urban development practices, while its performance in environmental and economic standards remains moderate. However, social sustainability is notably weak, reflecting significant gaps in inclusivity and community resilience. Overall, the evaluation positions ANC at a medium level of sustainable application, suggesting that further efforts are required to enhance the city's alignment with comprehensive sustainability goals.

7. Results

The comparative assessment of Vancouver, Masdar, and Al Alamein New City reveals sharp contrasts in how sustainable urban development standards are addressed under climate change. Vancouver demonstrates the most balanced and comprehensive performance, integrating resilient infrastructure, compact land-use planning, renewable energy adoption, and strong community participation. Its policies link environmental goals with economic growth while ensuring equity, making it the strongest model among the three.

Masdar presents mixed outcomes. While it excels in compact urban form, renewable energy investments, and contributions to economic diversification, it falls short in maintaining its original zero-carbon vision and in addressing social equity, as the city largely excludes affordable housing and community integration. New Alamein shows partial achievement: it has invested heavily in infrastructure and attracted tourism and real estate investment, but its environmental measures remain limited and its social outcomes weak, with development geared toward luxury rather than inclusivity.

Overall, the results suggest that Vancouver offers an integrated model balancing urban, environmental, economic, and social dimensions, while Masdar and New Alamein reflect more fragmented approaches where technological and economic priorities outweigh ecological and social sustainability.

8. Recommendations

1. Adopt climate-resilient infrastructure in transport, utilities, and housing to reduce vulnerability to floods, heatwaves, and sea-level rise.
2. Implement compact city models supported by sustainable land-use planning to minimize uncontrolled urban sprawl and optimize land resources.
3. Enforce green building standards and energy-efficient designs across all new developments, particularly in fast-growing urban areas.
4. Strengthen community participation in planning processes to ensure inclusive decision-making and improve social equity.
5. Expand affordable housing and basic services (clean water, sanitation, and healthcare) to enhance social resilience in vulnerable groups.

6. Scale up renewable energy adoption and integrate decentralized energy systems to reduce carbon intensity and dependency on fossil fuels.
7. Prioritize ecosystem preservation by protecting coastal zones, wetlands, and biodiversity corridors while integrating nature-based solutions.
8. Develop advanced water and waste management systems with recycling, desalination, and sustainable treatment technologies.
9. Introduce sustainable financing mechanisms (green bonds, carbon markets, climate funds) to secure long-term investment in low-carbon projects.
10. Promote green jobs and economic diversification in renewable energy, sustainable transport, and eco-tourism to strengthen economic resilience.
11. Encourage public–private partnerships (PPPs) with strong accountability frameworks to support eco-friendly infrastructure and services.
12. Enhance disaster risk reduction strategies by embedding resilience measures in urban design and integrating smart city technologies.

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