



FORGING PATHWAYS *for* **URBAN RESILIENCE** *in the* MENA REGION

Edited by
LEIGH MANTE



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***in the* MENA REGION**



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Contents

Editor's Note	6
<i>Leigh Mante</i>	
1 Cities Are Where Our Shared Humanity Will Be Won or Lost	9
<i>Sukaina Abdul Ilah Al-Nasrawi</i>	
2 Utopia Under Pressure: Rationale and Realities of Mega-Giga-Tera-Projects	16
<i>Mannat Jaspal and Leigh Mante</i>	
3 Enhancing the Legacy of Mega-Events in the GCC	22
<i>Victoria Lee</i>	
4 Strategies to Mitigate the 'Urban Heat Island' Effect in the Gulf Region	28
<i>Basit Khan, Olivier Pauluis, and Francesco Paparella</i>	
5 Synchronising Solar and eMobility in the GCC: The Next Frontier in Clean Transport	40
<i>Heiko Seitz</i>	
6 Liquid Gold in the GCC: Unlocking Wastewater for Sustainable Urban Water Systems	47
<i>Maha Al-Zu'bi</i>	
7 Designing Circular Cities: Lessons from India for the Gulf Region	57
<i>Dikshu C. Kukreja</i>	
8 Mobilising the Youth for Climate Action and Governance: Lessons from Casablanca	63
<i>Oumaima El Idrissi</i>	
9 The Need for an Integrated Framework to Address the Climate-Health-Migration Nexus in Iraq	70
<i>Leigh Mante and Reem Sagahyoon</i>	
10 From Reactive Responses to Integrated Urban Resilience Systems: Insights from Jordan	80
<i>Montaser Hiyari</i>	
11 Designing for Urban Resilience: The Story of the Oasis City of Ouarzazate	86
<i>Nour-Dine Salimi and Idar Hidi</i>	

Editor's Note

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The Middle East and North Africa (MENA) region is rapidly urbanising. It faces compounding vulnerabilities including extreme heat, water scarcity, geopolitical instability, and infrastructural and demographic pressures. Cities remain at the forefront of these converging challenges, tasked with conceptualising systems that ensure that infrastructure design, public services, and governance remain modern and locally rooted, to enforce circularity, resilience, and liveability for years to come.

Forging Pathways for Urban Resilience in the MENA Region convenes diverse perspectives from scholars, practitioners, and city leaders to unpack the structural, technological, and institutional mechanisms required to navigate this transition. Across 11 essays, the authors present compelling frameworks on how to leverage human-centred planning approaches, large-scale infrastructure pursuits, nature-based solutions, circular water systems, and clean transport networks alongside coordinated governance to safeguard sustainable urban transformation.

The report also highlights how, despite increasing global emphasis on adopting technological innovation, inclusive and integrated governance remains necessary. The contributors underline the importance of simultaneously retaining traditional knowledge systems, encouraging enhanced vertical and horizontal coordination, and enforcing South–South learning exchanges to scale actionable solutions across the region.

Sukaina Abdul Ilah Al-Nasrawi sets the stage, underscoring how cities represent microcosms of humanity. Building liveable cities requires paying close attention to the preservation of human dignity and social equity. She argues for the development of a new urban planning paradigm that encompasses integrated planning, human-centred digital approaches, and economic resilience, all of which address the region's rapid urbanisation, high youth unemployment, displacement, and fragile infrastructure.

As countries within the region increasingly pursue mega-development, Mannat Jaspal and Leigh Mante interrogate the risks associated with such ambitious endeavours. Evaluating both the rationale and realities of mega-projects, they call for national-subnational governance coordination and financial and environmental guardrails to prevent cost overruns and socio-environmental damage. Victoria Lee offers a complementary perspective on mega-events, demonstrating how context-driven planning can transform temporary event infrastructure into long-term community benefits.

As extreme heat engulfs the MENA region, Basit Khan, Olivier Pauluis, and Francesco Paparella emphasise the severity of the issue, pointing to the resulting exacerbation of health, occupational, and economic risks. They also present layered strategies to temper the Urban Heat Island (UHI) effect intensification through a combination of passive cooling, district cooling expansion, and transit-oriented development.

Building circular systems by developing infrastructure that integrates key resources helps improve efficiency, reduce climate vulnerabilities, and foster sustainable economic growth. Heiko Seitz explores the largely unharnessed potential of synchronising electric vehicle charging infrastructure with solar power and battery storage across the Gulf Cooperation Council (GCC) countries to decarbonise transportation and enhance grid resilience. Maha Al-Zu'bi advocates for the expansion of wastewater reuse to diversify water supply and reduce over-reliance on desalination, which poses long-term environmental and energy challenges. Dikshu C. Kukreja offers lessons from India to minimise waste loss, leverage low-carbon materials, and develop circular value chains and climate-responsive design. By applying lessons from other countries, GCC cities can scale nascent technologies to build resource-efficient and resilient urban centres.

Beyond the proposed technological solutions, the remaining chapters offer case studies from MENA cities to highlight the importance of engaging the youth and vulnerable populations through integrated governance frameworks. Oumaima El Idrissi demonstrates how youth participation serves as a strategic lever to implement climate projects, acting as a trust-building network

between institutions and communities in Casablanca. Leigh Mante and Reem Sagahyroon showcase how formalising a clear framework for internal climate migration would minimise negative health impacts and facilitate safe and inclusive migratory movements in Iraq. Montaser Hiyari doubles down on how resilience is fundamentally a governance challenge, requiring stable institutions and synergised policies to safeguard urban cities, using Jordan as a case study. Nour-Dine Salimi and Idar Hidi emphasise how traditional oasis models and local knowledge systems in Ouarzazate remain core pillars of sustainability that should not be disregarded as technology evolves.

As cities in the MENA region rapidly urbanise and digitise, this compendium offers balanced and practical perspectives to help city leaders pursue integrated pathways towards urban resilience. Through context-specific case studies, it aims to inform policymakers, urban planners, private actors, and grassroots and academic organisations on ways to conceptualise smart, regenerative, and locally relevant city solutions.

Cities Are Where Our Shared Humanity Will Be Won or Lost

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The question is no longer whether cities will grow, but whether they can remain liveable under pressure. Across the Arab region,^a urban expansion is accelerating, with more than 60 percent of the population living in cities and the share projected to rise to approximately 70 percent by 2050.^{1,2} At the same time, nearly 29 percent of young people in the region are neither in school nor are employed or in training for a vocation—this proportion is at 39 percent in low-income countries.³ This places growing pressure on cities to generate opportunities and nurture inclusion.

The pressure is further intensified by instability. As of November 2024, violent conflicts have displaced more than 15 million people and left over 50 million in need of humanitarian assistance.⁴ These challenges

a The Arab region encompasses Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates, Yemen.

are mutually reinforcing: conflict, displacement, economic fragility, environmental stress, and infrastructure gaps interact with one another, continuously reshaping how cities function. In countries such as Lebanon and Jordan, municipalities face mounting pressure on housing and basic services,⁵ while in Iraq and Yemen, internal displacement has accelerated the expansion of informal settlements and deepened the strain on already fragile systems.⁶

At the same time, the scale of mobility underscores the challenge, with tens of millions of migrants, refugees, and internally displaced people, alongside more than 80 million people living in informal settlements.⁷ Rapid demographic change and a growing youth population are increasing demand for jobs, services, and infrastructure at a pace many cities struggle to meet. Cities have become the frontline where social and economic stability is tested in everyday life.

What is required is a new urban planning paradigm that aligns resilience, smartness, and human capability around improving quality of life. The proposed framework for the Arab region is built on three interconnected pillars: integrated planning, which aligns land use, infrastructure, and economic systems; economic resilience, which enhances the capacity of cities to absorb shocks while sustaining livelihoods and inclusion; and human-centred digital integration, which leverages technology to improve quality of life while addressing risks associated with inclusive development. Together, these pillars offer a practical approach for cities operating under conditions of uncertainty and structural pressure.

This requires moving beyond fragmented approaches towards integrated planning that enables people not only to cope with shocks but also to participate in decision-making, adapt to changing conditions, and expand their capabilities by accessing opportunities and services that improve their livelihoods and well-being. In a region shaped by uncertainty, cities are not just engines of growth; they are where stability, inclusion, and shared humanity are either sustained or lost.

Integrated Planning as the Foundation of Urban Resilience

Responding to this reality requires moving beyond incremental adjustments towards a deliberate and coordinated approach to urban development. This means aligning how cities grow with how people access opportunities and placing urban planning at the centre of economic resilience and quality of life. Planning is not merely a technical exercise but a strategic instrument for managing risk, directing investment, and shaping how societies function under pressure.

Urban systems across the region are operating under continuous strain. Economic volatility, infrastructure deficits, environmental pressures, and protracted crises are not temporary disruptions but structural conditions. Addressing them requires a fundamentally different approach to planning and governance.

This shift demands stronger coordination across urban systems. It requires aligning land use with economic activity, ensuring transport is safe, affordable, and accessible, and directing investment

towards areas facing the greatest pressure. Without such integration, even well-designed strategies often fail to deliver tangible improvements in people's lives.

Emerging examples across the region illustrate this shift. In Riyadh (Saudi Arabia), large-scale urban transformation efforts are aligning land use, transport, and economic diversification within integrated planning frameworks. In Casablanca (Morocco), coordinated mobility and logistics systems are improving access to employment and reducing congestion. In Dubai (United Arab Emirates), integrated service platforms connect transport, utilities, and governance systems, enabling more responsive and efficient urban management. These examples demonstrate that integration is not merely conceptual; it is operational and directly shapes how people access opportunities and services in their daily lives.

Building urban resilience also requires embedding foresight into planning. Cities must anticipate risks, plan under uncertainty, and make decisions that strengthen long-term resilience rather than react to immediate crises. This includes strengthening coordination across levels of government, advancing decentralisation, and equipping local authorities with the ability, tools, and data needed to guide decision-making. At the core of this shift is the recognition that cities must be planned not only for growth and efficiency but also for disruption and uncertainty. In this context, risk preparedness becomes a central component of urban planning rather than a secondary consideration.

In Abu Dhabi (United Arab Emirates),⁸ the Emergencies, Crises and Disasters Management Centre operates a six-phase integrated emergency system to strengthen coordination and protect communities, while the emirate's climate strategy and adaptation plan seek to enhance the resilience and agility of key sectors.⁹ In Doha (Qatar), the Public Works Authority's Critical Asset Resilience Programme is constructing stormwater drainage infrastructure to protect vital assets, reduce rainwater accumulation, and improve road safety in high-pressure urban areas. Doha's integrated public transport network, including the Metro and Lusail Tram, further reflects a planning approach that links mobility, resilience, and service continuity.^{10,11}

These approaches have led to more reliable service delivery, faster response times, and improved institutional coordination, directly affecting how people experience safety, access, and stability in times of crisis. Integrated planning is therefore not only a governance tool, but a direct pathway to improving quality of life, ensuring that services, infrastructure, and opportunities are delivered in a coordinated, resilient, and inclusive manner.

Economic Resilience as the Core of Urban Stability

Within this context, resilience must be redefined. It is not a checklist but a mindset that shapes how cities plan, invest, and operate under continuous pressure. While urban resilience is often framed across social, environmental, physical, and institutional dimensions, its economic dimension remains underemphasised despite being central to urban stability. Urban economic

resilience is the capacity of cities to absorb shocks, sustain productive activity, protect livelihoods, and adapt to structural change while maintaining inclusive growth. It requires diversified local economies, functioning labour markets, resilient governance, enabling financial systems, and adequate infrastructure and connectivity.¹² When these elements are weak, cities struggle to respond effectively to disruption.

This challenge is particularly acute in the Arab region. An estimated 17.5 million people who want to work are unable to find employment. Youth unemployment remains the highest globally, at 3.8 times the rate for adults, and has consistently ranked among the highest globally over the past 25 years. Women are twice as likely to be unemployed as men. Informality dominates labour markets, with a large share of workers, particularly youth, engaged in insecure and unprotected jobs.¹³ These conditions mean that economic shocks quickly translate into income instability, exclusion, and reduced access to basic needs and services. As a result, economic instability directly affects quality of life by limiting access to employment, housing, mobility, and essential services.

Strengthening resilience therefore requires investing in local economic ecosystems, expanding access to formal employment, and supporting small and medium enterprises to adapt and grow. It also requires addressing structural inequalities, including the disproportionate burden of unpaid care work carried by women. Periods of disruption also create opportunities to address long-standing vulnerabilities and build more inclusive and adaptive urban systems. Urban economic resilience is ultimately the bridge between managing present risks and preparing cities for future transformations, including the transition to digital and more sustainable economies.

Across the region, a growing number of cities are translating these principles into targeted policies and interventions. In Amman (Jordan), investments in public transport and service accessibility have expanded women's mobility and improved access to employment opportunities. In Cairo (Egypt), initiatives supporting micro and small enterprises, including improved access to finance and business formalisation mechanisms, are helping segments of the informal economy transition towards greater economic stability. In Rabat (Morocco), gender-responsive urban planning initiatives are integrating safety, accessibility, and inclusivity considerations into the design of public spaces and urban services.

These interventions demonstrate that reducing inequality is not separate from resilience; it is foundational to it. Cities that improve access to decent work, reduce gender-based barriers, and support informal workers in transitioning toward more secure livelihoods are better positioned to absorb shocks and sustain inclusive growth. These experiences suggest that resilience strategies are most effective when they address inequality not as a social afterthought but as a structural component of economic stability.

Human-Centred Digital Integration for Resilient Cities

Human-centred digital integration recognises that technological transformation must ultimately serve people, strengthen inclusion, and improve quality of life. Digital technologies can strengthen urban resilience. Yet technology also introduces new risks, including cyber threats, privacy concerns, and widening digital inequalities. Building digital resilience therefore requires ethical data governance, secure systems, and inclusive access to digital capabilities.

This is why the concept of the Smart Sustainable City must be reframed, and treated not as a race for more data or more technology but an approach to accelerating human-centred development. ‘Smartness’ is defined not by what cities deploy but by how effectively they translate technology into improved quality of life. It operates across two interrelated dimensions: the systems cities build and the capabilities people must engage with and benefit from. Together, these dimensions determine whether technology expands opportunity or reinforces inequality.¹⁴

To be sure, resilience and smartness are not ends in themselves. They are means to advance human development and improve quality of life. This requires a shift towards planning that is both people-centred and capability-driven. It means prioritising inclusion, engaging communities as co-creators of their urban future, and focusing not only on what cities build but also on what people are able to do and become. Cities that expand human capability will be more resilient, more adaptive and, ultimately, more just.

Across the Arab region, a growing number of cities are demonstrating how these approaches can be applied. In Dubai (United Arab Emirates), integrated smart-city platforms enable real-time management of urban services, from mobility to energy and public safety, improving efficiency, responsiveness, and quality of life within a broader governance framework.¹⁵ In Casablanca (Morocco), intelligent transport systems are improving mobility through data-driven traffic management, strengthening core urban functions when aligned with planning priorities.¹⁶ In Ramallah (Palestine), the municipality’s e-services platform has digitised public services, allowing citizens to submit requests online and, over time, to track requests, make payments, and receive confirmations electronically, supporting more transparent and responsive local governance.^{17,18} In Riyadh (Saudi Arabia), investments in digital infrastructure and smart mobility support broader urban transformation, integrating technology into long-term planning to manage growth and improve service delivery.¹⁹ These examples point to a broader transformation in the role of planning. In a world of accelerating change, planners are no longer technicians of space; they are architects of the possible and stewards of human aspiration.

When applied thoughtfully, digital integration becomes a powerful pathway to improving quality of life, enabling more inclusive access to services, better decision-making, and stronger connections between people and institutions. Ultimately, these transformations matter not because cities become more technologically advanced, but because they become more capable of protecting

people, expanding opportunities, and sustaining dignity under conditions of uncertainty and change. The future of cities in the Arab region will be shaped by how effectively these three pillars are operationalised in practice.

To conclude, building liveable cities requires a deliberate shift towards integrated planning that strengthens resilience, integrates human-centred digital approaches, and expands human capabilities. These dimensions must advance together if cities are to remain functional, adaptive, and equitable in periods of uncertainty. At its core, this is about safeguarding what we share as human beings: dignity, inclusion, access to opportunity, and the ability to shape our own lives. Planning, therefore, should be understood as an act of hope and responsibility. It is a commitment to building cities that are more resilient, inclusive, and humane than those we inherit today. In an era of growing uncertainty, cities are where our shared humanity will ultimately be won or lost.

The views and opinions expressed in this article are those of the author. They do not reflect the views or positions of any entities the author represents or is associated with.

Endnotes

- 1 UN DESA, *World Urbanization Prospects 2022*, New York, United Nations Department of Economic and Social Affairs, 2022.
- 2 United Nations ESCWA, "Urbanization and Sustainable Development in the Arab Region," *Social Development Bulletin* 5, no. 4, <https://www.unescwa.org/sites/default/files/pubs/pdf/social-development-bulletin-urbanization-sustainable-development-arab-region-english.pdf>.
- 3 ESCWA, *Inequality in the Arab Region: Rights Denied, Promises Broken*, Beirut, United Nations Economic and Social Commission for Western Asia, 2017.
- 4 Humanitarian Action, "Global Humanitarian Overview 2024," December 4, 2024, <https://humanitarianaction.info/document/global-humanitarian-overview-2025/article/middle-east-and-north-africa-2>.
- 5 United Nations Economic and Social Commission for Western Asia (ESCWA), "SDG 11 Profile," <https://asdr-2024.unescwa.org/sdg-11.html>.
- 6 UNDRR, *Global Assessment Report on Disaster Risk Reduction 2021: Special Report on Disaster Risk in the Arab Region*, Geneva, United Nations Office for Disaster Risk Reduction, 2021.
- 7 ILO, *Global Employment Trends for Youth 2024: Arab States*, Geneva, International Labour Organization, 2024.
- 8 Abu Dhabi Emergencies, Crises and Disasters Management Centre (ADCMC), "About ADCMC," <https://www.adcmc.gov.ae>.
- 9 Environment Agency – Abu Dhabi, *Abu Dhabi Climate Change Adaptation Plan*, 2024, <https://www.ead.gov.ae/en/knowledge-hub/reports/climate-change-adaptation-plan-for-the-environment-sector-of-abu-dhabi>.
- 10 Ashghal (Public Works Authority Qatar), "South Doha Stormwater Tunnel Project," 2026, <https://www.ashghal.gov.qa/en/MediaHub/News/Pages/South-Doha-Stormwater-Tunnel.aspx>.
- 11 Qatar Rail, "Doha Metro and Lusail Tram Integrated Network," <https://www.qr.com.qa>.
- 12 ESCWA, *Economic Recovery and Urban Resilience: Diagnosis and Planning Tool*, United Nations Economic and Social Commission for Western Asia, <https://www.unescwa.org/publications/economic-recovery-urban-resilience-diagnosis-planning-tool>.
- 13 ESCWA, *Inequality in the Arab Region: Rights Denied, Promises Broken*, Beirut, United Nations Economic and Social Commission for Western Asia, 2017.
- 14 Sukaina Abdul Ilah Al-Nasrawi, *Sustainable Smartness of Cities: A Human-Centric Approach* (United Kingdom: Mobi Publishing, 2022), <https://www.amazon.com/Sustainable-Smartness-Cities-Centric-Approach-ebook/dp/B0BNR2VTWP>.
- 15 International Telecommunication Union (ITU), *United for Smart Sustainable Cities (U4SSC) case studies on Dubai*, <https://www.itu.int/en/publications/Documents/tsb/2016-DubaiCase/files/downloads/Dubai%20Case%20Study-410059-FINAL.pdf>.
- 16 World Bank, *Greater Casablanca Mobility and Logistics Hub*, <https://www.worldbank.org/>.
- 17 "Ramallah Municipality," <https://ramallah.ps/en/Category/1102/Electronic-Services>.
- 18 Ramallah Municipality, "Electronic Services," https://ramallah.ps/en/Category/1102/Electronic-Services?utm_source=chatgpt.com.
- 19 Riyadh Municipality, "Smart City Initiatives," <https://www.alriyadh.gov.sa/en/content/smart-cities-initiatives>.

Utopia Under Pressure: Rationale and Realities of Mega-Giga-Tera- Projects

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The growing wave of mega-giga-tera- projects, alongside the development of entirely new cities, has drawn the attention of both advocates who view these initiatives as powerful engines of economic growth and urban transformation, as well as sceptics, who question the financial viability, technical feasibility, and governance systems associated with such projects.

Over the past 20 years, emerging and developing economies have embraced large- scale projects and new city development as a strategic response to mitigate urbanisation challenges, attract investment, and create environmentally conscious and digitally-driven epicentres.¹

The Rationale

More than 55 percent of the world's population lives in cities today, a figure projected to exceed 68 percent by 2050.² As urban populations continue to grow, rising density has exacerbated traffic, housing shortages, and environmental degradation, increasing pressure on existing

infrastructure and public services while also invoking serious public health and safety concerns.³ The overconcentration of economic activities in existing urban centres has led to higher living and operational costs, reinforcing unequal patterns of wealth creation and development.

Climate change has further intensified these pressures. Cities are experiencing rising temperatures, frequent flooding, rising sea levels, prolonged droughts, and extreme precipitation, threatening physical infrastructure, economic productivity, and even human lives.⁴

As a result, governments are increasingly investing in new cities and large-scale urban development projects to alleviate pressure on existing infrastructure while promising holistic urban ecosystems that enhance quality of life, expand access to affordable housing, and spur economic and job creation. These projects have the potential to generate positive spillover effects for the broader community and become veritable socio-economic powerhouses if guided by inclusive principles and sound governance.

New cities offer a clean slate to address these urban challenges. In Indonesia's case, Jakarta's geography rendered the city susceptible to land subsidence and frequent flooding, prompting a shift to Nusantara.⁵ Malaysia similarly constructed Putrajaya to relieve urban congestion in Kuala Lumpur. Egypt's New Administrative Capital (NAC) aims to alleviate similar congestion and overpopulation issues in Cairo.⁶

Political and cultural drivers are equally important, especially for administrative capital relocations. Politically, a new capital can rebalance power dynamics to unify a country or ringfence it from geopolitical risks.⁷ Culturally, relocating an administrative centre offers an opportunity to rebrand national identity or better reflect a country's cultural diversity. Nigeria's capital shift from Lagos to centrally-located Abuja was intended to mitigate ethnic tensions and safeguard against potential security threats along Lagos' coast.⁸ Similarly, Indonesia's capital shift from Jakarta in West Java to Nusantara in East Kalimantan demonstrates an effort to physically re-concentrate political power to the country's geographic centre.⁹ Besides, Jakarta's island topography makes retrofitting historical and heavily populated coastal megacities nearly impossible. Such projects also lend themselves as powerful symbols of prestige, visibility, and national ambition, as exemplified by Saudi Arabia's NEOM.

Economic considerations further reinforce the case for large-scale project or new city development. Many political leaders argue that modernising ageing infrastructure is costlier, while new cities offer gateways to investment and a launchpad for economic growth.^{10,11} If carefully designed, keeping the socio-economic lens in mind, these cities could emerge either as a trade, finance, or innovation hub, such as Cyberjaya (Malaysia's technology hub) or Songdo (South Korea's international economic hub) or as a multi-purpose mega-centre of sustainable innovation, biotech, and tourism like Saudi Arabia's NEOM.¹² Across Africa, projects such as South Africa's Southern Farms Mega City, Egypt's New Administrative Capital (NAC), Tatu City in Kenya, and Eko Atlantic City in Nigeria reflect the growing effort to build future-ready urban centres capable of supporting

long-term economic growth and improving quality of life.¹³ Such efforts also allow governments to embed smart technologies and increase resource efficiency and sustainability considerations in project developments, as demonstrated by projects such as Masdar City and NEOM in the United Arab Emirates and Saudi Arabia, respectively.

While the motivations behind these projects may vary, cutting across cultural, social, economic, political, and environmental factors, their success ultimately depends on effective governance, sustainable financing, and realistic implementation.

The Realities

The gap between the original vision and the realised outcome is often significant. Social inequalities, environmental pressures, and economic uncertainty tend to persist in existing models and risk being replicated in new centres.

First, cost overruns are rampant, and financial challenges can become a fiscal strain at best and a political disaster at worst. Building new cities is a costly and long-term endeavour which does not lend itself well to the swinging pendulum of democratic election cycles or a volatile global economy.¹⁴ Launched during Jokowi's administration, Nusantara does not exactly fit within the current Prabowo administration's ambitions,¹⁵ as seen through recent public funding shortfalls which undermine the project's financial sustainability and long-term political legitimacy.¹⁶ In another instance, the budget for the Line at Neom increased from US\$1.6 trillion to US\$4.5 trillion,¹⁷ and the project has faced multiple engineering challenges and supply chain deficiencies¹⁸ since its inception, forcing the emergence of a smaller-scoped version of the futuristic city. Given these large-scale mega projects are multi-decadal in nature, measuring progress and ensuring accountability becomes difficult, heightening the risks of fiscal mismanagement and corruption.

Second, despite promises of inclusivity and affordability, these projects risk becoming exclusive enclaves catering to the ultra-rich given the high development costs. The rapid relocation of Brazil's capital from Rio de Janeiro to Brasília led to social stratification, with wealthy groups concentrating in the city centre and poorer communities forced to reside on the outskirts, mirroring the urban settlement trends in Rio that the move had sought to overcome.¹⁹ In Nusantara as well, lack of consultation with local communities heightened concerns of community displacement as well as deforestation and biodiversity loss.

Third, the environmental cost and the impact on biodiversity can also be significant. Large swathes of land are required to build out new mega projects, which may lead to not only displacement of people but also loss of forest cover and biodiversity. For instance, the Line in NEOM's Saudi Arabia is believed to block the migration routes through the mountains for several species of mammal and migratory birds, including endangered species, prompting conservation groups to identify it as an "emerging issue of concern for global biodiversity conservation".²⁰ Furthermore, the

construction of entirely new cities also carries a substantial carbon footprint, given the intensive demand for cement, steel, aluminum, and other emissions-intensive materials.

Finally, redirecting government funding and planning towards new urban centres will not necessarily reduce the environmental and population pressures in the existing cities. For instance, although Nusantara is intended to ease Jakarta's ecological pressures, the shift will only relocate an estimated 1.9 million people by 2056, which is a slim fraction of Jakarta's projected growth from 42 million to 52 million in 2050.^{21,22} Ultimately, the tradeoffs must be considered more prudently as the fiscal resources allocated to build new projects eat away at the capital available for upgrading existing centres.

Pathways for Inclusive and Sustainable Development

Strong governance systems will be key to ensuring the necessary guardrails and enforcing accountability on stakeholders involved. Governments must ensure rigorous front-end planning followed by regular tracking and measurement protocols to evaluate progress and make necessary adjustments before it is too late. Independent third-party review and audit of forecasts and progress reports should be mandatory. Establishing structured community engagement channels would help integrate local feedback into project planning and ensure equitable social outcomes. This also enhances transparency, allowing for better alignment of incentives among project sponsors, contractors, and communities.

At the same time, such large-scale projects require consistent financing and coordination across multiple sectors and levels of government. Establishing a country-led secretariat would facilitate inter-agency policy coordination while helping to structure and blend public and private capital, thus avoiding siloed decision-making and adequately allocating capital. The urban management framework should be all-encompassing and capable of integrating physical infrastructure, environmental management, economic development, social services, land-use planning, and digital information systems within its fold.

Digitisation can further improve the governance dimension by supporting intelligent transport systems, energy and water management, environmental monitoring, public safety, emergency response, and more evidence-based service delivery. The idea is to not only adopt technology but also utilise data to support evidence-based urban governance.

Nevertheless, the long-term success ultimately depends on placing social inclusion, environmental sustainability, and community participation at the heart of urban development rather than treating them as secondary considerations.

Endnotes

- 1 Eva Klaus, "Emerging Horizons: The Rise of New Cities in the Global South," Charter Cities Institute, May 18, 2023, <https://chartercitiesinstitute.org/blog-posts/rise-of-new-cities/>.
- 2 United Nations Department of Economic and Social Affairs, "68% of the World Population Projected to Live in Urban Areas by 2050, Says UN," <https://www.un.org/en/desa/68-world-population-projected-live-urban-areas-2050-says-un>.
- 3 Deren Li et al., "Challenges and Opportunities for the Development of MEGACITIES," *International Journal of Digital Earth* 12, no. 12 (2019), <https://doi.org/10.1080/17538947.2018.1512662>, pp. 1382-1395.
- 4 Deren Li et al., "Challenges and Opportunities for the Development of MEGACITIES."
- 5 Tom X. Hackbarth and Walter T. de Vries, "An Evaluation of Massive Land Interventions for the Relocation of Capital Cities," *Urban Sci.* 4, no. 1 (2021), <https://doi.org/10.3390/urbansci5010025>.
- 6 Ivy Lerner-Frank, "Climate Mitigation in Capital Cities Costs. Is Building New Ones the Solution?," *The Globe and Mail*, 2022, <https://www.theglobeandmail.com/business/article-climate-mitigation-in-capital-cities-costs-is-building-new-ones-the/>.
- 7 Taraneh Meshkani, "The Dichotomy of Cities: Build on Legacy or Start from Scratch," *The Plan Journal* 9, no. 1 (2024), <https://www.doi.org/10.15274/tpj.2024.09.01.17>.
- 8 Onyanta Adama, "State, Space and Power in Postcolonial Africa: Capital Relocation as a State Building Project in Nigeria," *Hemispheres. Studies on Cultures and Societies*, (2012), <https://www.proquest.com/openview/6388ff6594351d1d91ff8cfc5f58611e/1.pdf?pq-origsite=gscholar&cbl=856346>.
- 9 Alfath Satria Negara Syaban and Seth Appiah-Opoku, "Perspective Chapter: Indonesia's Capital City Relocation as Multi-Dimensional National Conflicts Resolution Strategy," June 26, 2025, <https://www.intechopen.com/chapters/1217433>.
- 10 Edesio Fernandes, "Regularization of Informal Settlements in Latin America," https://www.lincolnst.edu/app/uploads/legacy-files/pubfiles/regularization-informal-settlements-latin-america-full_0.pdf.
- 11 Wade Shepard, "Should We Build Cities from Scratch?," *The Guardian*, July 10, 2019, <https://www.theguardian.com/cities/2019/jul/10/should-we-build-cities-from-scratch#:~:text='A%20wild%20west%20atmosphere',real%20estate%20and%20construction%20sectors>.
- 12 Wade Shepard, "Ghost Towns or Boomtowns? What New Cities Really Become," *Forbes*, March 19, 2018, <https://www.forbes.com/sites/wadeshepard/2018/03/19/ghost-towns-or-boomtowns-what-new-cities-really-become/>.
- 13 Honore Banda, "Inside Africa's New Cities: Egypt, Kenya and Nigeria Bet Big on Urban Mega-projects," *The Africa Report*, July 28, 2025, <https://www.theafricareport.com/388780/inside-africas-new-cities-egypt-kenya-and-nigeria-bet-big-on-urban-mega-projects/>.
- 14 Shepard, "Ghost Towns or Boomtowns? What New Cities Really Become".
- 15 Yanuar Nugroho and Julia Lau, "Does Indonesia's New Capital City, Nusantara, Fit into the President's Long-Term Vision?," *Fulcrum Institute*, August 4, 2025, <https://fulcrum.sg/does-indonesias-new-capital-city-nusantara-fit-into-the-presidents-long-term-vision/>.
- 16 Michael Nielson, "Indonesia's New Capital, Nusantara, in Danger of Becoming a 'Ghost City,'" <https://www.theguardian.com/world/2025/oct/29/indonesia-new-capital-city-nusantara>.
- 17 Alison Killing, "End of The Line: How Saudi Arabia's Neom Dream Unraveled," <https://ig.ft.com/saudi-neom-line/>.
- 18 Killing, "End of The Line: How Saudi Arabia's Neom Dream Unraveled."

- 19 David Henley and Giulia Frigo, "Lessons from Brasilia: on the Empty Modernity of Indonesia's New Capital," New Mandala, April 14, 2020, <https://www.newmandala.org/lessons-from-brasilia-on-the-empty-modernity-of-indonesias-new-capital/#:~:text=There%20are%2C%20it%20is%20true,in%20the%20direction%20of%20an>.
- 20 Killing, "End of The Line: How Saudi Arabia's Neom Dream Unraveled".
- 21 Charmaine Jacob, "Indonesia is Moving its Capital from Jakarta to Nusantara. Here's Why It Won't Be So Easy," *CNBC*, August 27, 2023, <https://www.cnbc.com/2023/08/28/indonesia-to-move-capital-from-jakarta-to-nusantara-but-it-wont-be-easy.html>.
- 22 United Nations Department of Economic and Social Affairs, "World Urbanization Prospects 2025 – Summary of Results," https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/undesapd_2025_wup2025_summary_of_results.pdf.

Enhancing the Legacy of Mega-Events in the GCC

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Mega-events can help the Gulf Cooperation Council (GCC) countries achieve their national and shared regional objectives through urban planning and development. These objectives include economic diversification, the celebration of cultural values, and sustainable development. To begin this process, the specific role, value, and legacy of mega-events could be explored in the regional context.

Three key factors underpin this proposition. First, the phase of global sport and cultural exposition has emerged at large for countries in the region, having hosted, in the recent past, the World Expo 2020 (Dubai) and the FIFA World Cup 2022 (Doha). These events can be considered a turning point for the region.¹ The next few years will see successive mega-events in Saudi Arabia, including the World Expo in 2030 and the FIFA World Cup in 2034. Preparations by planning authorities and local and international consultancies, from Riyadh to Aseer, are underway.^{2,3}

Second, mega-events held in the GCC region have inspired and accelerated urban planning practices and development at local, national, and international scales. These mega-events are enabled through the national vision statements of individual GCC nations. The 2022 FIFA World Cup in Doha is a pertinent example, as illustrated at varying geographic levels in a study by Liang Zhou et al. At a local level, this mega-event helped to improve walkability and urban greening.⁴ At a national level, it has had a “profound impact on the host country’s socio-economy”.⁵ At the international level, Liang Zhou et al. posit that World Cup urban greening initiatives have contributed positively to the United Nations Sustainable Development Goals (SDGs), specifically SDG 11 (Sustainable Cities and Communities).⁶

Third, in the study of urban planning and development, the definitions of ‘mega-event’ and ‘legacy’ remain obscure. Therefore, it may be difficult to accurately compare mega-events and their legacies across cities, countries, and regions. Notwithstanding this etymological issue, the following definitions are used in this article: mega-events are viewed through the lens of “visitor attractiveness, mediated reach, costs and transformative impact”, as defined by Muller, rather than scale.⁷ Legacy, meanwhile, is attributed to “all the planned and unplanned, positive and negative, intangible and tangible structures created through a sports event that remain after the event,” as defined by Meza and Ghamdi.⁸

Mega-Events and Legacy Framework

Professional insights and experience are critical to the study of mega-events, their legacy, and impact on urban planning and development. In this context, knowledge is largely transferred through international urban planning and design practices that underpin such global projects, and between relevant governments, stakeholders, investors, and mega-event organising committees.⁹ Additionally, there is a growing body of academic research connected to the respective mega-events and their legacies. Three legacy approaches are suggested in the following paragraphs,^a which pivot established urban planning and development practices in the context of mega-events.

Adaptive Legacies

GCC countries can potentially explore the notion of ‘adaptive legacies’ at the outset of and throughout the delivery of mega-events in the region. Through adaptive legacies, multiple yet smaller-scale initiatives and interventions are prioritised. Such initiatives can create positive environmental and socio-economic benefits for local places and people.¹⁰ These initiatives and interventions may be delivered over a longer period. For instance, Liang Zhou et al. propose that urban greening in mega-event masterplans should not be approached from a “static” perspective.¹¹ As a reference point, Qatar’s World Cup contributed 73 percent of green space at a national scale—a notable achievement.¹² A more adaptive approach to land allocation for urban greening

a These recommendations are offered in good faith towards the continued growth and success of the GCC region.

may catalyse better results in the future, when informed through baseline per capita calculations and supported by parallel urban greening initiatives. Furthermore, more pilots or trials for urban planning and development initiatives could be encouraged.¹³ For instance, after a mega-event, large unused parking lots could be repurposed through a “flexible events streets policy”.¹⁴ In this way, the legacy of mega-events can adapt to the needs of the locality and community over time.

In London, while urban planning and development approaches for the 2012 Olympic Games were adapted to local needs over time, the underpinning legacy concept of “convergence” was largely fixed from the bidding phase.¹⁵ This concept related to uplifting under-represented communities in East London through improved infrastructure, housing, and job opportunities. Convergence was cited across many urban planning policies and reports, business strategies, and communications before and after the Games. However, the concept was increasingly difficult to achieve during the legacy phase due to the increasing land value on the Olympic Park.^{16,17} Laterally, the city of Paris adopted a multi-scalar and multi-pronged approach to the legacy of the 2024 Olympic Games. It focused more on “eco-innovative” quick wins, reuse, and medium to small-scale interventions to deliver its strategic objectives.¹⁸

Context as Anchors

GCC countries can explore ways to further deepen the relationship between mega-event policies, masterplans, and placemaking initiatives and the regional and national context. Context in this regard ranges from physical, environmental, and economic to social, heritage, and cultural themes. The importance of culture in mega-event and legacy delivery in the GCC region has been cited in urban planning study and research, such as in Zaidan and Abulideh’s work.¹⁹ The architectural design of the pavilions at Dubai’s 2020 World Expo celebrated culture, which in turn provided an “immersive experience” for local youths.²⁰ Nevertheless, there is scope for further focus on culture in the delivery of mega-events beyond the architectural design of venues.²¹ The design of the public realm surrounding venues, for instance, can support longer-term legacies and further reinforce culture beyond the perimeter of the site.²²

Context can also help to drive urban planning innovation, particularly as mega-events can be an “experimentation arena for spectacular urban planning”.²³ Innovation is needed to address critical issues, such as rapid urbanisation and population increase across the GCC nations. Qatar’s population, for instance, increased by 183 percent over the past 20 years.²⁴

The physical context played a key role in the urban design and planning approach for the FIFA World Cup 2022 in Doha. The concept of a “compact city” masterplan emerged in response to the tight, existing urban administrative boundary and constraints of the existing topography.²⁵ It reinforced existing urban growth and population distribution patterns, while addressing future growth. This concept has had positive impacts on walkability and reinforced existing urban policy initiatives to promote mixed land uses and sustainable mobility.

Integrated Planning and Knowledge Transfer

Existing studies of mega-event delivery in the GCC region have pinpointed the key role of urban planning governance systems.²⁶ Such systems, however, “must be contextualised within the normative and political-economic contexts of host cities”.²⁷ Therefore, they should be informed by key local government organisations involved in urban planning and development decision-making. Mega-event and legacy committees, bolstered by expertise in urban planning and development, could engage the public and private sectors. For instance, to avoid mega-events being inadvertently used as proxy policy frameworks, such governance systems can help to reinforce the role of national objectives, approved policies, and stakeholder engagement.²⁸

In a similar vein, technical knowledge and expertise in mega-event and legacy delivery can be captured through integrated urban planning systems. This critical knowledge and expertise can lay the foundation for future, and even more successful mega-events in the region. To support knowledge transfer between GCC nations, intermittent participation by host cities in the aforementioned special committee may be considered. The city of Milan, for example, has utilised learnings from its 2015 World Expo. It developed and delivered the Expo in Città cultural programme to extend the legacy of the Milan-Cortina Winter Olympics.²⁹ The cultural programme expanded the geographical area and timescale of the mega-event, and thus its legacy. Such an approach could also be applied in Saudi Arabia, which will be hosting the World Expo and FIFA World Cup in quick succession.

Conclusion

The GCC region can play an exceptional role in the (re)conception of global mega-events and their legacies. Through this approach, their legacies and national and regional objectives can be further secured over time. Moving the needle on urban planning and development in the GCC context can potentially bring a range of benefits. The regional and national identities of its nation-states can be boosted to further support tourism and socio-economic growth.

Given the number and frequency of mega-events in the coming years, the GCC region is ideally placed to shape mega-events at a global scale. Saudi Arabia’s mega-events, for one, are likely to inform regional and local planning practices and development in Saudi Arabia and beyond for years to come.

AI has been used to help research relevant topics underpinning this article and to compile the citation list. The content of the article, however, has been developed by the author, and reviewed by ORF’s editors.

Endnotes

- 1 Sahera Bleibleh et al., "Dubai World Expo 2020: A Youth-Centric Analysis of Mega Events and Their Preliminary Influence on Sustainable Development," *Resilient Planning and Design for Sustainable Cities*, 2024, https://doi.org/10.1007/978-3-031-47794-2_5, pp. 51-59.
- 2 "Riyadh 2030: The Vanderbilt Terminal for Saudi Expo 2030 and Vision 2030," <https://www.riyadh2030.ai/governance/municipal-governance/>.
- 3 "Aseer Readies Its Infrastructure for World Cup Hosting Duties," May 5, 2026, <https://enterpriseam.com/ksa/2026/05/05/aseer-readies-its-infrastructure-for-world-cup-hosting-duties/>.
- 4 Liang Zhou et al., "The World Cup Reshaped the Urban Green Space Pattern of Qatar," *Ecological Informatics* 81 (2024), <https://doi.org/10.1016/j.ecoinf.2024.102551>.
- 5 Zhou et al., "The World Cup Reshaped the Urban Green Space Pattern of Qatar".
- 6 Zhou et al., "The World Cup Reshaped the Urban Green Space Pattern of Qatar".
- 7 Martin Muller, "What Makes an Event a Mega-Event? Definition and Sizes," *Leisure Studies* 34, no. 6 (2025), <https://doi.org/10.1080/02614367.2014.993333>, pp. 627-42.
- 8 Abel Meza and Sami G. Al-Ghamdi, "Sustainability in Mega-Events: Beyond Qatar 2022," *Sustainability* 11, no. 22 (2019), https://doi.org/10.3390/su11226407?urlappend=%3Futm_source%3Dresearchgate.net%26utm_medium%3Darticle.
- 9 Simona Azzali, "Mega-Events and Urban Planning: Doha as a Case Study," *URBAN DESIGN International* 22 (2017), <https://doi.org/10.1057/s41289-016-0011-y>.
- 10 Bleibleh et al., "Dubai World Expo 2020: A Youth-Centric Analysis of Mega Events and Their Preliminary Influence on Sustainable Development".
- 11 Zhou et al., "The World Cup Reshaped the Urban Green Space Pattern of Qatar".
- 12 Zhou et al., "The World Cup Reshaped the Urban Green Space Pattern of Qatar".
- 13 Azzali, "Mega-Events and Urban Planning: Doha as a Case Study".
- 14 Ola M. Jarrar and Majd Al-Homoud, "Sustainable Urban Development in Riyadh: A Projected Model for Walkability," *International Journal of Urban Sustainable Development* 16, no. 1 (2024), <https://doi.org/10.1080/19463138.2024.2421163>, pp. 398-421.
- 15 Larissa Davies, "Beyond the Games: Regeneration Legacies and London 2012," *Leisure Studies – LEIS STUD* 31 (2012), <https://doi.org/10.1080/02614367.2011.649779>, pp. 1-29.
- 16 Gustavo Lopes dos Santos, Ana Morais de Sa, Beatriz Condessa, "Olympic Regeneration vs. Social (In)Justice: Value Capture as a Referee," *Cities* 156 (2025), <https://doi.org/10.1016/j.cities.2024.105520>.
- 17 Mary Christine Wheatley, "The Impact of Mega-Events on Urban Development: A Review," *Premier Journal of Social Science* (2024), <https://doi.org/10.70389/PJSS.100001>.
- 18 Monika Smiralova, "Eco-Innovation and Responsibility: the Paris Olympics 2024 and its Impact on City Urbanism," *ESF Web of Conferences* (2024), <https://doi.org/10.1051/e3sconf/202560805020>.
- 19 Esmat Zaidan and Ammar Abulibdeh, "Master Planning and the Evolving Urban Model in the Gulf Cities: Principles, Policies, and Practices for the Transition to Sustainable Urbanism," *Planning Practice & Research* 36, no. 2 (2021), <https://doi.org/10.1080/02697459.2020.1829278>, pp. 193-215.
- 20 Bleibleh, "Dubai World Expo 2020: A Youth-Centric Analysis of Mega Events and Their Preliminary Influence on Sustainable Development".
- 21 Zaidan and Abulibdeh, "Master Planning and the Evolving Urban Model in the Gulf Cities: Principles, Policies, and Practices for the Transition to Sustainable Urbanism."

- 22 Deepthi John and Kayvan Karimi, "Mega-Event Legacies: Establishing a Framework for Evaluating the Role of the Spatial Network in Fostering Positive Legacies of Sporting Events in Barcelona, Athens, London, and Doha, Tested on the Case of Qatar FIFA 2022," 12th International Space Syntax Symposium (2019), <https://www.researchgate.net/publication/353164294>.
- 23 Mohammad Al-Saidi and Esmat Zaidan, "Gulf Futuristic Cities Beyond the Headlines: Understanding the Planned Cities Megatrend," *Energy Reports* 6 (2024), <https://doi.org/10.1016/j.egy.2020.10.061>, pp. 114-121.
- 24 Mohammad Arif and Adel S. Aldosary, "Urban Spatial Strategies of the Gulf Cooperation Council: A Comparative Analysis and Lessons Learned," *Sustainability* 15, no. 18 (2023), <https://doi.org/10.3390/su151813344>, pp 133344.
- 25 Abel Meza Talavera, Sami G. Al-Ghamdi, Muammer Koc, "Sustainability in Mega-Events: Beyond Qatar 2022," *Sustainability* 11, no. 22 (2019), <https://doi.org/10.3390/su11226407>.
- 26 Bashar Taha and A. Allan, "Planning for Legacy – A Cost Effective and Sustainable Approach. Case Study: Dubai Expo 2020," *ISPRS Annals of the Photogrammetry Remote Sensing and Spatial Information Sciences* (2022), <https://doi.org/10.5194/isprs-annals-X-4-W3-2022-237-2022>.
- 27 Julia Jastrzabek, Sven Daniel Wolfe, and Martin Muller, "Planning Mega-Events: Entrepreneurial, Regulatory and Neo patrimonial Models," *Local Economy* 39 no. 7-8 (2025), <https://doi.org/10.1177/02690942251371560>.
- 28 Azzali, "Mega-Events and Urban Planning: Doha as a Case Study".
- 29 Zachary M. Jones, Stefano Di Vita, and Davide Ponzini, "Changing Mega-Events' Spatial Strategies and Cultural Policy: Scaling Down, Spacing Out, and Assembling Organizations in the Cases of London and Milan," *City, Territory and Architecture* 9, no. 34 (2022), <https://doi.org/10.1186/s40410-022-00175-0>.

Strategies to Mitigate the ‘Urban Heat Island’ Effect in the Gulf Region

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Cities remain engines of economic growth and innovation. They are, however, increasingly emerging as hotspots of ecological distress under the combined pressures of climate change and rapid urbanisation.^{1,2} This impact is most evident during heatwaves, when urban layouts, socio-economic inequalities, and demographic pressures converge to intensify thermal stress, worsen air quality, harm ecosystems, and compromise economic growth and resource security.³ Central to this crisis is the Urban Heat Island (UHI) effect, whereby cities become hotter than surrounding rural areas as natural land cover is replaced by heat-absorbing materials like concrete and asphalt, further compounded by anthropogenic waste heat. The effect is often strongest at night, when cities release stored heat more slowly, producing temperature differences of up to 10°C in large metropolitan areas.⁴

For the Gulf Cooperation Council (GCC) countries, the implications are particularly severe. The region’s extreme baseline climate, rapid urban expansion, and energy-intensive development are amplifying heat risks, with rising wet-bulb temperatures approaching thresholds that could

challenge human habitability without effective mitigation. Interestingly, the daytime UHI effect in many GCC cities can be negative; urban areas benefiting from vegetation, water features, and reflective materials may be cooler than surrounding desert landscapes. Nevertheless, extreme heat and humidity frequently push human thermal comfort to physiological limits, with “feels-like” temperatures exceeding 45°C.⁵ UHI-related heat stress increases mortality, restricts outdoor activity, and reinforces a heavy dependence on air-conditioned indoor environments. The burden falls disproportionately on low-income populations and outdoor workers.⁶ Higher temperatures increase cooling demand, which in turn consumes more energy, worsens air quality, raises water use, and generates additional waste heat and emissions. Mitigating urban heat is therefore an imperative for public health, economic resilience, and the long-term sustainability of Gulf cities.⁷

In response, GCC countries are advancing policy frameworks anchored in mandatory green building codes, including Estidama⁸ and Al Sa’fat (UAE),⁹ GSAS (Qatar),¹⁰ Mostadam (Saudi Arabia),¹¹ ONSS (Oman),¹² and Kuwait’s green building code.¹³ Regional climate initiatives, such as the UAE’s National Climate Change plans^{14,15} supporting district cooling and the Saudi Green Initiative (SGI) focusing on urban greening,^{16,17} establish a strong regulatory baseline for integrating heat mitigation into urban design.

However, a critical disconnect persists between architectural policy and urban microclimate dynamics. Current building codes mandate high solar reflectance^{18,19} but overlook cumulative heat reflection within urban canyons. Furthermore, the SGI²⁰ is constrained by the water–energy–heat nexus, as irrigating non-native species can offset any cooling gains. National strategies also frequently neglect anthropogenic waste heat from car-dependent urban layouts and lack an emphasis on transit-oriented development. These challenges are compounded by fossil fuel subsidies,²¹ low utility tariffs, fragmented governance, and weak data systems.^{22,23,24} This article examines UHI mitigation strategies in GCC cities, identifying gaps between policy and microclimate realities, and explores emerging technologies and integrated approaches to advance heat-resilient urban development.

Urban Heat Mitigation Strategies

To achieve thermal resilience, GCC cities must transition towards a passively cooled urban metabolism. The following section explores how strategically engineered urban form (physical urban layout), fabric (surface type and characteristics), and functions (heat-emitting human activities) can create naturally cooler cities while leveraging emerging mitigation technologies.

Nature-Based and Green-Blue Infrastructure

Nature-based solutions leverage biological and hydrological processes to provide cooling through shading, evaporation, evapotranspiration, and solar reflection. Green roofs can reduce daytime land surface temperatures by 0.6–1.6°C²⁵ and indoor temperatures by 4–11°C,²⁶ particularly when utilising drought-tolerant species such as succulents and xerophytes. Hybrid green-albedo roofs

that combine reflective and vegetated surfaces offer additional cooling capacity.²⁷ Meanwhile, green walls provide added insulation, reducing building heating demand by up to 16.5 percent and cooling demand by ~51 percent, while mitigating UHI by up to ~5°C.²⁸

However, the water–energy–heat nexus remains a primary constraint, as the irrigation of non-native landscaping can completely offset these cooling benefits. GCC cities must prioritise xeriscaping and native afforestation using drought-resistant species like the ‘*Ghaf*’ tree.²⁹ As freshwater scarcity makes conventional landscaping unsustainable, utilising halophytic and salt-tolerant plants irrigated with saline water can conserve desalinated water, reduce energy use, and lower maintenance costs while supporting urban cooling.³⁰ Additionally, evaporative cooling from blue infrastructure such as lakes, ponds, canals, and fountains can reduce ambient temperatures particularly in the inland cities such as Al-Ain, Liwa, and Riyadh. Well-designed blue infrastructure can lower land surface temperatures by ~0.5–8°C and reduce building cooling energy use by ~8 percent.^{31,32,33}

Figure 1: Green Roofs (Dubai)



Source: *A Greener Middle East*³⁴

Figure 2: Sustainable Garden for Halophytic Plants (Abu Dhabi)

Source: International Center for Baseline Agriculture (ICBA)³⁵

Energy Infrastructure

In GCC countries, air conditioning accounts for 70 percent of peak electricity demand. District cooling offers a high-efficiency alternative by producing chilled water at central plants and distributing it to clusters of buildings, reducing energy costs by up to 40 percent compared to conventional systems.^{36,37} While the UAE leads this transition, Qatar, Bahrain, and Saudi Arabia are rapidly advancing district cooling through retrofits and new developments. As regional cooling demand is increasing much faster than expected,³⁸ these networks must integrate technologies like Thermal Energy Storage (TES),³⁹ powered by solar thermal energy or waste-heat recovery (via absorption chillers) to reduce lifecycle emissions.^{40,41}

Geothermal energy can further complement district cooling. For example, deep geothermal wells at Masdar City⁴² directly power absorption chillers, meeting ~10 percent of local cooling demand while reducing emissions and waste heat.⁴³ Furthermore, photovoltaic (PV) canopies over open parking areas and pavements mitigate the UHI effect by shading heat-absorbing surfaces while generating power, effectively reducing surface temperatures by 3–5°C.⁴⁴ Incorporating moisture-harvesting passive cooling systems (which absorb moisture at night and release it during the day) can effectively regulate panel temperatures and enhance PV efficiency in extreme heat.⁴⁵ Pavement-integrated PV expands the usable area for generation,⁴⁶ but it presents a unique challenge as the sensible heat release from darker PV integrated pavements can offset cooling benefits without proper thermal management.

Figure 3: A Photovoltaic Canopy in an Open Car Park (Ancona, Italy)



Source: FuturaSun⁴⁷

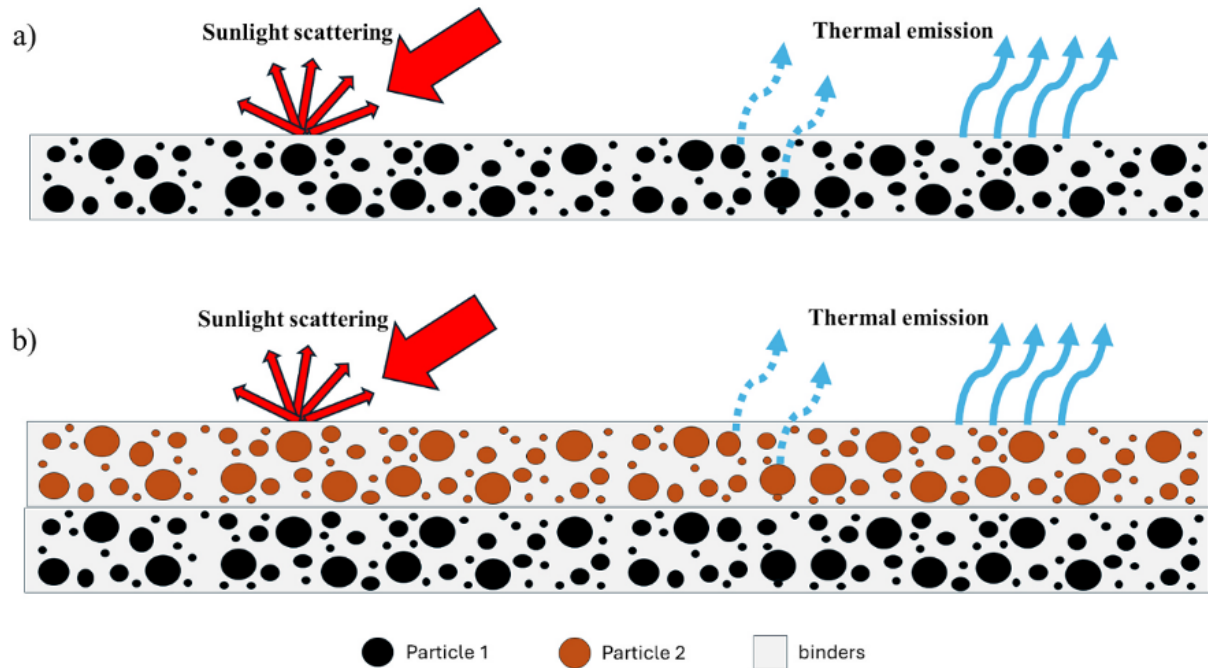
Note: This canopy produces 63 MWh per year.

Advanced Material Technologies

Conventional reflective coatings help reduce rooftop heat but are often unsuitable for streets and vertical facades because of intense glare and limited performance. Advanced solutions such as retro-reflective (RR) materials address this challenge by redirecting sunlight back toward its source (the Sun) rather than scattering it within the urban canyon, lowering surface temperatures by up to 20°C and air temperatures by 2.6°C.⁴⁸ Passive Radiative Cooling (PRC) materials, often referred to as super-cool paints, cool surfaces by reflecting sunlight and emitting heat through the 8–13 µm atmospheric window directly into space without heating the surrounding air.^{49,50} Variants include polymer coatings (cooling up to 21°C), porous paints (10.3°C), and fluorescent paints (~10°C).⁵¹

PRC-based cellular ceramics tested in Dubai have demonstrated a 17.5°C reduction in surface temperature, a 3–4°C reduction in ambient temperature, and ~20 percent energy savings.⁵² However, challenges regarding durability, UV degradation, and facade performance persist, requiring standardised metrics.⁵³ Dark pavements are major contributors to urban heat; replacing them with light-coloured, as seen in Abu Dhabi, has been shown to reduce surface temperatures by over 15°C.⁵⁴ Integrated designs using porous pavements, vegetation, and reflective coatings (such as Doha's blue-painted roads)⁵⁵ have achieved surface temperature reductions exceeding 30°C and air temperature drops of over 3°C.⁵⁶ Scaling these approaches alongside urban greening provides a highly practical pathway to improving street-level thermal comfort.

Figure 4: Cooling Mechanism and Structure of (a) Single-Layer Polymer-Particle Super-Cool Paint and (b) Dual-Layer Super-Cool Paint



Source: *Solar Energy*⁶⁷

Urban Design and Transport Networks

Passive urban design involves arranging buildings and streets to harness natural wind and shade, reducing reliance on mechanical cooling. In the hyper-arid GCC, optimising urban canyon geometry is critical. Deep, narrow streets with high height-to-width ratios ($H/W \geq 1.5:1$), modelled on traditional '*sikkas*', maximise shading (achieving 40–80 percent street shade)^{58,59} and lower the Physiological Equivalent Temperature (PET), a vital heat-stress indicator.⁶⁰ Aligning these grids with prevailing seasonal breezes, such as the prevailing '*Shamal*' winds, enhances natural ventilation to flush out trapped heat and pollutants. Developments like Masdar City and Msheireb Downtown Doha utilise these compact, carefully oriented layouts to drastically lower cooling demand. To optimise these complex interventions, planners can utilise urban climate digital twins, which are high-resolution 3D numerical models that integrate urban layouts with urban microclimate and anthropogenic heat to simulate 'what if' scenarios before implementation.⁶¹

Khalifa University, for example, has developed a digital twin for Abu Dhabi to test shading strategies and urban layouts.⁶² While cities like Dubai, Riyadh, and NEOM⁶³ are adopting similar tools, integrating building physics with micro-climate into these platforms remains essential. Additionally, integrating traditional *barjeels* (wind towers) with modern engineering helps capture breezes above the urban canopy and channel them downward, reducing street-level temperatures by $\sim 5^{\circ}\text{C}$,⁶⁴ a concept successfully deployed at Doha's Khalifa International Stadium during the 2022 FIFA World Cup.⁶⁵

Figure 5: Barjeel (Masdar City, Abu Dhabi)



Source: *The Earth Bound Report*⁶⁶

Note: The 45-metre-high tower captures cooler upper-level winds and directs them to the public square at its base.

Transit-Oriented Development (TOD) further limits anthropogenic waste heat by reducing car dependence. Initiatives like Dubai's Metro,⁶⁷ Riyadh's BRT,⁶⁸ and Doha's rail networks⁶⁹ are vital for cooling, yet their role in heat mitigation is severely under-recognised. Expanding public transport and improving last-mile connectivity must be explicitly aligned with heat-mitigation targets to meaningfully reduce street-level heat emissions.

Outdoor Human Thermal Comfort (OHTC)

Extreme heat across the Gulf is pushing wet-bulb temperatures toward the 35°C survivability threshold,⁷⁰ placing the elderly, children, pregnant women, people with pre-existing medical conditions, and outdoor workers at severe risk. While all GCC countries enforce afternoon work bans, these measures are temporally constrained and insufficiently responsive to actual microclimate conditions.⁷¹ The UAE has adopted more stringent measures based on the Thermal Work Limit, which incorporates humidity, wind, and solar radiation alongside temperature.

However, given the warming climate, expanded interventions, such as cooling vests, electrolytes, air-conditioned rest areas, a dynamic OHTC-based work ban, hydration stations, shaded pavements, cooling centres and misting systems are required to strengthen the protection of workers and the general public. Heat-Health Early Warning Systems (HHEWS), emergency preparedness plans, and widespread public awareness campaigns are essential.^{72,73,74} Emerging innovations, such as NYU Abu Dhabi's pilot mobile application for real-time thermal stress monitoring, offer valuable tools to improve risk awareness and adaptive responses. Sustained investment in these heat-health initiatives is critical to enhancing urban liveability across the GCC.

Recommendations and Conclusion

Urban heat mitigation in GCC cities is no longer optional; it is a structural necessity for ensuring long-term urban resilience. While progress has been made through green building codes and pilot interventions, scaling these efforts into integrated, city-wide strategies remains critical. Mitigating the UHI effect in the GCC requires integrated strategies that address the combined influence of urban form, fabric, and functions. A combination of passive design, advanced materials, clean cooling technologies, and data-driven planning offers a viable pathway forward.

While retrofitting the urban form of existing infrastructure—for example, by altering street geometry or adding underground transit—is often not feasible, adapting urban fabric and functions remains highly viable through a phased approach. Short-term interventions should prioritise immediate public resilience through physiological protections, heat-health early warning systems, localised misting, and super-cool coatings, guided by urban digital twins. In the long term, new developments should utilise microclimate digital twins to design passive urban geometry, expand district cooling networks, integrate nature-based infrastructure, and transition towards mixed-use, transit-oriented grids that permanently reduce car dependency and anthropogenic heat.

Nevertheless, success will depend on embedding these solutions within enforceable urban policy frameworks and aligning them with broader climate and development goals. Ultimately, addressing the UHI effect is not only about cooling cities but also about safeguarding public health, economic productivity, and liveability in one of the world's most heat-exposed regions.

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Endnotes

- 1 UNEP, "Beating the Heat: A Sustainable Cooling Handbook for Cities | UNEP - UN Environment Programme," November 8, 2021, <https://www.unep.org/resources/report/beating-heat-sustainable-cooling-handbook-cities>.
- 2 United Nations, *World Urbanization Prospects 2018* (2018), <https://population.un.org/wup/assets/WUP2018-Highlights.pdf>.
- 3 Leigh Mante, "Building A Heat Resilience Roadmap for the Gulf Region," ORF Middle East, 2026, <https://doi.org/2026>.
- 4 T. R. Oke et al., *Urban Climates*, 1st edn (Cambridge University Press, 2017), <https://doi.org/10.1017/9781139016476>.
- 5 "40°C but Feel Like 45°C: Why Does It Feel Hotter than the Actual Temperature in UAE?," 2025, *Gulf News*, <https://gulfnews.com/uae/weather/40c-but-feels-like-45c-why-does-it-feel-hotter-than-the-actual-temperature-1.500136293>.
- 6 Micheal Eisenstein, *City Try to Keep Their Cool* (2025), https://ideas.repec.org/a/nat/nature/v648y2025i8092d10.1038_d41586-025-03926-4.html.
- 7 Leigh Mante, "Building A Heat Resilience Roadmap for the Gulf Region," *ORF Occasional Paper No. 529*, Observer Research Foundation, March 2026, <https://www.orfonline.org/public/uploads/posts/pdf/20260313103509.pdf>.
- 8 Abu Dhabi Urban Planning Council, *The Pearl Rating System for Estidama Public Realm Rating System Design & Construction* (2016), <https://www.dmt.gov.ae/-/media/Project/DMT/DMT/E-Library/0001-Manuals/PRRS/PRRS-Version-10.pdf>.
- 9 Dubai Municipality, "Al Sa'fat Green Building System Guide | PDF | Sustainability | Green Building," Scribd, 2020, <https://www.scribd.com/document/554138690/Al-Safat-Regulations-Practice-Guide-Rev-01>.
- 10 GSAS, "GSAS Technical Guide V2.1 | PDF | Leadership In Energy And Environmental Design | Sustainability," Scribd, 2013, <https://www.scribd.com/document/286394726/GSAS-Technical-Guide-V2-1>.
- 11 KSA, *Mostadam Rating System*, <https://www.alpinme.com/mostadam-saudi-arabia/>.
- 12 PAL, 'Oman's 2040 National Spatial Strategy: Economic and Governance Components - EXPERIENCE', PAL Policy Analytics Lab, 2017, <https://www.palglobal.org/en/47159/Oman-s-2040-National-Spatial-Strategy-Economic-and-Governance-Components>.
- 13 NCOBC, *Kuwait Green Building Code*, December 30, 2024, <https://www.cornerstonemiddleeast.com/kuwait-green-building-code/>.
- 14 UAE, *National Climate Change Plan for the UAE*, file:///Users/bak8122/Downloads/National%20Climate%20Change%20Plan.pdf.
- 15 UAE, "National Climate Adaptation Action Plan | The Official Platform of the UAE Government," 2024, <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/national-climate-adaptation-action-plan>.
- 16 SGI, "Saudi Vision 2030 - Saudi Green Initiative," Saudi Vision 2030, 2024, <https://www.vision2030.gov.sa/en/explore/projects/saudi-green-initiative>.
- 17 GRP, *Green Riyadh Program - Royal Commission for Riyadh City*, 2022, <https://www.rcrc.gov.sa/en/projects/green-riyadh-project/>.
- 18 Dubai Municipality, "Al Sa'fat Green Building System Guide | PDF | Sustainability | Green Building".
- 19 Abu Dhabi Urban Planning Council, *The Pearl Rating System for Estidama Public Realm Rating System Design & Construction*, <https://www.dmt.gov.ae/-/media/Project/DMT/DMT/E-Library/0001-Manuals/PRRS/PRRS-Version-10.pdf>.

- 20 SGI, "Saudi Vision 2030 - Saudi Green Initiative".
- 21 Johan Lilliestam and Anthony Patt, "Barriers, Risks and Policies for Renewables in the Gulf States," *Energies* 8, no. 8 (2015): 8263–85, <https://doi.org/10.3390/en8088263>.
- 22 Osama D. Sweidan, "The Environmental and Energy Policies to Enable Sustainable Consumption and Production in the Gulf Cooperation Council Countries," *Clean Technologies and Environmental Policy* 23, no. 9 (2021): 2639–54, <https://doi.org/10.1007/s10098-021-02184-y>.
- 23 Marwa Elbannan et al., "Recent Review of Energy Conservation Plans and Targets in the Gulf Cooperation Council Region: Barriers and Challenges," December 19, 2022: 299–311, <https://doi.org/10.2495/SC220251>.
- 24 Aisha Al-Sarihi and Michael Mason, "Challenges and Opportunities for Climate Policy Integration in Oil-Producing Countries: The Case of the UAE and Oman," *Climate Policy* 20, no. 10 (2020): 1226–41, <https://doi.org/10.1080/14693062.2020.1781036>.
- 25 Hao Bai et al., "Cooling Potential of Global Urban Roof Greening," *Npj Urban Sustainability* 6, no. 1 (2026): 49, <https://doi.org/10.1038/s42949-026-00354-9>.
- 26 Girish Visvanathan et al., "Mitigating Urban Heat Island and Enhancing Indoor Thermal Comfort Using Terrace Garden," *Scientific Reports* 14, no. 1 (2024): 9697, <https://doi.org/10.1038/s41598-024-60546-0>.
- 27 Matei Georgescu et al., "Urban Adaptation Can Roll Back Warming of Emerging Megapolitan Regions," *Proceedings of the National Academy of Sciences* 111, no. 8 (2014): 2909–14, <https://doi.org/10.1073/pnas.1322280111>.
- 28 T. Susca et al., "Effect of Green Wall Installation on Urban Heat Island and Building Energy Use: A Climate-Informed Systematic Literature Review," *Renewable and Sustainable Energy Reviews* 159 (May 2022): 112100, <https://doi.org/10.1016/j.rser.2022.112100>.
- 29 Mohamed H. Elnabawi et al., "Integrated Passive Cooling Strategies for Neighborhood-Scale Urban Heat Mitigation in a Hot-Arid City: ENVI-Met Simulations in Al Ain, UAE," *Results in Engineering* 29 (March 2026): 109840, <https://doi.org/10.1016/j.rineng.2026.109840>.
- 30 ICBA, "Sustainable Garden of Halophytic Plants in Abu Dhabi: International Center for Biosaline Agriculture," 2022, <https://www.biosaline.org/news/2022-12-26-13210>.
- 31 Jahanbakhsh Balist et al., "Quantifying the Cooling Nexus of Green-Blue Infrastructure in Hyper-Arid Cities: A Spatial Ecosystem Services Approach," *Buildings* 15, no. 21 (2025): 3975, <https://doi.org/10.3390/buildings15213975>.
- 32 Tingzhen Ming et al., "Effect of Blue–Green Infrastructure in Mitigating Microenvironmental Heat Islands: Field- and Simulation-Based Insights," *Atmosphere* 16, no. 2 (2025): 134, <https://doi.org/10.3390/atmos16020134>.
- 33 Fatma Balany et al., "Studying the Effect of Blue-Green Infrastructure on Microclimate and Human Thermal Comfort in Melbourne's Central Business District," *Sustainability* 14, no. 15 (2022): 9057, <https://doi.org/10.3390/su14159057>.
- 34 AGreenerMiddle-East, "Green Roofs Dubai-Sustainable Rooftop Gardens UAE," <https://agreenermiddleeast.ae/products/green-roofs/>.
- 35 ICBA, "Sustainable Garden of Halophytic Plants in Abu Dhabi: International Center for Biosaline Agriculture".
- 36 MEED, "Is District Cooling the Answer to the Gulf's Power Demand?," 2008, <https://www.meed.com/is-district-cooling-the-answer-to-the-gulfs-power-demand-3>.
- 37 Leigh Mante, "Too Hot to Sustain: Confronting the Gulf's Extreme Heat," ORF Middle East, 2025, <https://orfme.org/expert-speak/too-hot-to-sustain-confronting-the-gulfs-extreme-heat/>.
- 38 Strategy&, *Unlocking the Potential of District Cooling; The Need for GCC Governments to Take Action*, 2012.
- 39 Ahmed Al-Nini et al., "A Review on Green Cooling: Exploring the Benefits of Sustainable Energy-Powered District Cooling with Thermal Energy Storage," *Sustainability* 15, no. 6 (2023), <https://doi.org/10.3390/su15065433>.

- 40 Norhafiza Kamarudin et al., "Direct and Indirect Integration of Organic Rankine Cycle in Total Site," *Chemical Engineering Transactions* (IT) 63 (2018): 379–84, <https://doi.org/10.3303/CET1863064>.
- 41 Al-Nini et al., "A Review on Green Cooling: Exploring the Benefits of Sustainable Energy-Powered District Cooling with Thermal Energy Storage".
- 42 John W. Lund and Tonya L. Boyd, "Direct Utilization of Geothermal Energy 2015 Worldwide Review," *Geothermics* 60 (March 2016): 66–93, <https://www.sciencedirect.com/science/article/abs/pii/S037565051500156X?via%3Dihub>.
- 43 John Benny, "Adnoc and Tabreed to Use Geothermal Energy to Power Masdar City," *The National*, 2023, <https://www.thenationalnews.com/climate/road-to-net-zero/2023/08/14/adnoc-and-tabreed-to-use-geothermal-energy-to-power-masdar-city/>.
- 44 Pengyu Xie and Hao Wang, "Potential Benefit of Photovoltaic Pavement for Mitigation of Urban Heat Island Effect," *Applied Thermal Engineering* 191 (June 2021): 116883, <https://doi.org/10.1016/j.applthermaleng.2021.116883>.
- 45 KAUST, "The Future of Sustainable Cooling Is Being Built in the Saudi Desert," 2025, <https://www.kaust.edu.sa/news/the-future-of-sustainable-cooling-is-being-built-in-the-saudi-desert>.
- 46 ALEC Energy, "ALEC Energy and Solar Earth Introduce the World's Most Rugged Pavement Integrated Photovoltaic (PIPV) Solution - Utilities Middle East," 2023, <https://www.utilities-me.com/news/alec-energy-and-solar-earth-introduce-the-worlds-most-rugged-pavement-integrated-photovoltaic-pipv-solution>.
- 47 FuturaSun, "FuturaSun: Solar Carport for E-Mobility: A Photovoltaic Canopy in an Open Car Park in Ancona (Italy) Producing 63 MWh per Year," FuturaSun - High Performance PV Modules, December 1, 2020, <https://www.futurasun.com/en/solar-carport-e-mobility/>.
- 48 Xinjie Huang et al., "Optimizing Retro-Reflective Surfaces to Untrap Radiation and Cool Cities," *Nature Cities* 1, no. 4 (2024): 275–85, <https://doi.org/10.1038/s44284-024-00047-3>.
- 49 Jiashuo Wang et al., "On the Development of Super Cool Paints for Cooling Purposes," *Solar Energy* 296 (August 2025): 113592.
- 50 Eisenstein, *City Try to Keep Their Cool*.
- 51 Wang et al., "On the Development of Super Cool Paints for Cooling Purposes".
- 52 Kaixin Lin et al., "Hierarchically Structured Passive Radiative Cooling Ceramic with High Solar Reflectivity," *Science* 382, no. 6671 (2023): 691–97, <https://doi.org/10.1126/science.adi4725>.
- 53 Wang et al., "On the Development of Super Cool Paints for Cooling Purposes".
- 54 Ministry of Energy and Infrastructure, "A Pilot of Coated Pavement Surfaces to Address the Heat Island Effect in the UAE," 2022, <https://infratech.github.io/infratech-case-studies/a-pilot-of-coated-pavement-surfaces-to-address-the-heat-island-effect-in-the-uae/>.
- 55 The Peninsula, "Blue Road Project to Bring Temperature Down," August 19, 2019, <https://thepeninsulaqatar.com/article/19/08/2019/Blue-road-project-to-bring-temperature-down>.
- 56 Paolo Peluso et al., "Effectiveness of Road Cool Pavements, Greenery, and Canopies to Reduce the Urban Heat Island Effects," *Sustainability* 14, no. 23 (2022), <https://doi.org/10.3390/su142316027>.
- 57 Wang et al., "On the Development of Super Cool Paints for Cooling Purposes".
- 58 Fazia Ali-Toudert and Helmut Mayer, "Numerical Study on the Effects of Aspect Ratio and Orientation of an Urban Street Canyon on Outdoor Thermal Comfort in Hot and Dry Climate," *Building and Environment* 41, no. 2 (2006): 94–108, <https://doi.org/10.1016/j.buildenv.2005.01.013>.
- 59 F. Bourbia and H. B. Awbi, "Building Cluster and Shading in Urban Canyon for Hot Dry Climate: Part 2: Shading Simulations," *Renewable Energy* 29, no. 2 (2004): 291–301, [https://doi.org/10.1016/S0960-1481\(03\)00171-X](https://doi.org/10.1016/S0960-1481(03)00171-X).
- 60 Peter Hoppe, "The Physiological Equivalent Temperature – a Universal Index for the Biometeorological Assessment of the Thermal Environment," *International Journal of Biometeorology*, 1999.

- 61 Michael Batty, "Digital Twins in City Planning," *Nature Computational Science* 4, no. 3 (2024): 192–99, <https://doi.org/10.1038/s43588-024-00606-7>.
- 62 Khalifa University, "A New Model to Support a Cooler, More Sustainable Abu Dhabi," Research News, *Khalifa University*, September 21, 2018, <https://www.ku.ac.ae/a-new-model-to-support-a-cooler-more-sustainable-abu-dhabi>.
- 63 Stonehaven, "Digital Twin Technology in the Middle East," Stonehaven, 2024, <https://www.stonehaven.ae/insights/how-digital-twin-technology-transforming-middle-east>.
- 64 Jeremy Williams, "Building of the Week: Masdar's Wind Tower," *The Earthbound Report*, August 24, 2018, <https://earthbound.report/2018/08/24/building-of-the-week-masdars-wind-tower/>.
- 65 Ben Foster, "Wind Towers a World Cup Winner - ACR Journal," 2017, <https://www.acrjournal.uk/features/wind-towers-a-world-cup-winner>.
- 66 Williams, "Building of the Week: Masdar's Wind Tower".
- 67 RTA, "Road Transport Authority UAE," 2026, <https://www.rta.ae/wps/portal/rta/ae/home>.
- 68 RCRC, *Royal Commission for Riyadh City*, May 10, 2023, <https://www.rcrc.gov.sa/en/>.
- 69 Qatar Rail, "Doha Metro & Tam," *RKH Qitarat*, <https://www.rkhqitarat.com/doha-metro/>.
- 70 Steven C. Sherwood and Matthew Huber, "An Adaptability Limit to Climate Change Due to Heat Stress," *Proceedings of the National Academy of Sciences* 107, no. 21 (2010): 9552–55, <https://doi.org/10.1073/pnas.0913352107>.
- 71 HRW, *Gulf States: Protect Workers from Extreme Heat*, 2025, <https://www.hrw.org/news/2025/06/01/gulf-states-protect-workers-extreme-heat>.
- 72 Sajeeth Kumar Sankar et al., "Effectiveness of Heat Stress Interventions among Outdoor Workers: A Protocol Paper," *Frontiers in Public Health* 12 (October 2024): 1477186, <https://doi.org/10.3389/fpubh.2024.1477186>.
- 73 Mante, "Building A Heat Resilience Roadmap for the Gulf Region".
- 74 Emily Groot et al., "Practical Strategies for Prevention and Treatment of Heat-Induced Illness," *Canadian Family Physician* 60, no. 8 (2014): 729–30, <https://pmc.ncbi.nlm.nih.gov/articles/PMC4131963/>.

Synchronising Solar and eMobility in the GCC: The Next Frontier in Clean Transport

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Across global transport systems, electric mobility has reached a turning point, becoming an integral part of mainstream transport networks. The focus has shifted from ambition to implementation at scale, with global Electric Vehicle (EV) sales exceeding 17 million units in 2024 and expected to rise to 23 million units in 2026, or 30 percent of all cars sold worldwide.¹ Indeed, electrification is now reshaping transport systems worldwide.² Yet, what is becoming clear is that vehicle adoption alone will not determine the success of this transition. EV growth needs to evolve in tandem with renewable energy deployment. In high-irradiance regions^a like the countries of the GCC (Gulf Cooperation Council), solar power offers a practical and scalable way to decarbonise mobility while strengthening energy resilience.

a High-irradiance regions are areas that receive consistently high levels of solar radiation throughout the year, making them particularly suitable for efficient solar power generation.

Bringing together solar generation and EV charging, supported by storage, smart infrastructure, and demand-side management, creates tangible system benefits. When properly designed, these integrated systems can deliver measurable impact by reducing grid emissions, optimising energy use, lowering charging costs, enhancing energy resilience, and releasing the pressure on electricity networks. This opportunity is further reinforced by vehicle usage patterns, in that they remain parked for approximately 95 percent of the time.³ This creates a massive but largely untapped potential to efficiently align charging demand with solar generation. Smart charging and effective planning can align EV charging with peak solar generation, highlighting the need for connected energy and mobility system design.

The Case for Solar-Powered eMobility Ecosystems in the GCC

The GCC is well positioned to advance unified solar–eMobility systems, building on its renewable energy ambitions and infrastructure investments. Ambitious renewable targets across the region reflect sustained investment in energy diversification:

- Saudi Arabia plans to generate 58.7 GW of renewable capacity by 2030.⁴
- Qatar targets a 30 percent solar share in electricity generation by 2030.⁵
- The United Arab Emirates (UAE) targets 30 percent clean energy in its electricity mix by 2030 and hosts the world's largest integrated solar and storage project⁶ (5 GW solar with 19 GWh storage capacity).⁷

Combined with strong electrification ambitions and abundant solar resources, this creates an advantage to design energy and mobility systems together from the outset, rather than retrofitting legacy infrastructure at a later time. This shift is shaped by changes in EV technology, particularly increasing battery capacities. In 2024, the average battery capacity across the global electric car fleet reached approximately 80 kWh, partly reflecting growing demand for larger vehicle segments such as SUVs.⁸ While greater EV range improves adoption, higher battery capacity increases electricity demand, making coordinated charging with renewable generation essential to avoid peak grid pressure and improve system efficiency.

Renewable generation and storage capacity across the GCC are expanding rapidly. Gulf countries have invested more than US\$42 billion in renewable energy projects and are scaling up solar, wind, and battery storage to help energy transition goals.⁹ In Saudi Arabia alone, renewable capacity connected to the grid has already exceeded 12 GW and has been accompanied by several gigawatt-hours of grid-scale battery storage. Beyond this, large-scale projects are currently under development.¹⁰

Table 1: Case Studies of Solar–EV Integration and Potential GCC Applications

Solar–EV Coupling Model	Project Name	Location	Potential GCC Application
Solar carport EV charging	NEC solar carport EV charging project	Birmingham, United Kingdom	Solar carports at malls, airports and public parking areas
Solar-powered EV charging carport	Servotech solar EV charging carport	New Delhi, India	Solar charging hubs for delivery fleets and commercial vehicles
Solar carport + EV charging infrastructure	MBS International Airport solar EV charging project	Michigan, United States	Solar parking infrastructure at airports and transport hubs
Solar + EV smart grid integration	EV-PV smart grid project (TU Delft)	Netherlands	Smart charging aligned with solar generation
Solar-powered public infrastructure with EV charging	Arail solar public plaza EV charging project	India	Solar EV charging in public spaces and tourism areas

Source: Author's own, using various open sources.

Key barriers include misaligned charging patterns, limited integrated infrastructure, and insufficient coordination between energy and transport systems. Addressing these challenges will require a cohesive system design that combines smart charging, energy storage, solar-EV hubs, bidirectional charging technologies, and stronger cross-sector planning.

Models of Solar-EV Coupling: From Local to Virtual Integration

Solar and EV charging can be connected in several ways, depending on scale and system maturity, including the models listed in Table 2.

Table 2: Renewable Energy Integration in EV Charging Infrastructure

Type	Description	Examples
On-site renewable charging	Direct integration of solar Photovoltaic (PV) with EV chargers at homes, workplaces, or charging hubs	The Winchester EV Superhub combines solar panels and battery storage to supply renewable power to EV charging stations and reduce grid dependence. ¹¹
Community-level integration	Local energy systems combining distributed solar, shared storage, and neighborhood EV charging infrastructure	Collective self-consumption projects, such as France's Izarbel technology park, share locally generated solar power among multiple buildings to support energy demand and EV charging. ¹²
Virtual coupling	Digital platforms that optimise EV charging by matching it with renewable energy generation through smart energy management systems.	Fastned signed a corporate PPA to source solar electricity from rooftop PV installations to power its EV fast-charging network in the Netherlands. ¹³

Source: Author's own, using various sources, as cited.

Priority Use Cases

Charger placement becomes a strategic decision as vehicles spend most of their time at a standstill. When charging locations are aligned with solar availability, reliance on costly grid upgrades or fossil-based backup generation can be reduced.

Table 3. Residential Solar–EV Integration: Models and Explanations

Coupling Type	Advantages	Benefits	Where to be Installed
Home charging with rooftop solar	A simple and cost-effective model, particularly in regions with suitable housing like Saudi Arabia and the UAE.	To reduce electricity costs and grid demand, especially when smart charging aligns with solar generation	Can be implemented in new homes or retrofitted in villas with sufficient roof space, while apartment buildings may require shared infrastructure solutions.
Workplace charging powered by on-site solar	Daytime solar generation powers workplace slow-charging as vehicles remain parked for long periods.	To enable the direct use of local renewable electricity and improve grid flexibility	Can be retrofitted in commercial buildings and offices with large rooftops or parking areas, allowing the daytime charging demand to be partly met by solar power.

Public charging hubs with local renewable supply	Fast-charging stations are increasingly combined with on-site solar and storage to manage peak loads and lower grid stress.	To ease grid stress and infrastructure costs, with modelling suggesting potential cost reductions of up to ~40 percent as PV prices decline.	Can be implemented in new developments but can also be retrofitted at highway rest areas, fuel stations, and large parking facilities with solar and storage systems.
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Source: Author's own, based on techno-economic analysis of grid-connected highway solar EV charging station. (The 40 percent number is for South Korea.)

Policy Considerations and Implementation Challenges

Integrating solar PV with EV charging offers strong potential to decarbonise transport and power systems, minimise charging costs and emissions, and ease grid pressure, particularly in workplaces and fleet applications where solar generation aligns with parking patterns. However, scaling deployment across the GCC requires addressing several interconnected challenges.

Policy and regulatory alignment remain a barrier. While the UAE has more advanced frameworks for distributed solar and EV infrastructure, and Saudi Arabia is progressing under Vision 2030, gaps persist around tariffs, grid access, storage, and V2G (Vehicle-to-Grid), limiting investment. More advanced urban centres are better positioned to pilot merged systems, while newer developments offer opportunities to embed integration from the outset. Clear and consistent regulatory frameworks will be essential to facilitate aligned business models and long-term financing.

Grid readiness also varies. Cities in the UAE benefit from more advanced smart grids and charging infrastructure, while Doha's compact urban form supports managed charging.^b To keep pace with rising EV demand and variable solar generation, networks must adapt to variable solar generation and growing EV demand through smarter grid management, demand-side flexibility, and local storage to address timing mismatches between generation and charging.

Technology and market maturity present additional barriers. Solar-storage-EV systems still face interoperability challenges, while high upfront costs—particularly for storage and energy management—slow adoption, highlighting the need for financial de-risking mechanisms. Market awareness and behaviour also play a role, as charging is often not aligned with solar availability. Stronger pricing signals and digital tools will be needed to better align demand with renewable generation.

^b Doha's compact urban form concentrates travel demand, buildings and charging points within a relatively small area, making it easier to coordinate charging schedules, manage peak loads, and deploy centralised smart-charging systems.

Security and governance considerations are also increasingly important. Cybersecurity risks, data management issues, and consumer hesitancy toward V2G require clear frameworks and protections. And finally, local execution capacity is critical. Cities can streamline deployment by integrating EV infrastructure into planning, permitting, and procurement. Overall, scaling integrated PV–EV systems will depend on coherent policy design, regulatory clarity, financial support, standardisation, and strong digital security. Greater collaboration across cities and stakeholders in the GCC can increase deployment through shared standards, practical experience and knowledge exchange.

Why Integration Matters Now

Integrating solar with e-mobility can accelerate decarbonisation, alleviate costs, and build grid resilience. For the GCC, acting early will provide a strategic opportunity to strengthen clean mobility while enhancing long-term economic competitiveness and energy resilience. The real possibility lies in designing energy and mobility systems that work together from the outset, rather than solving challenges later.

Moving forward, success will be defined by how strategically we connect mobility, energy, and infrastructure. By bringing these elements together, the GCC has an opportunity to build transport systems that are not only cleaner, but also more resilient, more efficient, and better prepared for the future.

Endnotes

- 1 International Energy Agency, *Global EV Outlook 2026*, May 20, 2026.
- 2 International Energy Agency, "Global EV Outlook 2025 - Trends in Electric Car Markets," <https://www.iea.org/reports/global-ev-outlook-2025/trends-in-electric-car-markets-2>.
- 3 U.S. Department of Energy, "FOTW#1356, August 19, 2024: Household Vehicles Were Parked 95% on a Typical Day," August 19, 2024, <https://www.energy.gov/cmei/vehicles/articles/fotw-1356-august-19-2024-household-vehicles-were-parked-95-typical-day-2022>.
- 4 Abeer Abdulkareem, Amgad Ellaboudy, "Saudi Arabia's Vision 2030's Renewable Energy Project Initiatives," February 1, 2025, <https://www.climatescorecard.org/2025/02/saudi-arabias-vision-2030s-renewable-energy-project-initiatives/>.
- 5 Sanaullah Ataullah, "Solar Power to Produce 30% of Total Electricity by 2030," September 2, 2023, <https://thepeninsulaqatar.com/article/02/09/2023/solar-power-to-produce-30-of-total-electricity-by-2030>.
- 6 Malcolm Moore, "Middle East Becomes Fastest-Growing Renewables Market Outside China," *Financial Times*, January 28, 2025, <https://www.ft.com/content/f3c69a7d-0db1-4882-8d35-02ec4c57ea53?syn-25a6b1a6=1>.
- 7 International Energy Agency, "Global EV Outlook 2024," April 23, 2024, <https://www.iea.org/reports/global-ev-outlook-2024>.
- 8 Salem Alhajraf, "Renewable Energy Development in the GCC: Progress Made and Challenges Ahead," Columbia | SIPA Center on Global Energy Policy, <https://www.energypolicy.columbia.edu/renewable-energy-development-in-the-gcc-progress-made-and-challenges-ahead/>.
- 9 Anna Vassileva, "Saudi Arabia Reaches 12.3 GW of Renewables, 8 GWh of Energy Storage," December 16, 2025, <https://renewablesnow.com/news/saudi-arabia-reaches-12-3-gw-of-renewables-8-gwh-of-energy-storage-1286718/>.
- 10 Michelle Lewis, "Meet the UK's Largest Solar + Storage EV Charging 'Superhub'," Electrek, March 2025, <https://electrek.co/2025/03/24/uk-largest-solar-storage-ev-charging-superhub/>.
- 11 Lewis, "Meet the UK's largest solar + storage EV charging 'Superhub'".
- 12 Camblong H., Curea O., Ugartemendia J.J., Boussaada Z., Lizarralde I., Etxegarai G., "Photovoltaic Energy Sharing: Implementation and Tests on a Real Collective Self-Consumption System," January 25, 2026, <https://arxiv.org/abs/2601.17974>.
- 13 EU GLP, "GLP Clean Energy Signs Power Purchase Agreement with Fastned at G-Park Zevenaar, the Netherlands," February 22, 2024, <https://eu.glp.com/nl/persbericht/glp-clean-energy-signs-power-purchase-agreement-with-fastned/>.

Liquid Gold in the GCC: Unlocking Wastewater for Sustainable Urban Water Systems

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Water scarcity is a defining challenge in the Gulf Cooperation Council (GCC) region that comprises Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE). While the region has always been naturally water-scarce due to its arid climate, pressures have intensified since the 1970s due to rapid population growth, urbanisation, economic diversification, and rising water demand. Climate change exacerbates these challenges through increasing temperatures, prolonged droughts, and greater variability in rainfall. The annual renewable freshwater availability is only around 500 m³ per capita, compared with the global average of approximately 6,000 m³ per capita, making the GCC one of the most water-scarce regions in the world.¹ Yet, water consumption has continued to rise, frequently exceeding 500 litres per person per day—more than four times the average consumption in countries such as Germany (approximately 120 litres per person per day).² This unsustainable demand is placing increasing pressure on groundwater reserves and desalinated water supplies.

The GCC collects approximately 4.0 billion m³ of municipal wastewater annually, of which 73 percent is treated, yet only about 39 percent is currently reused.³ Most treated effluent is used for landscaping, industrial applications, and non-food irrigation, while the remainder is discharged into the environment, representing an important untapped resource for urban water security, climate resilience, and sustainable economic development. At the same time, the region operates some 439 desalination plants that collectively produce around 5.75 billion m³ of desalinated water annually, supplying the majority of potable water for cities such as Dubai, Riyadh, and Kuwait City.⁴ While desalination has enabled urban and industrial growth, its high energy intensity, associated carbon emissions, concentration along vulnerable coastlines, and exposure to climate and geopolitical risks highlight the strategic limitations of existing water systems. Expanding the reuse of treated wastewater (TWW) offers a complementary and more circular water resource that can reduce dependence on desalination, enhance resource efficiency, strengthen climate resilience, and support the GCC's broader circular economy and net-zero ambitions.

The Opportunities and Remaining Gaps in Wastewater Reuse

Despite the growing recognition of TWW as a strategic water resource, its adoption remains uneven across the region. Studies conducted in 2024 identified wastewater reuse as a critical component of integrated water resource management, capable of reducing dependence on desalination and groundwater while supporting agricultural irrigation, industrial processes, urban landscaping, aquifer recharge, and ecosystem restoration.⁵ Beyond augmenting water supplies, wastewater reuse contributes to circular water economy approaches by recovering valuable water and nutrients, improving resource efficiency, and reducing environmental pollution.⁶

However, barriers continue to constrain large-scale implementation in the GCC. Technical challenges include limited advanced treatment capacity, inadequate storage and distribution networks, and incomplete wastewater collection systems. Economic constraints stem from the high capital and operational costs of advanced treatment technologies. Fragmented institutional responsibilities across water, agriculture, environment, and health agencies often delay coordinated planning and implementation. Public acceptance also remains a challenge, particularly for food crop irrigation and potable reuse,^{a,7,8,9} where concerns about health risks and treatment safety continue to influence consumer confidence.

a Advocates of treated wastewater reuse argue that, when treated to appropriate standards and supported by robust monitoring and regulatory oversight, reclaimed water provides a safe, reliable, and climate-resilient water source. Its use can reduce pressure on scarce freshwater resources, enhance water security, lower environmental pollution from wastewater discharges, support agricultural productivity and, where advanced treatment is applied, augment potable water supplies (WHO, 2017; FAO, 2025; Lahnsteiner, Lazarova, and Lefebvre 2024).

These challenges are especially pertinent in rapidly growing GCC cities that are highly dependent on desalination. Expanding the reuse of TWW for irrigation, industry, district cooling, and aquifer recharge can diversify water supplies, reduce reliance on desalination, and strengthen climate resilience. For example, Dubai is expanding reuse for landscaping and district cooling, while Saudi Arabia is increasing the use of reclaimed water for non-potable applications. Similar opportunities exist across Kuwait, Qatar, Bahrain, and Oman. Realising this potential requires integrated investment in treatment and distribution infrastructure, supportive policies, innovative financing, institutional coordination, digital monitoring, and public engagement to transform TWW into a strategic resource for water security and a circular water economy.

Lessons from the MENA Context

Experiences from the MENA region demonstrate that successful wastewater reuse depends not only on technological capacity but also on enabling governance, financing, and stakeholder engagement. Several regional examples provide practical lessons and enablers that can inform wastewater reuse scaling across the GCC.

Risk-based Regulation and Fit-for-purpose Standards: Jordan applies WHO (World Health Organization)-aligned risk-based standards for TWW reuse in agriculture, particularly in the Jordan Valley, while the UAE uses fit-for-purpose quality classes under its reuse regulations (Abu Dhabi/ Dubai Treated Sewage Effluent or TSE standards) to match treatment levels with end uses, such as irrigation and district cooling. Morocco has also strengthened its regulatory framework by integrating wastewater reuse into the National Water Plan and adopting reuse standards that support agricultural irrigation, particularly in water-stressed basins such as Souss-Massa and Marrakech. These experiences demonstrate the importance of aligning water quality requirements with intended end uses while embedding reuse within national water planning.

Stakeholder Engagement and Public Trust-building: Building confidence among water users is equally important. In Jordan, farmer engagement, demonstration projects, and the successful operation of the As-Samra Wastewater Treatment Plant have increased the acceptance of reclaimed water for agricultural irrigation, highlighting the value of transparent communication and user participation. Similarly, Tunisia has promoted reclaimed water use through long-standing irrigation schemes supported by farmer outreach, institutional coordination, and gradual confidence-building measures. These experiences show that sustained stakeholder engagement and transparent risk communication are essential for increasing public acceptance and long-term adoption.

Innovative Financing and Project Bundling: In Egypt and Jordan, large-scale wastewater treatment and reuse systems (e.g., As-Samra WWTP in Jordan) have been developed through public-private partnerships (PPPs) and donor-backed financing structures, enabling cost recovery and long-term operation. Saudi Arabia has increasingly pursued utility-led PPP models and bundled infrastructure investments to scale wastewater treatment capacity and reuse networks. Morocco has

complemented public investment with international climate and development finance to expand wastewater treatment and reuse infrastructure, particularly for agricultural irrigation and urban green spaces. These experiences demonstrate that blended financing approaches, combining public funding, private investment, and development finance, can accelerate wastewater reuse while improving the long-term financial sustainability of reuse systems.

Strategic Pathways to Scaling Wastewater Reuse

GCC countries face growing water security challenges due to limited freshwater resources, low rainfall, population growth, and rising demand. While desalination and groundwater abstraction remain key sources, they pose sustainability challenges. TWW offers an important opportunity to reduce pressure on freshwater supplies; however, despite massive investments in treatment infrastructure, reuse remains underutilised, leaving substantial potential for expansion across sectors.

Pathway 1: Establish Integrated Water Reuse Policies and Regulatory Frameworks

Scaling wastewater reuse requires shifting from a treatment-oriented approach towards integrated water resource management, where TWW is recognised as a strategic component of national water portfolios. GCC countries are increasingly developing policies and standards that define reuse applications, treatment requirements, and quality controls.

The UAE provides one of the most advanced examples through the UAE Water Security Strategy 2036, which aims to increase TWW reuse to 95 percent while reducing per capita water consumption by 30 percent by 2036.¹⁰ At the emirate level, the Abu Dhabi Recycled Water and Biosolids Regulations (2021) establish a regulatory framework for the safe production, management, and reuse of recycled water and biosolids, supported by national guidelines developed by the Ministry of Energy and Infrastructure.¹¹

Similarly, Saudi Arabia has strengthened wastewater reuse through mandatory tertiary treatment requirements and sector-specific reuse classifications established by the Ministry of Environment, Water and Agriculture (MEWA). These standards regulate reclaimed water use for agriculture, industry, and aquifer recharge, while promoting greywater reuse as part of broader water conservation efforts aligned with Vision 2030 and the circular carbon economy approach.¹²

Kuwait is advancing water sustainability by promoting wastewater, oil-associated water, and graywater reuse to reduce the pressure on limited freshwater resources and dependence on desalination.¹³ Through research, technological innovation, and partnerships led by the Kuwait Institute for Scientific Research (KISR), reclaimed water is increasingly being used for irrigation, landscaping, industrial, and other non-potable applications, supporting water security and a circular water economy. Oman similarly integrates wastewater reuse within its broader circular economy and Vision 2040 agenda, promoting resource efficiency, sustainable water management, recycling, and green growth.¹⁴

Qatar's new Water Law (Law No. 23 of 2025) recognises TWW as a strategic water resource and establishes a regulatory framework to expand safe reuse.¹⁵ It defines the standards and controls for reuse applications, including irrigation, landscaping, construction, and industrial uses, while ensuring compliance with health and environmental requirements. The law supports Qatar's transition toward a circular water economy by reducing reliance on desalinated water for non-potable uses and strengthening long-term water security. Bahrain is also strengthening environmental sustainability through policies promoting recycling, resource efficiency, and improved waste management, supporting broader efforts to reduce pressure on limited natural resources.¹⁶

Pathway 2: Expand Infrastructure and Diversify Reuse Applications

GCC countries should accelerate investment in advanced wastewater treatment, storage, and distribution networks to expand TWW reuse beyond landscaping and limited agricultural use. In Qatar, studies highlight that treated sewage effluent has immense potential for agriculture and industry but requires further treatment upgrades and infrastructure expansion to reduce reliance on desalinated water.¹⁷ Diversifying reuse applications—including industrial processes, cooling, urban landscaping, and environmental restoration—can strengthen circular water systems. For example, Qatar's Lusail development demonstrates the potential of closed-loop water systems, where TWW is reused for non-potable applications, reducing demand for freshwater and supporting urban sustainability.¹⁸

Bahrain has expanded TWW reuse through upgraded tertiary treatment facilities and distribution networks, particularly for agricultural irrigation and urban applications.¹⁹ This approach reduces pressure on scarce freshwater resources and demonstrates the role of advanced treatment, monitoring, and dedicated reuse infrastructure in strengthening circular water economy practices. GCC countries should, therefore, prioritise integrated water reuse infrastructure, quality monitoring, and regulatory frameworks to enable safe and scalable reuse.²⁰

Pathway 3: Mobilise Innovative Financing and Private-sector Investment

To accelerate circular water economy solutions, GCC countries can leverage green finance instruments, including *green sukuk*^{21,22} and other Sharia-compliant financial mechanisms^b alongside blended finance, and public-private partnerships to mobilise long-term investment in wastewater reuse and circular water infrastructure. The UAE and Saudi Arabia have emerged as

b 'Green sukuk' are Sharia-compliant financial instruments that finance environmentally sustainable projects. Unlike conventional bonds, they are asset-backed and generate returns from underlying assets or investment activities rather than interest (riba). They can support projects such as renewable energy, sustainable water infrastructure, wastewater reuse, and climate adaptation.

regional leaders in sustainable finance, developing green bonds and sustainability-linked financing frameworks to support environmental infrastructure. In Saudi Arabia, the Public Investment Fund (PIF) provides a platform for strategic investments in sustainability-related sectors, while green sukuk offer opportunities to mobilise Sharia-compliant financing for water and climate-resilient infrastructure.²³

The UAE provides a leading example through its Sustainable Finance Framework (2021–2030), which aims to strengthen sustainable finance markets, promote green taxonomies, and expand the use of instruments such as green bonds and sukuk to finance low-carbon and climate-resilient investments.²⁴ These financing mechanisms can help bridge public and private investment, enabling the expansion of TWW reuse systems and supporting circular water economy pathways linked to climate adaptation, food security, and resource efficiency.

Pathway 4: Strengthen Circular Water Economy Approaches and Digital Governance

Wastewater reuse should be integrated into the broader circular economy and net-zero strategies that link urban water systems, agriculture, industry, energy recovery, and ecosystem restoration. This approach can enhance water security, improve resource efficiency, reduce desalination-related emissions, and strengthen climate resilience. A number of GCC countries are already advancing this transition. Digital governance can further accelerate wastewater reuse through Artificial Intelligence (AI), remote sensing, and data-driven decision-support systems that improve monitoring, planning, and investment decisions. For example, IWMI's (International Water Management Institute) Google-supported e-ReWater platform uses AI, Earth observation, and satellite data to assess wastewater availability and reuse potential, while providing digital dashboards for policymakers and utilities in the UAE and Saudi Arabia, demonstrating how digital tools can strengthen evidence-based water governance and circular water management.²⁵

Kuwait is advancing the principles of circular economy by integrating resource efficiency and sustainable management approaches into its Kuwait Vision 2035 framework.²⁶ Through initiatives led by the Kuwait Environment Public Authority, the country is strengthening data-driven environmental governance and promoting resource recovery approaches that support more efficient water and waste management. These efforts provide an enabling foundation for expanding TWW reuse, improving monitoring systems, and advancing circular water economy practices across urban, agricultural, and industrial sectors.

Saudi Arabia's G20-endorsed Circular Carbon Economy (CCE) Framework recognises resource efficiency and circular resource management as key pathways to achieving low-carbon development, creating opportunities to integrate wastewater reuse into broader climate, industrial, and water security strategies.

Oman, for its part, is developing a national circular economy roadmap to support sustainable, low-carbon development and guide future resource management.²⁷ Led by the Ministry of Economy, the initiative aims to measure Oman's circular economy gap, benchmark progress internationally, and identify opportunities for green investment, job creation, and improved resource efficiency. The roadmap includes digital tools for monitoring progress and supports the country's Net Zero 2050 commitment by promoting resource recovery and sustainable water management.

The UAE's Net Zero by 2050 Strategic Initiative similarly recognises circular resource management and water efficiency as important components of climate resilience. Dubai is advancing a circular water economy model by treating wastewater as a valuable resource, expanding treated water reuse for irrigation, landscaping, and other non-potable applications while integrating digital monitoring, smart infrastructure, and resource recovery to optimise urban water systems and reduce dependence on freshwater and desalinated supplies.²⁸

Qatar's National Environment and Climate Change Strategy, together with the new Water Law (2025), positions TWW reuse as an important component of climate adaptation, environmental sustainability, and long-term water security by promoting safe reuse and improved resource efficiency.

Pathway 5: Build Public Awareness and Social Acceptance

Expanding TWW reuse in the GCC requires complementing technical solutions with efforts to build public trust, address risk perceptions, and strengthen institutional communication. Social acceptance—particularly for food-related applications—remains a barrier, underscoring the need for transparent safety standards, credible monitoring, and stakeholder engagement.²⁹

Regional experience offers important lessons. In the UAE, growing volumes of TWW have reinforced the need for stronger public awareness and governance,³⁰ while studies in Saudi Arabia indicate that acceptance is closely linked to trust in treatment authorities and is consistently higher for non-food applications.³¹ Oman has also promoted reclaimed water through public awareness and school outreach programmes.

A regional pathway should therefore focus on objectives, such as strengthening quality assurance and risk communication, engaging farmers and consumers, and integrating water reuse into education. In Qatar, studies have found that while science teachers recognise the environmental benefits of TWW reuse, concerns about food crop irrigation persist due to perceived health risks and limited confidence in the safety of the treatment—this highlights the need for professional development, curriculum integration, and evidence-based communication.³² Together, these measures can strengthen institutional trust and public confidence, enabling broader and more sustainable wastewater reuse across the GCC.

Conclusion: Unlocking the GCC's Water Potential

The GCC stands at a critical point where TWW can be transformed from an underutilised resource into a strategic pillar of long-term water security and sustainable development. Although the region has made remarkable progress in wastewater treatment capacity and reuse infrastructure, achieving large-scale reuse requires a shift from fragmented projects toward integrated circular water economy approaches that combine policy reform, infrastructure investment, innovative financing, digital governance, and public engagement.

The pathways demonstrate that scaling wastewater reuse is not only a technical challenge but also an imperative for institutional and societal transformation. Strengthening regulatory frameworks, expanding fit-for-purpose reuse applications, mobilising green finance and private-sector investment, and improving data-driven water governance will enable GCC countries to maximise the value of TWW. Equally important is building public trust through transparent communication, education, and stakeholder engagement. These will all be essential to overcoming social barriers, particularly for agricultural reuse.

By positioning TWW as a valuable resource rather than a waste stream, GCC countries can reduce pressure on desalination and groundwater resources, enhance climate resilience, and support circular approaches across urban, agricultural, and industrial systems. With strong governance, sustained investment, and societal support, wastewater reuse can become a cornerstone of a more resilient, resource-efficient, and sustainable water future for the Gulf region.

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Endnotes

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- 1 Asad Sarwar Qureshi, "Challenges and Prospects of Using Treated Wastewater to Manage Water Scarcity Crises in the Gulf Cooperation Council (GCC) Countries," *Water* 12, no. 7 (2020), <https://doi.org/10.3390/w12071971>.
 - 2 Safaa El Tayeb El-Kogali, "From Scarcity to Sustainability: The GCC's Journey Towards Water Security," *World Bank Group*, March 26, 2024, <https://www.worldbank.org/en/news/opinion/2024/03/26/from-scarcity-to-sustainability-the-gcc-s-journey-towards-water-security>.
 - 3 Qureshi, "Challenges and Prospects of Using Treated Wastewater to Manage Water Scarcity Crises in the Gulf Cooperation Council (GCC) Countries".
 - 4 Qureshi, "Challenges and Prospects of Using Treated Wastewater to Manage Water Scarcity Crises in the Gulf Cooperation Council (GCC) Countries".
 - 5 Fivos Florides et al., "Water Reuse: A Comprehensive Review," *Environments* 11, no. 4 (2024), <https://www.mdpi.com/2076-3298/11/4/81>.
 - 6 Ioannis Kostakis et al., "Circular Economy Policies for Water and Wastewater," *Water Policy* 27, no. 10 (2025), <https://doi.org/10.2166/wp.2025.077>.
 - 7 WHO, *Potable Reuse: Guidance for Producing Safe Drinking-Water*, Geneva, World Health Organization, 2017, 17147_Potable reuse For Web.pdf 02-012-18.
 - 8 FAO, *The State of the World's Land and Water Resources for Food and Agriculture*, 2025.
 - 9 Josef Lahnsteiner et al., "Water Reuse: Overcoming the Challenges of Growth and Climate Change," *Water Reuse* 14, no. 4 (2024): iii–iv, <https://doi.org/10.2166/wrd.2024.104>.
 - 10 Government of the United Arab Emirates, "The UAE Water Security Strategy 2036," *The Official Platform of the UAE Government*, <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/the-uae-water-security-strategy-2036>.
 - 11 United Arab Emirates Department of Energy, "Recycled Water and Biosolids Regulations 2021," January 1, 2021, <https://www.doe.gov.ae/-/media/Project/DOE/Department-Of-Energy/Media-Center-Publications/Regulations/English/Recycled-Water--Biosolids-Regulations-2021-Edition-3.pdf>.
 - 12 Kingdom of Saudi Arabia, "Vision 2030," <https://www.vision2030.gov.sa/media/quudi5wq/vision-2030-overview.pdf>.
 - 13 "New Kuwait 2035: Kuwait National Development Plan-Revised Version," State of Kuwait, 2020, https://media.gov.kw/assets/img/Ommah22_Awareness/PDF/NewKuwait/Revised KNDP - EN.pdf.
 - 14 "Oman Vision 2040," Oman Vision 2040 Implementation Follow-up Unit, <https://www.oman2040.om/?lang=en>.
 - 15 "Qatar New Water Law," <https://marhaba.qa/wp-content/uploads/2025/10/NEW-WATER-LAW-KAHRAMA.pdf>.
 - 16 "Water Recycling and Reuse: IPR, DPR, and Diversification Strategies in Bahrain," Our Future Water Intelligence, <https://ourfuturewaterintelligence.com/blogs/news/water-recycling-and-reuse-ipr-dpr-and-diversification-strategies-in-bahrain>.
 - 17 Yehia Manawi et al., "Evaluation of the Current State and Perspective of Wastewater Treatment and Reuse in Qatar," *Desalination and Water Treatment* 71 (2017), <https://doi.org/10.5004/dwt.2017.20174>.
 - 18 Wahidul K. Biswas et al., "Techno-economic and Environmental Implications of the Use of a Closed Loop Water Recycling System in Qatar," *Chemical Engineering Transactions* 72 (2019), <https://doi.org/10.3303/CET1972035>.
 - 19 "Guidelines and Procedures for Wastewater Re-use in Bahrain," Stantec, https://www.stantec.com/en/projects/middle-east-projects/guidelines-procedures-for-wastewater-reuse-bahrain?utm_source=chatgpt.com.

- 20 Noredidine Ghaffour, Thomas M. Missimer, and Gary L. Amy, "Combined Desalination, Water Reuse, and Aquifer Storage and Recovery to Meet Water Supply Demands in the GCC/MENA Region," *Desalination and Water Treatment* 51 (Issues 1-3), <https://doi.org/10.1080/19443994.2012.700034>.
- 21 World Bank; Bank, Islamic Development, *Islamic Finance and Climate Agenda: From Green Sukuk Innovation to Greener Halal Value Chains (English)*, Washington D.C., World Bank Group, <http://documents.worldbank.org/curated/en/099111425065521240>.
- 22 International Capital Market Association (ICMA), Islamic Development Bank (IsDB), and London Stock Exchange Group (LSEG), *Guidance on Green, Social and Sustainability Sukuk* (Zurich, Jeddah, and London, ICMA, IsDB, and LSEG, April 2024, <https://www.icmagroup.org/assets/documents/Sustainable-finance/ICMA-IsDB-LSEG-Guidance-on-Green-Social-and-Sustainability-Sukuk-April-2024.pdf>.
- 23 "Kingdom of Saudi Arabia Public Investment Fund," Public Investment Fund, <https://www.pif.gov.sa/en/>.
- 24 Dr Jelena Janjusevic, "Sustainable Finance in the UAE: From Vision to Structure," November 17, 2025, <https://economymiddleeast.com/news/sustainable-finance-in-the-uae-from-vision-to-structure/>.
- 25 "IWMI Announces Development of a New, Google-supported Tool That Will Harness AI and Satellite Data for Water Reuse in the Middle East and North Africa," International Water Management Institute, November 27, 2023, <https://www.iwmi.org/news/new-google-supported-tool-will-harness-ai-and-satellite-data-for-water-reuse-in-mena/>.
- 26 Sameera Al-Kandari et al., "Kuwait's Transformation Pathway Toward Sustainable Consumption, Production, and Circular Economy," *Springer Handbook of Circular Plastics Economy*, June 27, 2025, https://link.springer.com/chapter/10.1007/978-3-031-66209-6_8.
- 27 "National Roadmap to Drive Oman's Circular Economy Transition," *Muscat Daily*, July 21, 2025, <https://www.muscatdaily.com/2025/07/21/national-roadmap-to-drive-omans-circular-economy-transition/>.
- 28 "Dubai's Successful Water Reclamation Programme Accelerates Its Green Economy Vision," Government of Dubai Media Office, August 21, 2023, https://mediaoffice.ae/en/news/2023/august/21-08/dubais-successful-water-reclamation-programme?utm_source=chatgpt.com.
- 29 Qureshi, "Challenges and Prospects of Using Treated Wastewater to Manage Water Scarcity Crises in the Gulf Cooperation Council (GCC) Countries."
- 30 Rasha M. Abdelrahman, Sameh E. Khamis, and Zeinelabidin E. Rizk, "Public Attitude Toward Expanding the Reuse of Treated Wastewater in the United Arab Emirates," *Environment, Development and Sustainability* 22, no. 8 (2020), <https://doi.org/10.1007/s10668-019-00551-w>.
- 31 Fahad Alzahrani, Momtaz Elsebaei, and Rady Tawfik, "Public Acceptance of Treated Wastewater Reuse in the Agricultural Sector in Saudi Arabia," *Sustainability* 15, no. 21 (2023), <https://doi.org/10.3390/su152115434>.
- 32 Nasser Mansour et al., "Science Teachers' Knowledge, Attitudes, and Pedagogical Readiness for Teaching Treated Wastewater Reuse in Qatar: A Socio-demographic Analysis," *Sustainable Environment* 12, no. 1 (2026), <https://doi.org/10.1080/27658511.2026.2701486>.

Designing Circular Cities: Lessons from India for the Gulf Region

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The twenty-first century is being shaped by cities. By 2050, nearly 70 percent of the world's population are expected to live in urban areas.¹ Nowhere is this transformation more visible than in India and the Gulf region. India is projected to add nearly 400 million urban residents by 2050, while Gulf states are pursuing some of the world's most ambitious urban development programmes under initiatives such as Saudi Vision 2030, the Dubai 2040 Urban Master Plan, and Qatar National Vision 2030.²

Yet the urban challenges confronting these regions differ significantly. India's cities grapple with density, informality, infrastructure deficits, and resource stress on an unprecedented scale. Gulf cities, by contrast, contend with extreme climatic conditions, water scarcity, energy-intensive urban systems, and the demands of economic diversification. Despite these differences, both regions face a common challenge: sustaining urban growth within increasingly constrained environmental limits.

This challenge has elevated the concept of the circular city from a sustainability aspiration to an urban imperative. Circular cities seek to eliminate waste, maximise resource productivity, and create regenerative systems for water, energy, materials, mobility, and governance. The objective is not simply to make cities greener, but more resilient, efficient, and economically competitive. India's urban experience offers valuable lessons for Gulf cities seeking to operationalise circularity at scale.

1. Build Water Security Through Circular Systems

Water security may be the defining urban challenge of the coming decades. Indian cities such as Chennai, Bengaluru, and Hyderabad have experienced acute water stress due to rapid urbanisation, groundwater depletion, and climate variability.³ Chennai's 2019 "Day Zero" crisis became a global warning of the consequences of unsustainable urban water management.

In response, India has increasingly adopted integrated water planning. The Atal Mission for Rejuvenation and Urban Transformation (AMRUT), launched in 2015, focused on universal water supply, sewerage infrastructure, stormwater management, and urban water-body restoration.⁴ AMRUT 2.0 expanded this approach by requiring cities to prepare comprehensive water balance plans and promote wastewater recycling.⁵

Several elements of this framework are relevant to Gulf cities. Universal metering, non-revenue water, wastewater reuse targets, and city-level water budgeting can complement existing desalination infrastructure while improving resilience.

This is particularly important given the Gulf's reliance on desalination. Recent geopolitical tensions have highlighted the vulnerability of concentrated desalination infrastructure and reinforced the need to diversify urban water sources.⁶ Wastewater reuse, aquifer recharge, and demand-side management should therefore be viewed not merely as sustainability measures, but as strategic investments in urban resilience.

Circular cities treat wastewater as a resource rather than a liability.

2. Treat Mobility as Resource Efficiency

Transportation is often discussed as a mobility challenge. In reality, it is a resource-efficiency challenge. The way cities move people shapes energy consumption, land-use patterns, infrastructure costs, and carbon emissions. India's experience demonstrates both the risks of automobile-dependent growth and the benefits of integrated public transport systems.

The Delhi Metro, which carries millions of passengers daily, has reduced congestion and emissions while reshaping urban development patterns.⁷ Ahmedabad's Janmarg Bus Rapid Transit System demonstrated how cost-effective transit infrastructure can improve accessibility and support more

compact urban growth.⁸ More recently, transit-oriented development policies in Delhi, Ahmedabad, and Kochi have sought to integrate housing, employment, and transportation within walkable urban districts.

The Gulf is undergoing a similar transition. Projects such as the Dubai Metro, Riyadh Metro, and the Dubai 2040 Urban Master Plan prioritise walkability, mixed-use development, and transit accessibility.⁹ NEOM's "The Line" similarly seeks to reimagine urban mobility by reducing dependence on private vehicles.

The lesson from India is clear: mobility systems are most effective when transport planning is integrated with land-use planning. Circular cities reduce travel demand before optimising transportation networks. Mixed-use neighbourhoods, walkable districts, and transit-oriented development improve economic efficiency while reducing resource consumption.

3. Create Circular Construction Value Chains

The construction sector represents one of the largest opportunities for advancing circular urbanism. Globally, buildings and construction account for approximately 37 percent of energy-related carbon emissions and consume vast quantities of raw materials.¹⁰ For rapidly urbanising regions such as India and the Gulf, the environmental footprint of construction will significantly shape future sustainability outcomes.

Indian cities have begun establishing construction and demolition (C&D) waste recycling facilities, particularly in Delhi, Ahmedabad, and Hyderabad.¹¹ Recycled aggregates are increasingly being incorporated into infrastructure projects, while the cement industry has expanded its use of fly ash, blast furnace slag, and refuse-derived fuels to reduce material and energy intensity.

These lessons are particularly relevant to the Gulf's large-scale development programmes. Sectors well suited to the early adoption of circular construction practices include infrastructure projects, affordable housing programmes, industrial parks, and the cement industry. Integrating waste-to-energy systems and refuse-derived fuel into cement manufacturing offers one of the most immediate opportunities to reduce landfill dependence while lowering industrial emissions.

Urban growth should not be measured solely by the volume of construction, but by the efficiency with which materials are used, recovered, and reintegrated into the urban economy.

4. Rediscover Climate-Responsive Urbanism

For much of the twentieth century, architectural modernity became associated with a universal visual language that often ignored local climatic realities. Glass façades, sealed building envelopes, and mechanically conditioned interiors were replicated across diverse geographies, frequently increasing rather than reducing energy consumption.

Historic settlements such as Jaipur, Jaisalmer, and Ahmedabad in India, and Al Fahidi in Dubai, Muharraq in Bahrain, and the old quarters of Muscat evolved sophisticated responses to heat, sunlight, wind, and water scarcity through courtyards, shading devices, narrow streets, thermal mass, and passive cooling systems. These principles remain highly relevant. As cities face rising temperatures and growing cooling demands, climate-responsive architecture must become a core component of urban resilience strategies. Contemporary technologies should complement, not replace, environmental intelligence.

The challenge is not to replicate historic forms, but to integrate traditional climatic knowledge with contemporary design innovation. Cities designed for their climate will ultimately prove more resilient than those designed primarily for image.

5. Measure What Matters: Governance for Implementation

Perhaps the most important lesson from India's urban experience is that sustainability cannot be achieved through technology alone. Urban transformation requires institutions capable of translating policy into implementation. India's experience with programmes such as AMRUT and the Smart Cities Mission illustrates the importance of dedicated implementation agencies, outcome-based funding, city-level performance indicators, and digital monitoring systems.¹²

For Gulf cities pursuing ambitious sustainability agendas, governance frameworks must prioritise measurable outcomes. Policymakers should track indicators such as wastewater reuse rates, landfill diversion rates, recycled construction material usage, per-capita water consumption, and building energy performance. Equally important is accountability. Annual sustainability reporting, independent auditing mechanisms, digital performance dashboards, and performance-linked funding can help ensure that planning frameworks translate into measurable progress. Circularity succeeds when it becomes embedded within governance systems rather than remaining confined to individual projects.

Towards an India-Gulf Circular Urbanism Partnership

The future of urbanisation will be defined not by how efficiently cities consume resources, but by how effectively they regenerate them. India's experience demonstrates that circularity is not a single technology or policy intervention, but a systemic approach that integrates water management, mobility, construction, climate-responsive design, and governance into a coherent urban framework.

This presents a massive opportunity for India-Gulf cooperation. Both regions would benefit from joint research programmes on water resilience, the collaborative development of circular construction standards, knowledge-sharing platforms for municipal governance, and pilot projects focused on climate-responsive urban design. Institutions such as Expo City Dubai, alongside Indian urban research organisations, could play an important role in facilitating such exchanges. As Gulf cities pursue ambitious long-term development agendas and India continues its urban transformation, the opportunity is not simply to build smarter cities, but to build cities capable of sustaining prosperity while operating within ecological limits. Resilience is no longer an environmental aspiration; it is becoming the defining condition for urban success in the twenty-first century.

Endnotes

- 1 United Nations Department of Economic and Social Affairs (UN DESA), *World Urbanization Prospects 2018*, <https://www.un.org/en/desa/2018-revision-world-urbanization-prospects>.
- 2 World Bank, Urban Development Overview, Dubai 2040 Urban Master Plan, *Saudi Vision 2030*.
- 3 NITI Aayog, Government of India, *Composite Water Management Index*, <https://www.niti.gov.in/sites/default/files/2023-03/CompositeWaterManagementIndex.pdf>.
- 4 Ministry of Housing and Urban Affairs (MoHUA), Government of India, *AMRUT Mission Guidelines*.
- 5 Ministry of Housing and Urban Affairs, *AMRUT 2.0 Operational Guidelines*, https://amrut.mohua.gov.in/uploads/AMRUT_2.0_Operational_Guidelines.pdf.
- 6 International Water Association, *Urban Water Security and Resilience Frameworks*.
- 7 Delhi Metro Corporation (DMRC), *Annual Reports*, <https://backend.delhimetrorail.com/documents/9862/Annual-Report-2024-2025-English.pdf>.
- 8 Institute for Transportation and Development Policy (ITDP), *Ahmedabad Janmarg BRTS Case Study*,
- 9 Government of Dubai, *Dubai 2040 Urban Master Plan*, Royal Commission for Riyadh City, Riyadh Metro Project.
- 10 UNEP and Global Alliance for Buildings and Construction, *Global Status Report for Buildings and Construction 2023*.
- 11 Central Pollution Control Board (CPCB), *Construction and Demolition Waste Management in India*.
- 12 Ministry of Housing and Urban Affairs, *Smart Cities Mission: Integrated Impact Assessment Report*.

Mobilising the Youth for Climate Action and Governance: Lessons from Casablanca

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Across the MENA (Middle East and North Africa) region, cities are entering a crucial decade: climate pressures are intensifying, urban populations are growing, and public institutions are under pressure to deliver both resilience and inclusion. Rising temperatures, continued droughts, and environmental degradation are no longer future risks—they are already shaping the everyday realities of cities, especially in one of the world's most climate-vulnerable regions.¹

At the same time, the region is defined by one of its most important assets: a large and dynamic youth population. Young people account for a considerable share of the population across the MENA region, with those under 30 representing nearly 60 percent in many countries.² Yet, they continue to be viewed primarily as beneficiaries of climate policies or participants in awareness campaigns. This approach is no longer sufficient. Tackling the climate challenge requires moving beyond participation towards models in which young people help shape, implement, and drive climate solutions.³

Casablanca offers an irrefutable case in this regard. As Morocco's economic capital and one of the largest cities in Africa, the city has many of the dynamics present across the MENA region: strong growth, territorial inequalities, environmental stress, and rising expectations from younger generations.⁴ In response, the city has begun to move the youth from the margins to the centre of climate action and urban governance.

Operationalising Youth Climate Action in Casablanca

In Casablanca, mobilising the youth for climate action is not an isolated initiative—it reflects a thoughtful political choice. This is especially pertinent in a city where young people represent over 40 percent of the population, making them an important part of both present challenges and future solutions.⁵ This political orientation is reflected in the role of local development companies (Sociétés de Développement Local or SDLs), which are mandated to integrate youth-focused components into their project roadmaps. The underlying principle is clear: the city must first lead by example before asking the youth to act.

A number of SDLs illustrate how this approach is operationalised. Casa Baia, an entity in charge of environmental management, has developed a long-term engagement model through its Green Schools (**Écoles Vertes**) programme. The initiative reaches over 24,000 students annually across approximately 48 public primary schools per edition and has been operational in more than 120 schools since its launch in 2022.⁶ It combines awareness with tools, including workshops on waste segregation and recycling alongside the installation of dedicated infrastructure and tailored educational materials. By making students the ambassadors of environmental protection and responsibility within their own communities, the programme extends its impact beyond the classroom and anchors climate action in long-term behavioural change.

There is also Casa Event, which contributes through a more innovative approach, notably via the Casablanca Smart City programme. Through regular hackathons, the initiative brings together over 200 young participants per edition—students, developers, entrepreneurs, and others in various creative fields—to co-design solutions to urban challenges.⁷ Participants develop prototypes addressing issues such as sustainable mobility, waste management, and energy efficiency, with selected projects benefiting from mentorship and follow-up support. These initiatives position the youth as active problem-solvers within the city's governance ecosystem, contributing directly to the design of practical and technology-oriented solutions.

In parallel, Casa Transport contributes through investments in sustainable urban mobility infrastructure. The development of a tramway and bus rapid transit network spanning over 70 km has expanded access to public transport while reducing reliance on private vehicles.⁸ These investments have contributed to measurable environmental improvements, including reductions in air pollution in the areas served.⁹

While not explicitly youth-targeted, such infrastructure shapes everyday behaviours, particularly among younger populations who rely more heavily on public transport.¹⁰ In this sense, the youth become central actors in the transition towards low-carbon mobility.

Beyond these structural approaches, Casablanca has also introduced more direct mechanisms to mobilise youth-led climate action. The Youth Climate Action Fund (YCAF), supported by Bloomberg Philanthropies, is one such initiative. It provides funding and technical support to cities to mobilise young people ages 15 to 24 to design and implement local climate solutions.¹¹ In Casablanca, grants were capped at 50,000 MAD and reserved only for youth-led organisations, with projects aligned to city priorities such as water conservation, urban greening, and waste management. This mechanism facilitates a shift from indirect mobilisation to direct empowerment, allowing the youth to implement concrete, community-based initiatives.^a

At the same time, Casablanca has increasingly relied on digital tools to facilitate engagement with the youth. Platforms such as Casaln centralise application processes, streamline communication, and improve transparency, creating a more direct interface between the city and its younger population.¹² Their effectiveness, however, remains dependent on accessibility and digital inclusion. Together, these initiatives reflect a structured and systematic approach: leading by example through public operators, enabling youth-led action through targeted funding, and facilitating engagement through digital tools.

What Works: Strengths of the Casablanca Approach

Several elements of Casablanca's approach stand out for their effectiveness in bridging the gap between policy ambition and local impact. First, youth-led initiatives demonstrate a strong proximity to neighbourhood-level realities. Projects are rooted in lived experiences: youth in coastal areas focus on seaside protection, those in industrial zones address pollution challenges, while youth in peripheral neighbourhoods work on mobility and access to basic services. This specifically territorial approach ensures that climate action is context-related rather than generic, increasing both relevance and impact. This local approach also increases community ownership, as solutions are created and implemented by young people who understand the specific environmental and social realities of their own neighbourhoods.

a Under Casablanca's Youth Climate Action Fund (YCAF), youth-led organisations were eligible for grants of up to MAD 50,000 (approximately US\$5,000) per project. Funded initiatives included community-led urban greening and tree planting, awareness campaigns on waste reduction and recycling, water conservation projects, climate education workshops, and neighbourhood clean-up initiatives, all designed and implemented by young people in response to local environmental priorities.

Second, the microgrant model provides a cost-effective and scalable mechanism for engagement. By allocating relatively small amounts of funding, the city can support multiple initiatives simultaneously, diversifying impact across territories and thematic areas. This distributed approach enables experimentation and adaptability at scale. Third, positioning the youth as implementers rather than beneficiaries has been important in rebuilding trust between local government institutions and younger generations. By giving them direct responsibility over project implementation, the city fosters ownership, accountability, and a more collective relationship with public authorities. Finally, Casablanca's experience highlights the importance of connecting local youth action with global climate frameworks. As a member of C40 Cities, which the city joined as its 97th member in 2024, Casablanca is aligning its climate strategies with global standards while strengthening cooperation to accelerate action locally.¹³

For the youth, this global-local connection is empowering. It situates local initiatives within a larger movement and opens pathways for collaboration across the MENA region and beyond.

What Does Not Work: Limits and Adaptation

While Casablanca's approach shows clear strengths, its implementation has not been without challenges. A barrier is the lack of trust from young people towards public institutions, which made initial engagement particularly difficult. Overcoming this initially required more than just programmes—it called for strong and visible political will. The commitment at the highest level of the city, particularly from the Mayor, was crucial in mobilising resources and demonstrating credibility. This initial investment helped shift perceptions and progressively enabled more meaningful youth engagement.

Administrative complexity also proved to be an issue. Coordination across the city's departments, local development companies, and external partners occasionally slowed implementation. In response, the model evolved by simplifying procedures, clarifying governance frameworks, and leveraging digital tools to streamline access and communication. Efforts were also made to broaden inclusivity, extending engagement beyond already active youth through partnerships with local associations and more targeted outreach.

From Casablanca to MENA: Lessons for Urban Climate Governance

Casablanca's experience offers practical lessons for cities across the MENA region, where similar dynamics—youthful populations, institutional complexity, and climate vulnerability—are present. First, meaningful youth engagement requires strong political will. Leaders must go beyond rhetorical support and actively integrate young people into the design and implementation of policies. Without this, initiatives risk remaining symbolic. Second, cities need to move from awareness to action by funding and empowering the youth, not just engaging them. Mechanisms such as microgrants or dedicated programme budgets enable young actors to translate ideas into concrete projects, strengthening both impact and credibility.

Third, policies must be designed with institutional realities in mind. Administrative procedures, political cycles, and governance fragmentation are not exceptions in MENA cities—they are the norm.¹⁴ Effective strategies must therefore anticipate delays, remain flexible, and align with existing systems, including SDLs, whose operational continuity allows initiatives to extend beyond political cycles.

Inclusivity is another critical dimension. Making sure that engagement tools—whether digital platforms or funding mechanisms—are accessible to diverse youth profiles is essential to avoid worsening existing inequalities. This requires combining digital solutions with on-the-ground mobilisation.

Finally, cities should connect local action to global frameworks. Engagement in international networks such as C40 Cities and Association Internationale des Maires Francophones (AIMF) enables municipalities to strengthen their strategies and access technical and financial support.

In Casablanca, earlier cooperation through AIMF helped improve access to drinking water and sanitation in Lahraouiye Nord, a peripheral area of Greater Casablanca, at a time when basic infrastructure remained limited in some neighbourhoods. The intervention formed part of a broader national programme to extend access to basic services in underserved communities, which benefited approximately 500,000 residents. The AIMF-supported project specifically provided drinking water and sanitation infrastructure to some 10,600 households (approximately 55,000 people) in Lahraouiye Nord.

In 2025, through its engagement within the C40 network, Casablanca designed and submitted a funding request to the City Climate Finance Gap Fund of the World Bank, securing technical assistance to develop its first integrated Climate Action Plan. Designed as a strategic roadmap for the city, the Climate Plan will identify climate risks and vulnerabilities, define priority mitigation and adaptation measures, establish measurable targets, and guide institutional and private investments across key sectors. By aligning local government action, Morocco's national priorities and international climate standards, this initiative aims to strengthen Casablanca's resilience to climate change while improving urban sustainability and quality of life for its residents.¹⁵

These partnerships, whether with AIMF or C40, illustrate how international networks can both deliver tangible local impact and unlock global strategic financing pathways, while positioning youth-led initiatives within broader climate and development agendas.

Conclusion

Casablanca's experience portrays a fundamental shift in urban climate governance: youth participation is no longer optional in climate policy but are a strategic lever for its delivery and implementation. Moving from engagement to empowerment requires more than programmes; it requires strong political will and rethinking how cities design, fund, and implement climate action. When positioned as implementers, young people strengthen the link between institutions and communities, accelerate local impact, and contribute to rebuilding trust in public institutions. In a region where both climate and governance pressures are growing, this shift is no longer optional. The question is no longer whether cities should engage youth, but whether they are ready to share agency with them. The resilience of MENA cities will increasingly depend on the answer.

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Endnotes

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- 1 World Bank, *Climate Change Roadmap – Middle East and North Africa FY21–25: Mid-Term Progress Report*, Washington DC, World Bank, 2024, <http://hdl.handle.net/10986/41842>.
 - 2 UNDP, *Arab Human Development Report 2016: Youth and the Prospects for Human Development in a Changing Reality*, New York, United Nations Development Programme, 2016.
 - 3 UNEP, *Annual Report 2023*, Nairobi, United Nations Environment Programme, 2024, <https://wedocs.unep.org/rest/api/core/bitstreams/6d6d2e3c-8c2a-44d5-a951-1e4fb64931c0/content>.
 - 4 OECD, *National Urban Policy Review of Morocco*, Paris, Organisation for Economic Co-operation and Development, 2025, <https://doi.org/10.1787/af7ee02f-en>.
 - 5 Haut-Commissariat au Plan (HCP), *Population légale du Royaume du Maroc répartie par régions, provinces et préfectures et communes selon les résultats du Recensement général de la population et de l'habitat 2024*, November 7, 2024, https://www.hcp.ma/Population-legale-du-Royaume-du-Maroc-repartie-par-regions-provinces-et-prefectures-et-communes-selon-les-resultats-du-Recensement-general-de-la-population-et-de-l-habitat-2024_a4046.html.
 - 6 Casablanca Baia, "Le programme « Écoles Vertes » 2023 lancé par Casablanca Baia," May 3, 2023, <https://casabaia.ma/le-programme-ecoles-vertes-2023-lance-par-casablanca-baia/>.
 - 7 Casablanca Smart City, "Hackathon," <https://www.casablancasmartcity.com/side-events/hackathon-2/>.
 - 8 Casatramway, "Qui sommes-nous ?," <https://www.casatramway.ma/propos/qui-sommes-nous>.
 - 9 Centre Régional d'Investissement Casablanca-Settat (Casa Invest), "Tramway de Casablanca," <https://casainvest.ma/fr/projets/tramway-de-casablanca>.
 - 10 International Transport Forum, *Youth on the Move: Young People and Transport in the 21st Century*, International Transport Forum Policy Papers, No. 128, Paris, OECD Publishing, 2024, <https://doi.org/10.1787/686a7ed5-en>.
 - 11 Bloomberg Philanthropies, *Youth Climate Action Fund: Program Overview and Charter*, 2024, <https://data.mesaaz.gov/api/views/jcys-68y7/files/af308370-d3bf-4566-817e-81a56159f7fa?download=true&filename=Youth+Climate+Action+Fund+-+Program+Overview.pdf>.
 - 12 Ville de Casablanca, "Portail Officiel de la Ville de Casablanca," <https://www.casablancacity.ma/fr>.
 - 13 C40 Cities, "Casablanca to Become 97th City to Join C40 Cities," December 17, 2024, <https://www.c40.org/news/casablanca-to-become-97th-city-to-join-c40-cities/>.
 - 14 Organisation for Economic Co-operation and Development (OECD), *Governing for Sustainable Prosperity in the Middle East and North Africa*, OECD Public Governance Reviews, Paris, OECD Publishing, 2024, <https://doi.org/10.1787/d0da1d30-en>.
 - 15 Ville de Casablanca, "La Commune de Casablanca lance l'élaboration du Plan Climat Casablanca avec l'appui de la Banque mondiale," Portail officiel de la Ville de Casablanca, February 27, 2025, <https://www.casablancacity.ma/fr/actualite/2058/la-commune-de-casablanca-lance-lelaboration-du-plan-climat-casablanca-avec-lappui-de-la-banque-mondiale>.

The Need for an Integrated Framework to Address the Climate–Health–Migration Nexus in Iraq

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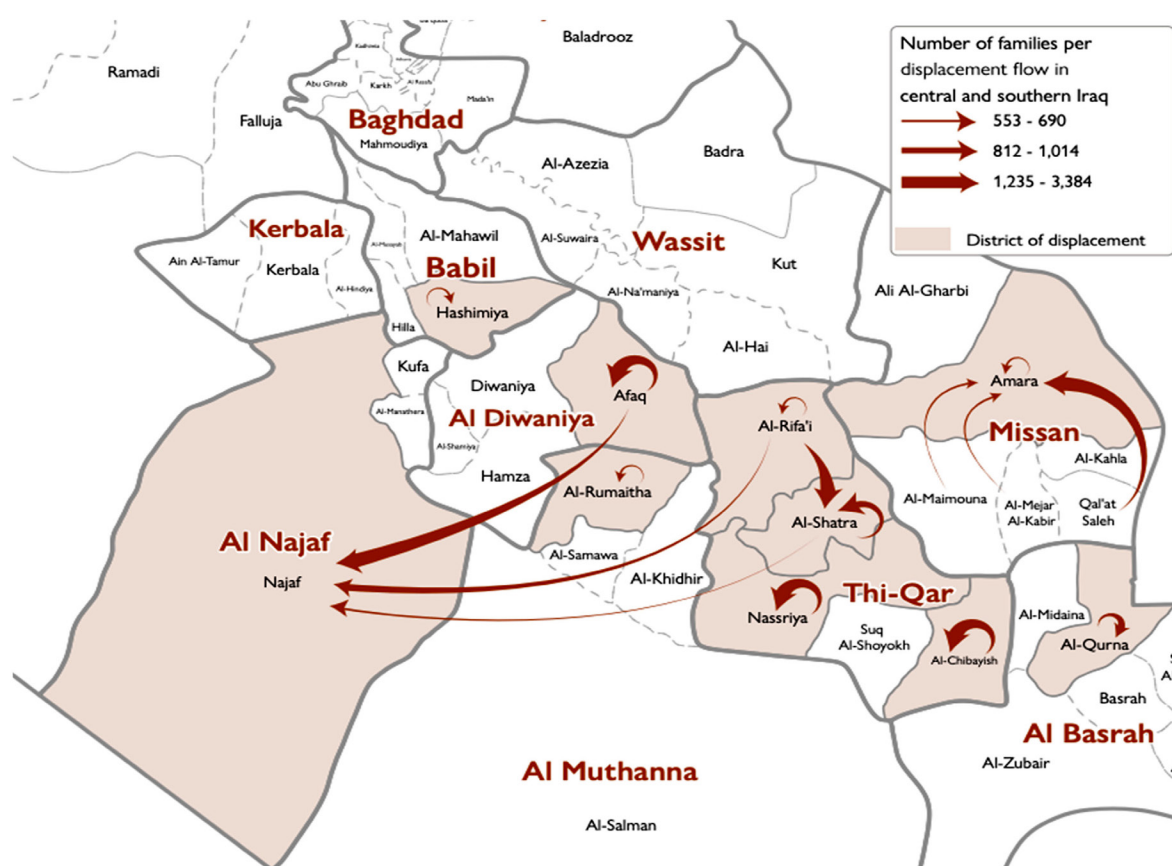
Middle East and North Africa (MENA) countries are located in some of the driest and most water-stressed regions of the world. Many of them face compounding challenges, including governance instability, rapid population growth, energy insecurity, fiscal pressures, and vulnerable infrastructure. Climate change exacerbates the scale and impact of these fragilities, serving as a ‘push factor’ for voluntary or forced migration.¹ Slow-onset events,² such as desertification, sea-level rise, and extreme heat, threaten spatial habitability leading to migration, while sudden-onset events, such as floods or desert storms, shut down public services, resulting in acute climate-induced displacement.

Iraq has been identified as being fifth-most vulnerable country to climate change.³ In 2024, southern Iraqi cities recorded the world’s highest global temperature levels (50°C);⁴ projections suggest that water availability in these places could decrease by up to 20 percent by 2050.⁵ These trends pose significant risks to Iraq’s public health.

Climate impacts also affect agricultural systems, threatening livelihoods and prompting rural-to-urban migration. As of September 2025, 31,001 Iraqi families across 12 governorates remain displaced due to climatic factors, with 63 percent migrating to urban areas.⁶ This creates a strain on host governorates, forcing them to provide infrastructure and services to facilitate enhanced migrant integration.

This article evaluates the intersection between climate, migration, and health in Iraq and argues for a unified framework to strengthen integrated governance over climate and health to enable safe migration pathways.

Figure 1: Mapping Climate-Induced Displacement in Iraq



Disclaimer: This map is for illustration purposes only. Names and boundaries on this map do not imply official endorsement or acceptance by IOM.

Source: IOM⁷

From Environmental Stress to Health Concerns and Human Mobility

Iraq has historically benefited from fertile lands that support a strong agricultural sector, but increased water scarcity is driving food insecurity and displacement. Agriculture contributes almost 3 percent of Iraq's gross domestic product (GDP) and employs more than 19 percent of the workforce, nearly 25 percent of whom are women.⁸ However, the central and southern regions, home to the majority of the population, bear the disproportionate impacts of climate change. Decline in precipitation has led to an increase in water and soil salinity, contributing to a

30-percent loss of productivity in agricultural land over the past three decades.⁹ Water shortages and decreased crop yields have worsened malnutrition trends, especially among women and children. Drought and disputes over water access further increase the risk of instability and displacement.¹⁰

Figure 2: Impact of Climate Change on Iraq



Source: IN-2¹¹

In late 2025, Iraq's northern regions experienced extreme flooding events, overwhelming drainage systems and forcing residents in low-lying neighbourhoods to evacuate.¹² Southern and coastal governorates also face frequent flooding risks from sea-level rise.¹³ Recurrent flooding contaminates drinking water, leading to the spread of waterborne diseases such as gastrointestinal infections and cholera.¹⁴

Yet, climate change does not work in isolation. The central and southern regions of Iraq face compounded pressures from unregulated upstream water use, the discharge of agricultural and industrial pollutants,¹⁵ inefficient agricultural methods such as limited crop diversification,¹⁶ and reduced water flow caused by water management in neighbouring countries.¹⁷ These interconnected challenges catalyse rural-to-urban migration, as individuals either voluntarily leave for better economic opportunities or are forced to relocate due to extreme weather patterns. Key districts for this displacement in Iraq include Al-Shatra, Amara, and Nassriya (see Figure 1).¹⁸

Urban Resilience and Public Health Systems

As of 2025, over 70 percent of Iraq's population live in urban areas.¹⁹ However, the country's urban infrastructure and institutional capacity remain fragile, limiting its capacity to meet the health needs of host and migrant communities. Over three million live in urban slums and informal settlements, increasing congestion and disease transmission.²⁰ Moreover, urban areas lack wastewater treatment plants, leading to improper discharging practices where untreated industrial and sewage waste are disposed into rivers, degrading water quality.²¹ Higher water demand, coupled with the inability of urban infrastructure to cope, will increase the risk of exposure to waterborne diseases.

Extreme heat conditions are expected to worsen, with more frequent heatwaves. Combined with power outages, this will impact human health and potentially lead to increased mortality. Baghdad and Basra are already experiencing temperatures over 50°C. The number of heat-related deaths is projected to double between 2000 and 2030, from 1.6 to 3.2 deaths per 100,000 people.²²

Increasing heatwaves will lead to a higher demand for healthcare services, placing more strain on urban health systems that already struggle to provide quality care. Large public health centres (PHCs) have limited resources and are overwhelmed with patients. Doctors often choose to work at private facilities that offer better healthcare over PHCs due to higher salaries, but only patients with available funds can avail private hospitals.

Iraq has historically benefited from international development aid, but this has now reduced. Due to this, financing urban and health resilience has become a challenge as civil society organisations and government agencies have lower financial capacity to provide adequate services. For example, the dismantling of USAID operations in February 2025 resulted in the discontinuation of a US\$20-million, four-year water and sanitation improvement initiative, negatively impacting 2.5 million people across five Iraqi provinces.²³

Moreover, Iraq's public health funds rely heavily on oil exports, which account for approximately 90 percent of government revenues.²⁴ This dependence creates fiscal vulnerabilities, as fluctuations in oil revenue can constrain government spending on healthcare, water infrastructure, and social services.

An Integrated Climate–Health–Migration Resilience Framework

In 2020, Iraq established a National Migration Management Strategy in accordance with its first National Plan to Promote Safe, Orderly and Regular Migration in August 2025.²⁵ However, the strategy focuses on conflict-induced cross-border displacement; there is no parallel unified framework for internal climate migration. Strict guidelines restrict its benefits to victims of security- and conflict-related displacement alone. Climate-induced migrants face difficulties in registering with the Ministry of Migration and Displacement (MoMD) for legal recognition as ‘drought and desertification internally displaced persons (IDPs)’ to avail social and health protection benefits.²⁶ Moreover, the Iraqi government views climate impacts as economic challenges rather than drivers of displacement, resulting in institutional silos regarding governance of environment, health, and migratory movements.²⁷ While local communities express confidence in their strategies to anticipate and handle climate-related events, they emphasise a lack of preparedness by state systems. Weak technical monitoring and slow coordination limits access to funds, delaying responses to climate shocks and contributing to displacement.

A clear governing framework for climate migration would help ensure formal recognition and allocation of rights for migrants, facilitate coordination to address systemic drivers of migration, and minimise negative health impacts on the population. The following three-pronged framework aims to strengthen intersectoral cooperation to enable anticipatory action, facilitate safe migratory movements, and ensure that urban areas have the capacity to absorb the influx of climate migrants.

1. Coordination for Anticipatory Climate-Health Adaptation

This would entail establishing a coordination mechanism between the Iraqi Meteorological Organization, Ministry of Agriculture, National Center for Water Resources Management, and Ministry of Health to develop shared data systems mapping climate effects, mobility drivers, and socioeconomic determinants of health within governorates.²⁸ Mapping the intersection of migratory movements and extreme weather events to inform early warning systems could assist in creating disaster risk reduction frameworks, leading to better public health planning and emergency management. Migration monitoring systems are largely nascent, since limited data is available on environment-driven displacement, such as the informal settlements in northern Iraq.^{29,30} Synergising disaster risk reduction, climate adaptation, health preparedness, and emergency planning can help create infrastructure, ensure health service continuity, and formalise operating procedures for migration during sudden-onset events such as floods.³¹ Iraq can parallel Sudan and Morocco’s integration of health considerations in their National Adaptation Plans, such as geo-mapping climate-health risks that increase migration (Sudan) and anticipating climate-driven evacuation scenarios (Morocco).³²

Since climate and the threat of livelihood loss are often interconnected migration drivers, partnerships between Iraq’s Ministry of Agriculture and international organisations can facilitate

knowledge exchange and technology transfer to implement climate-resilient agricultural methods, demand-side water management, water infrastructure rehabilitation, and capacity building to encourage diversified or alternative livelihoods and mitigate impacts of slow-onset events like droughts.^{33,34}

2. Facilitate Safe Migratory Processes

Increasing recognition of climate–health interactions within migratory governance frameworks can ensure dignified migration processes and sustained health access. Increasing preventative health measures would enable safe migration pathways—for instance, maintaining health access during relocation through mobile units, access to water and safe sanitation, and expanding cross-border health surveillance.³⁵ Previously, the Iraqi Red Crescent Society deployed mobile health teams to support those displaced by water shortages.³⁶ Easing administrative processes to gain legal recognition with the MoMD would fast-track migrant access to urban health and social protection systems.³⁷

3. Advance Climate-Resilient Urban and Health Systems

To accommodate rising patient numbers and address their unique health needs, capacity building for health facilities in high-risk zones should be increased, with tools to manage heat stress and waterborne diseases.³⁸ This would require closing the current funding gap for services at primary health centres on priority.³⁹ The urban heat island phenomenon can be mitigated through nature-based solutions, green infrastructure, and improved ventilation with local materials. Public and private funders could invest in local innovators, such as the Green Insulation and Ventilation (GVI) team that creates vertical gardens using low-maintenance plants reusing filtered sink water.⁴⁰

In addition, managing the proliferation of informal settlements is essential to reduce potential public health risks. This can be done through settlement rehabilitation, improvements in water and sanitation services, and upgrading infrastructure. The Roadmap for Addressing Informal Settlements in Iraq could serve as a useful guide to scale up such efforts.⁴¹

Conclusion

Intensifying climate risk is leading to an increase climate-related migration as an adaptation strategy. Iraq’s cities will continue to serve as primary destinations for climate migrants, adding pressure to already strained infrastructure and health systems. Developing a unified framework is the first step to strengthening institutional coordination.

While financing is critical for implementation, climate adaptation has historically struggled to attract funding due to uncertain financial returns, small project sizes, and long-time benefit horizons. However, the added health dimension opens new financing pathways. For example, green health insurance has been piloted in Egypt with support from the World Bank.⁴² According

to this, victims of climate change are eligible for free health insurance tailored to climate-sensitive health risks, while service providers are incentivised to reduce emissions or waste. The Iraqi government can structure revenue raising to finance infrastructure projects, leveraging green bonds for those with environmental benefits.⁴³ Islamic finance can also be leveraged for resilience initiatives. Pairing *takaful* coverage with parametric insurance can provide payouts to farmers based on drought triggers. Likewise, *waqf* or endowment funds can be directed towards water infrastructure restoration projects.⁴⁴

The assessment of Iraq's experience demonstrates the need for a more integrated governance approach that links climate adaptation, public health, urban planning, and migration management. This will address the primary drivers of climate-induced migration while supporting the successful integration of migrants into host communities.

Endnotes

- 1 The World Bank Group, *Middle East and North Africa Roadmap (2021-2025)*, 2022, <https://thedocs.worldbank.org/en/doc/6f868d4a875db3ef23ef1dc747fcf2ca-0280012022/original/MENA-Roadmap-Final-01-20.pdf>.
- 2 Davide T. Mosca and Michela Martini, “The Climate–Migration–Health Nexus: A Multisectoral Framework for Action, with Case Insights from MENA,” *Tropical Medicine and Infectious Disease* 11, no. 3 (2026), <https://doi.org/10.3390/tropicalmed11030079>.
- 3 International Organization for Migration (IOM), *Migration, Environment, and Climate Change in Iraq*, Baghdad, IOM Iraq, 2022, <https://iraq.un.org/sites/default/files/remote-resources/079bd27fc79b4084e48157653d335c8f.pdf>.
- 4 Anuradha Jangra, *Iraq: Climate Change, Migration and Security Implications*, National University of Singapore and Middle East Institute Singapore, 2025, <https://mei.nus.edu.sg/wp-content/uploads/2025/04/Insighr318.pdf>.
- 5 “Diwaniyah’s Bitter Harvest; Debt Over Amber Rice,” *The New Region*, August 1, 2024, <https://thenewregion.com/posts/742/diwaniyah-s-bitter-harvest-debt-over-amber-rice>.
- 6 IOM, *Iraq - Climate-Induced Displacement - Central and Southern Iraq*, Baghdad, IOM, 2025, <https://dtm.iom.int/reports/iraq-climate-induced-displacement-central-and-southern-iraq-september-2025?close=true>.
- 7 “Iraq - Climate-Induced Displacement - Central and Southern Iraq”.
- 8 Food and Agricultural Organisation (FAO), “Iraq Investment Proposal,” FAO, <https://www.fao.org/hand-in-hand/previous-editions/hih-investment-forum-2025/iraq/en>.
- 9 “Desertification Renders 60% of Iraq’s Soil Unusable,” *Shafaq News*, October 19, 2025, <https://shafaq.com/en/society/Desertification-renders-60-of-Iraq-s-soil-unusable>.
- 10 Lisa Binder, Barbora Šedová, Lukas Rüttinger, Julia Tomalka, Stephanie Gleixner, *Climate Risk Profile Iraq*, Potsdam Institute for Climate Impact Research (PIK) and Adelphi Research Gemeinnützige GmbH, 2022, https://weatheringrisk.org/sites/default/files/document/Climate_Risk_Profile_Iraq_8.pdf.
- 11 Rawan Barzan, *Climate Change and Migration in the Land of Two Rivers*, IN2, 2024, <https://www.in2-comms.com/insights/8>.
- 12 Reliefweb, “Iraq: Floods - Dec 2025,” <https://reliefweb.int/disaster/ff-2025-000222-irq>.
- 13 United Nations Development Program, *Climate Vulnerability Index of Iraq*, UNDP, 2025, <https://www.undp.org/sites/g/files/zskgke326/files/2026-03/cvi-en-sum.pdf>.
- 14 “Climate Risk Profile Iraq”.
- 15 Zeinab Shuker, “The Deep Roots of Iraq’s Climate Crisis,” The Century Foundation, July 2023, <https://tcf.org/content/report/the-deep-roots-of-iraqs-climate-crisis/>.
- 16 “Diwaniyah’s Bitter Harvest; Debt over Amber Rice”.
- 17 “Migration, Environment, and Climate Change in Iraq”.
- 18 IOM UN Migration, “Climate-Induced Displacement in Central and Southern Iraq,” April 29, 2025, https://iraqdurablesolutions.net/Uploads/PublicationFiles/202557_728_2025-04-29%20-%20Climate%20Displacement%20Tracking%20-%20RWG.pdf.
- 19 UN-Habitat, “Urban Numbers,” <https://unhabitat.org/iraq>.
- 20 UN-Habitat, “Urban Numbers.”
- 21 Saleem Ethaib et al., “Water Resources in South of Iraq: Current State, Future Evolutions, Challenges, and Potential Solutions,” *Hydrology* 13, no. 3 (2026), <https://doi.org/10.3390/hydrology13030087>.

- 22 "Climate Risk Profile Iraq".
- 23 Charlotte Kropf, "Climate Change Drives Internal Displacement in Iraq," *The International Affairs Review*, October 8, 2025, <https://www.iar-gwu.org/blog/fvytke55otm6ut17w76xgjon26x5nt>.
- 24 "Iraq Caught in the Middle: The Iran War's Impact and What Comes Next," *Epic*, April 2026, <https://enablingpeace.org/iraq-iran-war-impact/>.
- 25 United Nations Network on Migration, "Iraq Voluntary National Review (VNR) of the Implementation of the Global Compact for Safe, Orderly and Regular Migration (GCM)," 2026, https://migrationnetwork.un.org/system/files/resources_files/iraq-gcmr-2026.pdf.
- 26 IOM, "Understanding the Needs and Vulnerabilities of Climate-Induced Migrants in Iraq," June 22, 2025, <https://reliefweb.int/report/iraq/understanding-needs-and-vulnerabilities-climate-induced-migrants-iraq>.
- 27 Berghof Foundation, "From Climate Stress to Social Strain: Migration, Governance, and Local Resilience in Iraq," February 18, 2026, <https://reliefweb.int/report/iraq/climate-stress-social-strain-migration-governance-and-local-resilience-iraq>.
- 28 UNDP, "Climate Vulnerability Index of Iraq," 2025, <https://www.undp.org/sites/g/files/zskgke326/files/2026-03/cvi-en-sum.pdf>.
- 29 IOM Iraq, "Migration, Environment, and Climate Change in Iraq," 2022, <https://environmentalmigration.iom.int/sites/g/files/tmzbd1411/files/documents/Migration%2C%20Environment%20and%20Climate%20Change%20in%20Iraq.pdf>.
- 30 IOM Iraq, "Informal Sites Assessment 2024," January 2025, https://iraqdtm.iom.int/files/ILA/2025123124394_IOM_DTM_Informal_Sites_2024.pdf.
- 31 IOM UN Migration, "Understanding Climate Change, Migration, and Health Nexus: Insights from the MENA Region," 2025, IOM, Geneva, <https://publications.iom.int/system/files/pdf/pub2025-027-l-understanding-climate-change-migration-and-health-nexus.pdf>.
- 32 IOM, "Positioning the Climate Change-Health-Migration Nexus in the Middle East and North Africa Region: A Framework for Policy and Action: IOM, Geneva," 2025, <https://publications.iom.int/system/files/pdf/pub2025-024-el-positioning-the-climate-migration-health-in-mena-region.pdf>.
- 33 Berghof Foundation, "From Climate Stress to Social Strain: Migration, Governance, and Local Resilience in Iraq."
- 34 UNDP, "Climate Vulnerability Index of Iraq," 2025, <https://www.undp.org/sites/g/files/zskgke326/files/2026-03/cvi-en-sum.pdf>.
- 35 IOM UN Migration, "Understanding Climate Change, Migration, and Health Nexus: Insights from the MENA Region".
- 36 World Health Organization, "Health System Strengthening Interventions to Improve the Health of Displaced and Migrant Populations in the Context of Climate Change," 2025, Geneva, World Health Organization, <https://iris.who.int/server/api/core/bitstreams/1d9f855a-7427-49bb-907b-a38a60e20529/content>.
- 37 IOM, "Understanding the Needs and Vulnerabilities of Climate-induced Migrants in Iraq".
- 38 WHO, "WHO Continues Efforts to Strengthen Climate-Resilient Health Systems in Iraq," November 17, 2025, <https://reliefweb.int/report/iraq/who-continues-efforts-strengthen-climate-resilient-migrant-inclusive-health-systems-iraq>.
- 39 David Collins, ali Al-Taie, David Hipgrave, Omar Abdul Ameer Al Gumrawi, and Ahlam Aziz Ali, "Funding, Service and Resource Gaps at Primary Health Centres in Iraq," *World Health Organization Eastern Mediterranean Health Journal* 32, no. 4, <https://doi.org/10.26719/2026.32.4.182>.
- 40 United Nations Iraq, "Greening Iraq: Climate-Smart Insulation to Combat Extreme Heat," <https://iraq.un.org/en/293017-greening-iraq-climate-smart-insulation-combat-extreme-heat>.

- 41 UN-Habitat, “UN-Habitat and Iraq’s Ministry of Planning Lead Policy Dialogue on the Roadmap for Rehabilitation of Informal Settlements in Iraq [EN/AR],” *ReliefWeb*, <https://reliefweb.int/report/iraq/un-habitat-and-iraqs-ministry-planning-lead-policy-dialogue-roadmap-rehabilitation-informal-settlements-iraq-enar>.
- 42 Maarten Oranje, Inke Mathauer, “A Health Financing Policy Agenda for Climate Mitigation and Adaptation,” *Bulletin of the World Health Organization*, May 1, 2024, <https://doi.org/10.2471/BLT.23.291253>.
- 43 Oranje and Mathauer, “A Health Financing Policy Agenda for Climate Mitigation and Adaptation”.
- 44 World Bank and Islamic Development Bank, “Islamic Finance and Climate Agenda: From Green Sukuk Innovation to Greener Halal Value Chains,” November 2025, <https://www.isdb.org/sites/default/files/media/documents/2025-11/WB%20Islamic%20Finance%20and%20Climate%20Agenda%20%282%29.pdf>.

From Reactive Responses to Integrated Urban Resilience Systems: Insights from Jordan

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In Jordan's main cities, resilience is not an abstract idea. It is defined by how local communities and leaders manage extreme pressures every day. Amman exemplifies this reality as it faces two critical environmental challenges simultaneously. The first is chronic water scarcity: Jordan's renewable freshwater availability is estimated at around 61 m³ per person per year, far below the internationally recognised water scarcity threshold of 500 m³.¹ Second, the city is vulnerable to 'flash floods' that sweep through densely populated valleys, damaging roads, disrupting businesses, and restricting mobility.

Alongside these environmental pressures, Jordan's cities have absorbed population shifts over the last ten years. Cities have become the primary destinations for displaced people across the region. According to data from the United Nations High Commissioner for Refugees (UNHCR), approximately 82 percent of registered Syrian refugees in Jordan reside in towns and cities, placing sustained pressure on housing, clean water networks, trash management, and public service systems.²

Jordan has demonstrated adaptive capacity by strengthening local institutions and working closely with international partners to address immediate problems as they arise. However, the country has now reached a critical turning point. The current approach relies heavily on operational resilience: reacting to a crisis, recovering from it, and fixing problems after they happen. The immediate challenge for Jordan's next phase of urban development is to move toward systemic governance—making these adaptive practices permanent, embedded within long-term planning and institutional frameworks.

The Stress-Test on Jordan's Urban System

Jordan's urban system operates under multiple, overlapping pressures. Local governments in cities like Amman, Irbid, and Mafrqa are forced to manage challenges simultaneously, including increasingly unpredictable weather patterns, rapid city growth, constrained municipal finances, and continuous population increases.

Close cooperation between international agencies such as the UNHCR and local governments highlights a progressive, city-based approach to humanitarian aid. By creating support programmes that help both refugees and local citizens at the same time, these initiatives have successfully maintained social stability and kept public services from breaking down entirely.

As cities across the Middle East grapple with similar challenges of water scarcity and migration, Jordan's experiences offer lessons with broader global relevance. The question now is how to turn these temporary, situational successes into official policy.

From Resilience in Practice to Resilience by Design

A useful distinction in understanding Jordan's experience is between resilience in practice and resilience by design. Resilience in practice refers to the ability of cities and local authorities to respond effectively to immediate emergencies through crisis management, targeted interventions, and strong partnerships. Resilience by design, in contrast, embeds risk reduction, safety measures, and long-term resource planning into legislation, national policy, and urban planning systems.

Jordan has already laid the groundwork for this important shift. Strategic plans such as the Amman Resilience Strategy 2022-2026 outline priorities for infrastructure upgrades, public transport, and environmental management.³ Initiatives such as UN-Habitat's Smart Urban Water Management initiative⁴ and the community-led flood protection projects recorded by the Arab Urban Development Institute show a clear desire for improved risk management.⁵

Increasingly, these efforts are complemented by digital tools and data platforms, including AI-enabled analytics, that support more informed and adaptive decision-making. These technologies enable cities to better understand risk patterns, anticipate shocks, and respond more effectively in real time, while also supporting longer-term planning processes.

Despite this progress, a close look at current projects reveals a common weakness. Many successful programmes remain isolated from one another in separate initiatives. Because these programmes often rely on short-term international funding, their long-term survival is fragile. For these strategies to work across the whole country, local municipalities—the everyday providers of city services—must be given more financial independence and stronger administrative powers to keep these programmes alive on a city-wide scale.

Case Insights: Resilience in Practice Under Compound Stress

The tension between temporary, local success and long-term planning is best understood through two specific urban challenges depicted in the cases below. These cases illustrate that cities are capable of responding effectively to shocks, yet responses often remain fragmented or externally supported, providing the opportunity to strengthen systemic integration.

Flood Resilience in Amman

Amman's topography of steep hills and densely populated valleys, creates a natural vulnerability to 'flash flooding' during heavy rainfall. Recent projects have used advanced technology like flood risk mapping, early warning systems, and nature-based drainage solutions to absorb water.⁶ Projects supported by UN-Habitat's resilience programmes in Amman demonstrate how the city has paired these engineering fixes with local community training.⁷ Although these interventions reflect growing technical capability and innovation to enhance climate forecasting, scholars note how adaptation efforts have been delivered in partnership with international development organisations, and there are opportunities to further embed learning mechanisms within institutionalised long-term policy plans. Community engagement also remains inconsistent, and training remain ad hoc, illustrating gaps in participatory governance.⁸ Thus, the long-term impact of such projects could be further enhanced through ongoing integration into comprehensive urban planning, financing, data systems, and community-based disaster risk reduction (DRR) plans.

Service Delivery Under Refugee Pressure

In Jordan's cities like Amman, Irbid, Ramtha, and Mafraq, the influx of refugees has permanently increased demand for waste management, water delivery, housing, and public transport. Local governments have been highly flexible, expanding services quickly alongside humanitarian agencies. In Northern communities such as Mafraq, international NGOs have worked with municipal governments and local utilities to co-develop an adaptive approach, improving water treatment plants, transmission pipelines, and water storage tanks to boost water volumes and meet growing demand.⁹

Simultaneously, UNHCR programmes in urban areas support both refugees and host communities, helping maintain service delivery and social cohesion. For example, in Irbid, UNHCR supports 128,000 refugees with social protection, education, and livelihood support.¹⁰ Moreover, through

UNHCR's "One Refugee" strategy, Community Support Committees jointly led by Jordanian and refugee representatives offer livelihood trainings and social convening spaces.¹¹

Although humanitarian partnerships have alleviated immediate service pressures and improved social integration, municipal authorities remain strapped managing risks like flash flooding and water scarcity, which have increased in frequency and intensity. For example, during flash floods in Irbid and Ramtha, municipalities often rely on Civil Defense to lead evacuation and clean-up efforts without proactively preparing for the next disaster.¹² Persistent strain on local infrastructure renders municipalities under-resourced to pursue proactive DRR approaches and anticipatory action. Consequently, responses remain largely reactive, while proactive responses remain largely donor-led and fragmented. Fully integrating fixed-term projects within municipal governance systems would enhance sustainability and ensure alignment with long-term urban planning priorities.

Governing Resilience: From Projects to Systems

The next phase of urban resilience in Jordan requires a shift from delivering initiatives to governing resilience as an integrated system. Jordan's cities have demonstrated a strong capacity to respond to shocks; the next step is to embed these efforts within governance frameworks that ensure continuity, coordination, and long-term impact.

Building on these insights, the next step is to consolidate existing efforts within a coherent governance framework. This means moving Jordan from a state of constantly reacting to crises towards a fully integrated system. This shift requires five institutional priorities:

- Institutionalising success: Take the lessons from successful pilot projects and include them directly in national and municipal planning budgets.
- Empowering local governments: Give municipalities greater control over their own finances and legal decisions so they can act effectively without waiting for central approval.
- Integrating urban systems: Bring land use, water conservation, housing, and transport together into a single, cohesive city strategy instead of treating them as separate tasks.
- Aligning humanitarian and urban systems: Integrate refugee support programmes into standard municipal frameworks, accepting population shifts as a permanent part of the city layout.
- Building data-driven and technology-enabled systems: Use shared data platforms and predictive tools to help cities plan ahead.

These priorities build on Jordan's existing strengths and experiences while guiding a transition towards an integrated, resilient urban governance system.

Lessons for the Region

Jordan's experience highlights that urban resilience cannot be achieved through emergency response alone. It requires governance systems that are prepared to manage uncertainty, coordinate across institutions, and respond to changing urban realities.

A key lesson is that resilience depends on strong institutions, effective coordination, and long-term planning. While emergency measures are essential, they should evolve into permanent policies and institutional practices. The experience also highlights the need to treat demographic change as a core urban planning issue. Population growth, migration, and displacement have lasting implications for infrastructure, public services, and municipal capacity.

Ultimately, pilot initiatives create lasting value only when they are embedded within governance systems. The practices demonstrate the importance of moving beyond short-term projects towards institutional approaches that strengthen cities over time.

Jordan's experience suggests that the transition from project-based interventions to stronger governance systems is one of the most effective ways to build cities that are better prepared for future challenges.

Conclusion: A Governance Agenda for Resilience

Jordan's experience demonstrates that resilience is fundamentally a governance challenge, not simply an engineering one. Research and past experiences confirm that while a strong crisis response is vital, it must be backed by permanent laws and stable institutions to protect a city over time.

The future success of Jordan's cities will not be measured by the number of individual projects they launch, but by how well their everyday systems handle pressure. By building the lessons from environmental and demographic crises directly into government policy, Jordan is doing more than just stabilising its own cities. It is constructing a clear, reliable blueprint for sustainable urban governance across the entire Middle East.

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Endnotes

- 1 UNICEF, “The Costs of the Water Crisis in Jordan–Water Stress in Jordan Report,” <https://www.unicef.org/jordan/costs-water-crisis-jordan>.
- 2 UNHCR Jordan, “Urban and Rural Areas,” <https://www.unhcr.org/jo/urban-areas>.
- 3 Med Urban Tools, “Amman Resilience Strategy,” https://medurbantools.com/portfolio_page/amman-resilience-strategy/.
- 4 “Amman City Government Media Center, “GAM Participates in Launching the ‘Smart Urban Water Management’ Project to Enhance Urban Adaptation and Resilience in Amman,” https://media.ammancity.gov.jo/EN/NewsDetails/GAM_participates_in_launching_the_%E2%80%9CSmart_Urban_Water_Management%E2%80%9D_project_to_enhance_urban_adaptation_and_resilience_in_Amman.
- 5 Arab Urban Development Institute, “Stemming the Tide: Arab Cities Facing Climate Change,” <https://araburban.org/en/newsletter/issue-2-en/>.
- 6 UN Habitat, “Amman Climate Action Plan,” August 2024, https://unhabitat.org/sites/default/files/2024/09/amman_cap_-_final.pdf.
- 7 United Nations Jordan, “UN-Habitat: Strengthening Social Stability and Resilience of Vulnerable Population in Amman Against Flash Floods,” October 27, 2022, <https://jordan.un.org/en/205406-un-habitat-strengthening-social-stability-and-resilience-vulnerable-population-amman-against>.
- 8 Nermeen Dalgamoni and Mysaa Khwaileh, “Policy Gaps and Urban Flooding: A Critical Evaluation of Flash Flood Risk Management and Resilience in Amman, Jordan,” *International Journal of Disaster Risk Reduction* 131, December 2025, <https://doi.org/10.1016/j.ijdrr.2025.105896>.
- 9 International Committee of the Red Cross, “Jordan: Providing Water to Refugees and Host Communities,” December 22, 2014, <https://www.icrc.org/en/document/jordan-providing-water-refugees-and-host-communities#:~:text=In%20September%2C%20the%20ICRC%20signed%20a%20memorandum,in%20northern%20host%20communities%2C%22%20said%20Ms%20Brunton>.
- 10 Andrew Adam-Bradford, Alexandra Schindler, Abdullah Anagreh, and Sandra Ruckstuhl, “Climate and Water-Related Vulnerabilities in Refugee Hosting Communities in Northern Jordan: Irbid and Ramtha Municipalities,” CGIAR Initiative on Fragility, Conflict, and Migration, November 2024, <https://cgspace.cgiar.org/items/c48a8489-698f-46f3-b7d1-11f64d2ead0b>.
- 11 UNHCR, “Jordan Country Fact Sheet,” January 2024, <https://www.unhcr.org/sites/default/files/2024-03/Jordan%20Factsheet%20-%20January%202024.pdf>.
- 12 Bradford, Schindler, Anagreh, and Ruckstuhl, “Climate and Water-Related Vulnerabilities in Refugee Hosting Communities in Northern Jordan: Irbid and Ramtha Municipalities”.

Designing for Urban Resilience: The Story of the Oasis City of Ouarzazate

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Ouarzazate, gateway to the Sahara Desert, is a city uniquely distinguished by its oases—lending it the epithet of ‘Oasis City’. Covering an area of 50 km² and recording a population of 79,218 as of 2024, it is strategically located at the foothills of the Central High Atlas.¹ This connection to the oasis ecosystem will serve as a reference for time-honoured best practices in urban planning and natural resource management.

Any new urban development approach for Ouarzazate must draw upon the existing spatial organisation logic in place to identify the foundations that led to the creation of a space of such heritage value—one that persisted for centuries before its ecosystem began to degrade. Ouarzazate is situated on the southern slope of the High Atlas Mountains, where desert landscapes, oases, and the Draa and Dades valleys converge.² At the same time, Ouarzazate’s location on a bare plateau in the mountains renders the city vulnerable to desertification and desert storms, leading to land degradation and biodiversity loss.³

Furthermore, the city's development vision, jointly conceptualised with various stakeholders, is based on the rational management of natural resources (primarily water) and the enhancement of the fundamental elements of the rich, varied, and ancestral landscape (oasis agricultural zones, *wadis*, *ksars*, and *kasbahs*),^a integrating both the power of nature and the ingenuity of oasis dwellers in adapting to the harsh conditions characteristic of the remote oasis regions.

This article looks to present the specific characteristics of the urban oasis system and its capacity for resilience and adaptation in the face of ecological constraints. It will highlight the fundamental elements of the city's vision for sustainable development and enumerate some of its challenges.

Water Scarcity Management and Wastewater Reuse in an Arid Context

Water and Scarcity Management

Given its arid environment, the city faces a threefold challenge regarding water resources: increasingly scarce water, rapidly growing demand, and changes in water quality, coupled with soil salinisation.^{b,4} Increased agricultural production combined with high evaporation rates and inadequate water flushing have further exacerbated salinisation challenges.⁵

The water resources of the city of Ouarzazate rely on three components: groundwater from the Ouarzazate Basin aquifer, fed by infiltration from the High Atlas and foothill areas; the storage capacity of the El Mansour Eddahbi Dam Lake, a RAMSAR wetland^c (with a capacity of 428 million cubic metres); and the Sultan Moulay Ali Chérif Dam (with a capacity of 290 million cubic metres).⁶ The latter two both suffer from severe siltation and high evaporation rates.⁷

The city is located at the outlet of a vast watershed (the Upper Drâa, covering an area of 15,000 km²), drained by three main watercourses: the Dadès River, the Ouarzazate River, and the Aït Douchen River. This geographical configuration provides an abundant water supply, estimated at an average of 409 mm³. Part of these resources is allocated to the drinking water supply, while the remainder is used for downstream irrigation of the two dams.

The city's water needs are met primarily by surface water resources. However, groundwater salinity poses a constraint to its use. The oasis relies on both traditional and modern irrigation canals. These systems include a temporary diversion dam, a water supply canal, and a complex

a *Wadis* are dry valleys or riverbeds; *ksars* are traditional fortified villages; and *kasbahs* are North African fortresses traditionally constructed by local leaders as secure residences.

b Increases in soil salinity can be attributed to irrigation-dependent agriculture in arid regions such as Ouarzazate.

c The Ramsar Convention is an international treaty to designate and protect the ecological value, biodiversity, and sustainable resource use associated with wetlands.

network of branching distribution channels. As a result, small-scale water management, based on increasingly frequent pumping, cannot constitute a sustainable source, as it contributes to soil salinisation and water-table depletion.

To address this situation, the integrated vision developed in consultation with various local stakeholders—which aims to ensure integrated, equitable, and sustainable water resource management—is based on several key areas, including:

- The establishment of a water management governance system, the cornerstone of which is embodied by the Draa Oued Noun River Basin Agency and the provincial water committee established by Law 36/15^d that serves as the basis of water management measures at the city level and in the other municipalities of the province.⁸
- The development of the Drâa Oued Noun Integrated Water Resources Management Master Plan (PDAIRE), a planning document that outlines the water strategy at the watershed level, leading up to 2050.
- The setting up of desalination centres whose primary objective is to remove mineral salts.
- The devising of a participatory framework through the groundwater management contract—which is a formal agreement between the stakeholders involved in groundwater use, including the River Basin Agency, users (farmers, industrialists, local authorities), local authorities, and institutional partners, and the integration of irrigation associations into the water management process.
- The implementation of systems for the treatment and reuse of urban wastewater.
- Encouraging local water-efficient crops and phasing out water-intensive agricultural species (e.g., watermelon) while promoting water-saving technologies (e.g., drip irrigation, remote monitoring, and equipment modernisation).
- Maintain the *seguias* (traditional open-air irrigation canals) and *khattaras* (indigenous underground water systems to channel groundwater from mountain aquifers to desert oases using gravity), and the ancestral irrigation know-how adapted to local conditions, as well as encourage a return to collective work (*tawiza*) for the maintenance of oasis ecosystems.

Wastewater Reuse

The management of available resource consumption across various sectors (domestic, tourism, agricultural, services, and industrial consumption) takes into account the scarcity of water and the recurring droughts in the region. In this context, a pilot project for a green belt around Ouarzazate through wastewater reuse was launched in 2015 on an area of 625 hectares with a budget of 75

d Morocco's Law No 36-15 on water establishes a national framework for integrated water resource management, drought resilience, and decentralised basin planning. In Ouarzazate, the law governs local agricultural irrigation practices, aquifer protection, and protection of traditional water systems.

million dirhams covering four zones⁹ (Oued Rbat, Anatim, Hay Mohammadi, and in front of the military barracks) in partnership with the Ouarzazate Provincial Council, the Provincial Directorate of Water and Forests, and other stakeholders.

The objective of this project is threefold: to create a recreational green space around the city; contribute to the conservation of biodiversity; and protect the city from strong winds and sand encroachment and improve air quality.

The Enhancement and Revitalisation of Natural Resources and the Landscape

The Oasis Area: ‘The Lung of Ouarzazate’

Covering an area of 1,000 hectares, the Ouarzazate agricultural zone forms the southern boundary of the city; it is the ‘Lung of the City’, taking the form of an oasis composed of three landscape layers: date palms, fruit trees, and vegetable crops. This area, designated a World Heritage Site and part of the Southern Moroccan Oasis Biosphere Reserve (RBSOM) since 2000, has been managed for centuries through traditional customs governing the mobilisation and distribution of irrigation water and community labour. It serves both as a space for subsistence agriculture and as a recreational area for the city’s residents and tourists alike.

Oasis agriculture applies ancestral principles—referred to as ‘agroecological’—combining diverse crop layers with millennia-old expertise in water collection and management, which can serve as a model for the sustainable ecological management of water resources.

The preservation and enhancement of this heritage site are based on several key components:

- o The City Master Plan (approved in 2014), which requires general provisions to protect the agricultural zone from uncontrolled urban development and unsuitable tourism projects, along with safeguards to prevent adverse effects on the sustainability of the fragile oasis ecosystem.
- o Establishing an operational response mechanism for the effective management of the increasingly frequent fires within the oasis.
- o Law No. 01-06 (enacted in 2007), which aims to protect the date palm and regulate palm groves.¹⁰

The Oued Ouarzazate Corniche and the Green Corridor: Towards the Enhancement of Natural Resources

Ouarzazate is endowed with an abundance of invaluable natural resources: the urban oasis, the wadis, and the chaabas (ravines) including the Arguine and the Ouarzazate, constitute landscape elements that define the city’s spatial and functional identity. An analysis of the spatial dynamics driving the city’s green urban development reveals a shortage of green spaces and recreational

areas, necessitating projects that could address the issue. With this in mind, the municipality has planned studies and development projects for the Oued Ouarzazate waterfront and the green corridor in the city centre, in partnership with various local stakeholders.

The goal is to integrate these natural environments into the city's landscape through: the revitalisation of the riverbanks; installing street furniture and appropriate planting; enhancing landscape features and natural resources; and improving the quality of urban life by creating new spaces for social interaction.

Ecological Urban Planning: Heritage (Earth Architecture) As a Catalyst for Development

The city is known for its earthen architectural heritage, the *Ksar* or 'Ighrm, fortified village', and the *Kasbah* 'Tighrmt, fortified house'. The appropriate integration of this type of dwelling into its natural and human contexts, along with its rich and diverse architectural heritage value, is the primary characteristic of this traditional and authentic urban form. The *ksar* and the *kasbah* are traditional dwellings built with local materials (earth, rammed earth, dry stone, and wood), based on traditional construction techniques and the ancestral know-how of the artisans.

This heritage has enhanced thermal comfort, minimising energy use through urban forms, the isothermal materials used, and architectural typologies. As an example, the Kasbah of Taourirte, designated a national heritage site since 1954 and recently restored, is the jewel of earthen architecture in the heart of the city.

Sustainable interventions on the *ksar* and the *kasbah* aim to honour its past and build upon what already exists, while giving the site new meaning without neglecting its historical significance. This approach would undoubtedly position these heritage sites as levers for local economic development, with annual revenue estimated at 1,000,000.00 Dh (or over US\$100,000) derived from visits to the municipality.

This urban fabric has benefited from several rehabilitation programmes, such as the PVDKK (Sustainable Valorisation Programme for Ksours and Kasbahs). This programme adopts the "Ksour and Kasbah" approach, aiming to respect the city's local identity and heritage while nurturing a sense of belonging among locals and enabling the preservation of historic architecture. It provides infrastructure, income generating activities, and capacity building.¹¹

Various challenges hamper the implementation of certain actions and projects in the city. These are discussed in turn in the following points.

- The lack of alignment and coordination among stakeholders, which stems from having multiple actors involved in the preservation and management of resources (water, natural heritage, agricultural zones). There is a need to strengthen the local governance framework.

- Insufficient financial and human resources hinder the development and implementation of projects. New public and private financing mechanisms for projects must be established, particularly in marginal and vulnerable areas such as Ouarzazate.¹² This should be accompanied by capacity-building for local stakeholders in sustainable development.
- The issue of the uniform application of various laws across the entire national territory, without taking into account the local specificities of oasis regions, particularly in the areas of urban planning, water management, and investment promotion. This requires a revision of the various legislative texts to ensure adaptation to local specificities and to guarantee better management of natural and heritage resources.

Conclusion

The oasis model has established itself as a living laboratory for sustainable development and an active lever in the fight against desertification. Today, it faces a combination of increasingly complex constraints, both climatic and anthropogenic. In the face of climate change and environmental degradation, the preservation of the urban oasis landscape depends on the active engagement of local communities. The commitment of local oasis communities guides overall resilience. These communities have established customary rules governing the use of natural resources and ensuring shared governance. This form of local governance, born of solidarity and necessity, remains a pillar of sustainability today.

Projects initiated by the municipality of Ouarzazate, in close collaboration with local stakeholders, aim to strengthen the resilience of the various components of the urban oasis system and mitigate the multiple constraints it faces.

Endnotes

- 1 Data Commons, "Ouarzazate Population," <https://datacommons.org/place/wikidataId/Q505208>
- 2 International Workshop of Urban Planning, "Greater Ouarzazate, A 21st-Century Oasis City: Historical Benchmarks and International Visibility," Ouarzazate, Morocco 3rd-16th November 2018
- 3 UNEP, "Moroccan City Defies Desertification by Harnessing Solar Power and Treated Wastewater," October 23, 2015, <https://www.unep.org/news-and-stories/press-release/moroccan-city-defies-desertification-harnessing-solar-power-and>.
- 4 Ionna Kakabouki et al., "Enhancing Agricultural Resilience to Salinity in the MENA (Middle East and North Africa) Region," *Water, Air, & Soil Pollution*, Vol. 237 no. 577, February 20, 2026, <https://doi.org/10.1007/s11270-026-09249-y>
- 5 Mohammed Hssaisoune et al., "Moroccan Groundwater Resources and Evolution with Global Climate Changes," *Geosciences*, 2020 10(2), pp.81, <https://hal.science/hal-02904196/file/hss1.pdf>
- 6 Claudia Heidecke and Thomas Heckelei, "Impacts of Changing Water Inflow Distributions on Irrigation and Farm Income Along the Drâa River in Morocco," *Agricultural Economics* 41(2) :135-149, <https://doi.org/10.1111/j.1574-0862.2009.00431>.
- 7 Ormva Ouarzazte, "Large Hydraulic," December 17, 2022, <http://ormvao.ma/v1/solaire-grande-hydraulique/>
- 8 "Law No. 36-15 on Water," *Climate Change Laws of the World*, https://climate-laws.org/document/law-no-36-15-on-water_f432
- 9 International Workshop of Urban Planning, "Greater Ouarzazate, A 21st-Century Oasis City: Historical Benchmarks and International Visibility"
- 10 Law N 1-07-42 of 28 promulgating law n. 01-06 relating to the sustainable development of palm groves and protecting the date palm "phoenix dactylifera," *Official Bulletin* n. 5522, May 3, 2007, <https://www.ecolex.org/details/legislation/dahir-n-1-07-42-du-28-rabii-i-1428-17-avril-2007-portant-promulgation-de-la-loi-n-01-06-relative-au-developpement-durable-des-palmeraies-et-portant-protection-du-palmier-dattier-phoenix-dactylifera-lex-faoc074263/>
- 11 Africa-Europe Bioclimate Collaboration, "Overview of Main Stakeholders – Including a Detailed List and Contacts," 2021, https://www.abc21.eu/wp-content/uploads/2021/07/210722_ABC21_D4.1_Overview-stakeholders_e7_v3.pdf
- 12 International Workshop of Urban Planning, "Greater Ouarzazate, A 21st-Century Oasis City: Historical Benchmarks and International Visibility."



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