MIDDLE EAST AND
NORTH AFRICA

Egypt CCDR

Background Note

Pathways for Resilient and Green Cities[1]

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UKaid from the British people

[1] The team would like to express its gratitude for the important and timely contribution of the United Kingdom Foreign, Commonwealth, and Development Office (FCDO) Strategic Partnership for Egypt's Inclusive Growth Trust Fund, which provided funding for the analysis conducted for this paper.

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Acronyms

BAU	Business as Usual
CCDR	Country Climate and Development Report
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Usage and Storage
CO2	Carbon dioxide
EU	European Union
EV	Electric Vehicle
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
MtCO2e	Metric Tonne of Carbon Dioxide Equivalent
NDC	Nationally Determined Contribution
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
SO2	Sulphur Dioxide
tCO2e	Tonne of carbon dioxide
AAP	Ambient Air Pollution
BCM	Billion Cubic Meter
BRT	Bus Rapid Transit
Bscf	Billion standard cubic feet
BUR	Egypt's Biennial Updated Report
CAGR	Compund Annual Growth Rate
CC	Climate Change
CCCD	Climate Change Central Department
CCGT	Combined Cycle Gas Turbine
CH4	Methane
COP	Conference of the Parties
DSM	Demand-side Management
EE	Energy Efficiency
EEAA	Egyptian Environmental Affairs Agency
EEHC	Egyptian Electricity Holding Company
EG	Environmental Goods
EPR	Extended Producer Responsibility
ESCO	Energy Service Company
ESG	Environmental, Social and Governance
GOE	Government of Egypt
GoPP	General Organization for Physical Planning
GW	Gigawatt
GWh	Gigawatt Hour
ha	hectare
ICZM	Integrated Coastal Zone Management
IFC	International Finance Corporation
ILO	International Labor Organization
IPCC	Intergovernmental Panel on Climate Change
ITS	Intelligent Transportation Systems
KPI	Key Performance Indicator
LIH	Low Income Housing
lpcd	Liters Per Capita per Day
MACC	Marginal Abatement Cost Curve
MENA	Middle East and North Africa
MIGA	Multilateral Investment Guarantee Agency
MLD	Ministry of Local Development
MoE	Ministry of the Environment
MoHUUC	Ministry of Housing, Utilities and Urban Communities
MoLD	Ministry of Local Development
MoPED	Ministry of Planning and Economic Development
MRV	Monitoring, Reporting and Verification
MSME	Micro, Small and Medium Enterprises
MSMEDA	Micro, Small and Medium Enterprises Development Agency
MSP	Marine Spatial Planning
Mt	Metric tonne
MW	Megawatt
NbS	Nature-based Solution
NCCC	National Council on Climate Change
NCCS	National Climate Change Strategy
NMT	Non-motorized Transportation
NPV	Net Present Value
NRW	Non-revenue Water
NUCA	New Urban Communities Authority
O&M	Operation and Maintenance
PPP	Public Private Partnership
SLR	Sea Level Rise
SME	Small and Medium-sized Enterprise
SWD	Storm Water Drainage
SWM	Solid Waste Management
TTP	Tertiary Treatment Plant
UHI	Urban Heat Island
UN	United Nations
UNFCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USD	US Dollar
VAT	Value Added Tax
VKM	Vehicle Kilometer Traveled

WB	World Bank
WRI	World Resources Institute
WWTP	Wastewater Treatment Plant
μg/m3	Micrograms per Cubic Meter

Executive Summary

Egypt has recognized the need for a new growth model, one that moves the country toward a greener, more resilient, and inclusive development path. Egypt's commitment to a green growth trajectory is evident in its National Climate Change Strategy 2050, its June 2022 First Updated Nationally Determined Contributions (NDCs), and by several regulatory updates and initiatives launched in recent years.

This paper summarizes the effects of climate change on Egypt's cities and presents recommendations to enhance cities' climate resilience and put them on a transformative path toward a green and low-carbon future. It is a background note to the Egypt Climate Change and Development Report (CCDR), which explores how to reconcile Egypt's development ambitions and structural challenges with the urgent need for stronger action to respond to climate change risks and impacts. This background note first provides an overview of the context, covering the historical urbanization patterns of Egyptian cities and their importance to the country's economy; the government initiatives relevant to climate change adaptation and mitigation overall and to cities in particular; and the note's objectives, approach, and analytical framework. Second, the note explores the climate risks facing Egypt overall and its 14 major cities. Third, it presents the interplay between greenhouse gas (GHG) emissions and urban systems from a mitigation perspective, and then details how the existing institutional and fiscal landscape for urban functions is currently constraining the transition toward low-carbon and resilient cities. It then details the transformative levers that can be applied across urban and enabling systems, including associated financing needs and economic trade-offs. Finally, the note provides detailed short-, medium-, and long-term recommended actions to enact the required transformation.

The prospects for Egypt's cities are inextricably linked to the mitigation of—and adaptation to—climate change. Egypt's economic growth has been accompanied by rapid urbanization, and its growing cities are in many cases contributing to poverty alleviation, increased regional competitiveness, sustainable economic growth, and improved livability. Egypt's ability to fully leverage the economic potential of its cities will depend on whether it is able to sustainably meet the livability needs of existing and new urban inhabitants in an inclusive manner, while also ensuring economic competitiveness and environmental sustainability.

Cities—and their inhabitants—are increasingly exposed to climate stresses. Many of Egypt's cities are characterized by a high congruence of climate change risks and urban densities. Nearly 95-97% of the country's urban population is concentrated in the Nile Delta, spreading along the banks of the Nile River, Mediterranean coastal belt, and the Suez Canal. These are also among the key hotspots for multiple climate risks in Egypt, including high temperatures and associated heat stresses, variability in precipitation, increased frequency of extreme weather events (along with associated flooding), and water scarcity risks. The climate risk vulnerability assessment conducted for this report by the World Bank team and covering Egypt's 14 major cities highlighted that a major proportion of the population in these cities (80-100%) is exposed to at least one major climate risk.

Egypt's commitment to climate action represents an opportunity for cross-sectoral reforms and initiatives that would put its cities on a green and low-carbon path. Taking advantage of this opportunity will require a balanced, carefully calibrated approach centered around adaptation and mitigation. The implementation of this approach must be focused and spatially integrated across various city systems and services, most critically for the planning and management of land use, urban infrastructure, and the delivery of urban services. Critical sectors include buildings, water, energy, solid waste and wastewater management, and transportation. Effective implementation will depend on national reforms and, at the sub-national and local level, the strengthening of institutional capacities and mobilization of adequate financial resources, including through the private sector.

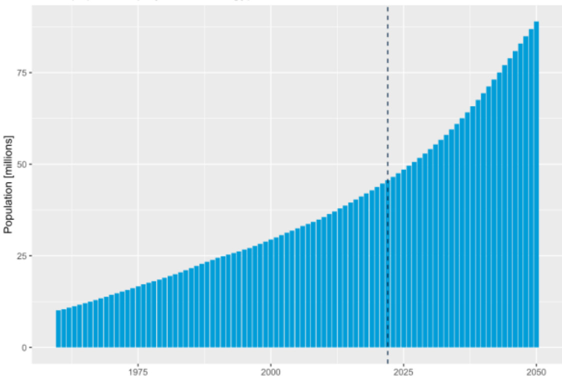
To ensure the green and resilient growth of Egypt's cities, the analysis in this note suggests that the Government of Egypt focus on five adaption- and mitigation-focused levers at the national and sub-national level. The first is nature-based solutions (NBS) for floods, higher temperatures, and improved coastal resilience. The second is integrated and risk-informed planning for spatial development, land use, and connectivity. The third is green building, housing, and energy efficiency. The fourth is resource-efficient and circular urban water management. And finally, solid waste management and resource circularity. Through a focus on these five transformative levers, Egypt's cities can deliver on the promise of inclusive and sustainable growth for their citizens.

1. Context

1.1. Urbanization and the economic importance of cities

Egypt's economic growth has been accompanied by rapid urbanization, and its growing cities are contributing to poverty alleviation, increased regional competitiveness, sustainable economic growth, and improved livability. Egypt's 6.3% GDP growth rate over the last three decades[1] has outpaced that of the MENA region, which was 4.3% during the same period.[2] The economic growth has coincided with a significant trend toward urbanization, with Egypt's urban population increasing from ~25 million in 1990 to ~44 million in 2020; urbanization reached ~43% in 2020.[3] The growth rate of the urban population has been increasing steadily across the past two decades and that trend is expected to continue—and perhaps even accelerate—in the coming decades.[4] Given Egypt's limited arable land area, these large urban populations translate into high population densities of approximately 21,000-78,000 people per square kilometer across key urban centers.

Figure 1: Urbanization trend in Egypt

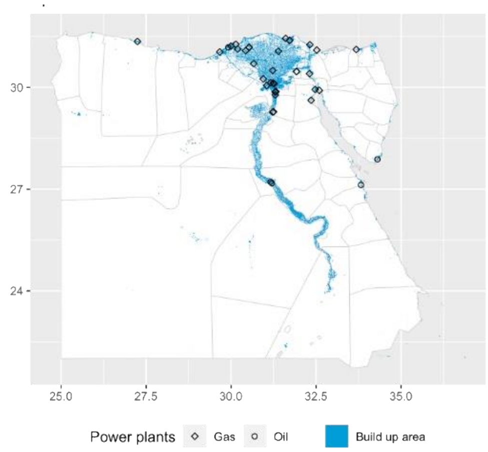


Source: Authors' elaboration using data from Urbanization Prospects: The 2018 Revision

Over the next 30 years, the urban population is expected to reach 85.3 million, representing 55.6% of the total population. Under these forecasts, cities will need to deliver services to 41.4 million new city dwellers over the next three decades[5]—a number equivalent to Egypt's current total urban population. In the Greater Cairo region, the urban population is expected to increase from 20.9 million in 2020 to 28.5 million by 2035.[6]

The spatial congruence of urban population concentration with economically productive areas highlights the important role that Egyptian cities play in the overall economy and in enabling regional competitiveness and sustainable economic growth. The urbanization pattern in Egypt is characterized by significant spatial concentration, with 95% of the country's population living in cities and urban areas on the coast and in the Nile Delta—Greater Cairo and Alexandria together account for approximately 59% of the country's urban population. Egypt's five fully urbanized governorates (with urbanization levels between 97% and 100%) contribute ~49% of the country's GDP. Existing and planned Qualifying Industrial Zones (QIZs) are concentrated in/around Egypt's larger cities—Alexandria, Suez, Port Said, and

Figure 2: Spatial distribution of urban clusters



Source: Authors' elaboration using World Pop. 2020 & WRI data

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[1] World Development Indicators, World Bank database

[2] World Development Indicators, World Bank database

[3] World Development Indicators, World Bank database

[4] The urban population growth rate increased from 1.83% over 1990-00 to ~1.98% over 2010-20 and the trend is envisaged to further accelerate over the next two decades, reaching 2.37% by 2040

[5] World Urbanization Prospects: The 2018 Revision, Online Edition, United Nations, Department of Economic and Social Affairs, Population Division (2018)

[6] World Urbanization Prospects: The 2018 Revision, Online Edition, United Nations, Department of Economic and Social Affairs, Population Division (2018)

El-Mahalla, as well as in and around the mid/large-size cities in the Central Delta and along the Nile Valley.

Egyptian cities are already facing a combination of climate change, resource scarcity, poor livability, and service delivery challenges. These challenges have the potential to severely impact the country's economic performance, productivity, and development potential. Combined with rapid urbanization, these risks are compounding the urban stresses related to cities' existing services, infrastructure, and environment (air, water, land). The Egyptian government is engaged in efforts to create "new cities," but these have not yet become a model for relieving urban stresses in existing cities while also providing sustainable, efficient, and inclusive service delivery and economic opportunities. While rapid urbanization presents socio-economic, environmental, and other challenges for local governments, it also holds opportunities for greater urban competitiveness, more jobs, and improved livability. Leveraging this untapped economic potential will depend on whether Egyptian cities are able to sustainably meet the livability needs of their existing and new inhabitants in an inclusive manner, while also ensuring the economic competitiveness and environmental sustainability.

1.2. Government initiatives

Since the ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, Egypt has developed national strategies and made commitments that demonstrate the government's policy direction in responding to climate change. To meet the global targets established in the UNFCC's Paris Agreement, in November 2015 Egypt developed its first Intended Nationally Determined Contribution (INDC). The most recent national articulations of climate policy are reflected in i) Egypt's May 2022 National Climate Change Strategy 2050 (NCCS), which provides a comprehensive institutional framework for the articulation of climate action to 2050 and includes goals on mitigation and adaptation priorities along with policy directions to address governance, financing and technology, and awareness constraints, and ii) Egypt's First Updated NDC, launched in June 2022, which provides a review of the adaptation and mitigation measures to which Egypt committed itself in the 2015 INDC, lays down additional adaptation and mitigation measures, and provides projections of GHG emissions to 2030.

Egypt aims to be a regional leader on climate change, and it has stated its commitment to a sustainable future and a just transition. Among Arab countries, Egypt has often been recognized for playing a coordinating and leading role in climate change negotiations. For instance, in 2018, Egypt acted as the Chair of the G-77/China in the UN and UNFCCC, and in 2019, Egypt chaired the African Group of climate change negotiators in the UNFCCC. It recently concluded its COP27 presidency, which provided a unique opportunity to strengthen its role on climate policy and action.

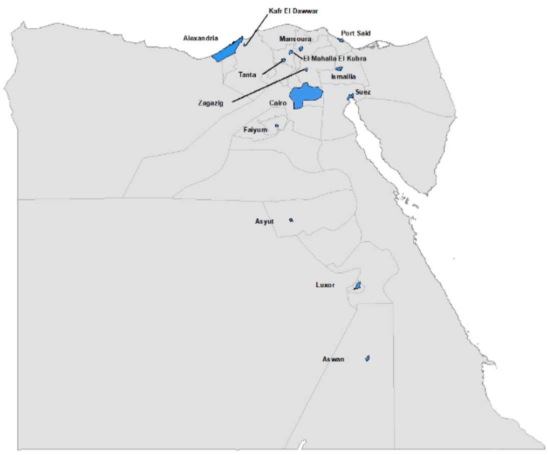
The Egyptian government's initiatives clearly highlight a balanced focus on adaptation and mitigation. Transitioning the current urbanization to resilient and low-carbon cities will further require i) making clear commitments, ii) strengthening sub-national/local institutions and providing them with adequate fiscal resources, iii) shifting from the creation of policies and plans to robust implementation, iv) strengthening national regulations and their enforcement, and v) effective coordination among the multiplicity of stakeholders involved in urban systems, including clearly defined roles and responsibilities.

1.3. Objective and approach for the study

This report presents key findings and recommendations based on a series of analytical activities regarding resilient cities and coastal economies that were conducted as part of the preparation of the full Egypt Climate Change and Development Report (CCDR).

The first of these analytical studies focused on urban growth modelling for the 14 major Egyptian cities, which account for 72% of the country's urban population. The study's framework was three-part: i) to understand the implications of climate change for urban growth at the city level and regionally, ii) identify future transformation pathways, and iii) determine possible outcomes in terms of climate change mitigation and adaptation, economic development, and livability. Two of the selected cities are situated along Egypt's Northern Coast, six across the Nile Delta (in addition to those along the northern cost), four are upstream along the Nile River and two are along the Red Sea coast. Together they represent the key spatial locations responsible for past urbanization trends in Egypt. The scenario modelling followed an integrated approach, in line with the three-part framework described above, to assess a variety of key climate change hazard categories[7] as well as the critical sectoral interventions[8] that could be adopted to mitigate the effects of climate change stresses on citizens. The projected timeline goes out to 2030, to align with the Government of Egypt's (GoE) Egypt 2030 plan and to ensure the reliability of estimates based on the 10 years of past data available for the analysis. The Business as Usual (BAU) scenario assumes that existing levels of service delivery gaps persist during the modelled time frame across each of the sectors. The transformative scenario modelling, on the other hands, assumes the application of various policy levers across multiple city systems that would be critical for transformation and that would i) reduce risks from climate change hazards, ii) build efficiencies in city systems to enable a shift toward resilient and sustainable urbanization, and iii) tap into the GHG co-benefits from adaptation actions as well as delink emission intensities from increasing urbanization.

Figure 3: Spatial distribution of Egypt's 14 major cities



Source: Climate risk assessment conducted by the team across 14

The second analytical study focused on comprehensive climate risk assessments at two levels. First, the World Bank team conducted a country-wide assessment of key climate risks to identify spatial variations and key hotspots. Second, the team conducted a focused assessment of the 14 major cities of Egypt to concretely identify the current severity and impact of climate risks. This focused assessment was supplemented by a deep-dive analytical assessment of the key climate risks faced by the city of Alexandria, using the city as a case study for coastal flooding, sea level rise (SLR), and land subsidence-related issues. The Alexandria study analyzed past trends, future projections, and the likely impact on the city's economic, infrastructure, and human capital of various climate change scenarios.

The team used the findings from these two analytical studies to conduct a further analysis regarding financing needs (for capital expenditures and operational expenditures) and economic trade-offs, and to assess the GHG mitigation potential of such investments across all the identified sectors.

Finally, the World Bank and the International Finance Corporation (IFC) jointly prepared a comprehensive city climate action plan for Alexandria based on the APEX modelling tool[9] and detailed climate risk assessments. The climate action plan provides a comprehensive and prioritized list of investment and

[7] Fluvial and pluvial flooding, heat stresses, coastal erosion, including sea level rise

[8] urban expansion, building energy efficiency, urban mobility & transportation choices, solid waste and wastewater management, water usage efficiency, integration of green areas & nature-based solutions (NBS)

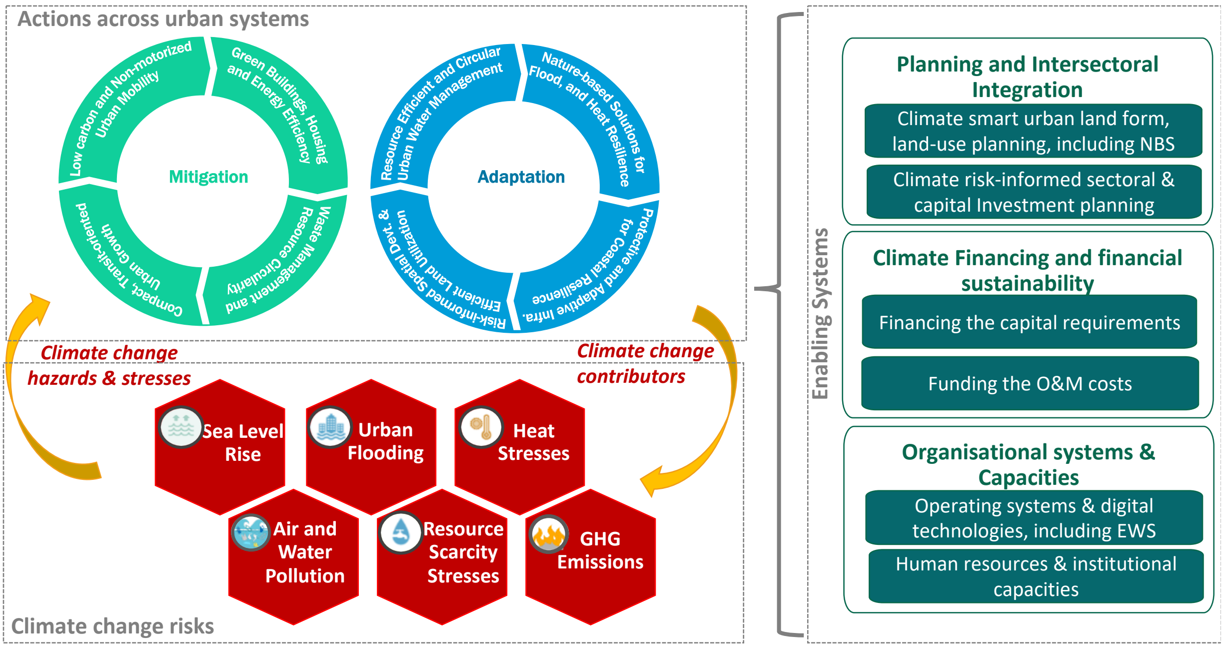
[9] The APEX ("Advanced Practices for Environmental Excellence in Cities") Green Cities Program is a new IFC initiative that supports cities in emerging economies to accelerate the implementation of ambitious and transformative policy actions and investments that significantly contribute to transitioning to low-carbon and resource-efficient growth pathways. The program leverages the online APEX software/tool which helps cities to quickly assess the most cost-effective way to incorporate measures into their investment and policy pipelines, in order to achieve targets related to energy, transportation, waste, water, and GHG emissions.

reform interventions that the governorate should undertake—with the funding support of national government—to enhance the city's climate resilience and pivot toward green and low-carbon solutions for public transport, solid waste management, public buildings, and energy efficiency.

1.4. Analytical framework for the study

This report adopts an integrated spatial framework to assess the nexus between cities and climate change (specific to the context of Egyptian cities). Specifically, the "climate change and cities nexus" framework i) brings climate change impacts, service performance, and emissions together in a spatially oriented manner—focusing on sustainability, liveability and productivity in the existing context, ii) assesses the correlation between climate risk vulnerabilities and existing urbanization patterns in Egypt's major cities, iii) adopts a multi-sectoral approach to identify the transformative pillars and conduct a scenario-based analysis, considering a 10-year horizon (to 2030), for a potential transformation across major Egyptian cities that could enhance city resilience as well as contribute to mitigating the country's GHG emissions, iv) presents trade-offs in terms of financing needs and avoided economic impacts to build the case for multi-sectoral, spatially targeted policy reforms and investments for adaptation and mitigation, v) assesses the role of local institutions, policies, planning systems and fiscal/financial arrangements to advance climate action at the local level, and vi) presents a roadmap with calibrated policy levers, institutional systems, and investments for various tiers of government, which is critical for a coordinated multi-stakeholder approach.

Figure 4: Cities and climate change nexus framework



The cities and climate change nexus framework rests upon three key pillars, described in detail below:

- **Pillar 1: Actions across urban systems,** which covers various urban systems (infrastructure and services) that contribute to either GHG mitigation or climate change adaptation. As such, this pillar encompasses the performance, adequacy, and sustainability of key urban systems, including i) low-carbon and non-motorized urban mobility (including electric vehicles (EVs)), ii) green buildings and energy efficiency across various urban services, iii) compact urban growth and public transportation networks, and iv) waste management and resource recovery. All these factors drive cities' GHG footprints. Across climate change adaptation, the resilience of a city is increased by i) leveraging nature-based solutions (NBS) for flood resilience and to build resilience against heat stresses, ii) building up protective and adaptive infrastructure to limit SLR risks, iii) limiting spatial development into flood-prone areas and ensuring optimal utilization of scarce land resources, and iv) ensuring resource-efficient and circular urban water management. The sustainability, resilience, and efficiency of urban systems play a key role in determining the degree to which urbanization contributes to externalities that amplify climate change vulnerabilities and the degree to which cities can adapt to climate change hazards and stresses.

- **Pillar 2: Climate change risks faced by cities**, which covers the multitude of climate change risks that cities face either as a direct consequence of global temperature increases or as a consequence of the externalities associated with unsustainable urbanization—or a mix or both.
- **Pillar 3: Enabling systems**, which focuses on the adequacy and robustness of i) urban planning practices/policies (spatial expansion, urban densification, land use, urban infrastructure, investment planning) to drive the necessary shifts toward resilient and low-carbon cities, ii) financial resources (fiscal transfer systems, as well as own-source revenues) to finance the capital expenditure and O&M needs of urban service delivery systems, and iii) the institutional landscape, delineation of roles and responsibilities, and the institutional capacities and digital systems (including early warning systems), with a key focus on the role of sub-national and local governments in enabling the implementation of the national government's climate ambitions.

Chapter 2 of this report presents the various climate risks that fall under Pillar 2 of the framework, first for Egypt overall and second for the 14 key cities mentioned previously. It is based on a comprehensive climate risk assessment conducted by the World Bank. Further, Chapter 2 presents the interplay between Pillar 1 and Pillar 2 from a climate change adaptation perspective, covering how the sustainability, efficiency, and resilience of urban systems are correlated with climate hazards and vulnerabilities across cities. Chapter 3 presents the interplay between GHG emissions and urban systems from a mitigation perspective, covering how urbanization patterns and low-emission choices across urban infrastructure and service delivery drive the GHG emission footprints of cities. Chapter 4 summarizes the challenges in the existing institutional and fiscal landscape for urban functions that constrain the transition toward low carbon and resilient cities. Chapter 5 presents the transformative levers that can be applied across urban systems (from Pillar 1) and enabling systems (Pillar 3). Further, Chapter 5 also provides a snapshot of the financing needs, GHG mitigation trade-offs, and economic trade-offs of the investments and policies that are crucial for the transition toward low-carbon and resilient cities. Finally, Chapter 6 provides key short-, medium-, and long-term actions that the government should undertake to mainstream the transformative levers proposed in Chapter 5.

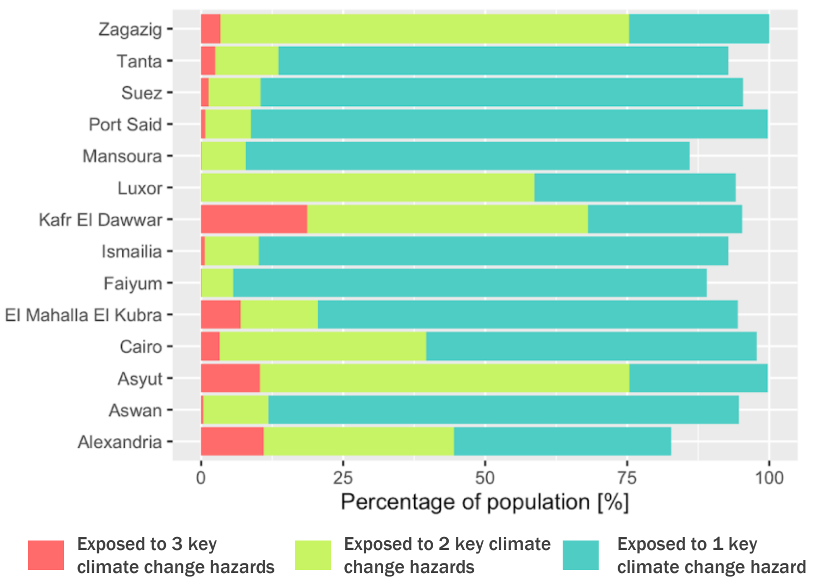
2. Climate Risks in Cities

The Intergovernmental Panel on Climate Change (IPCC) (2022) has identified, with high confidence, the increasing climate change vulnerabilities facing cities globally, noting that climate change poses rising "risks to cities, settlements, and key infrastructure in the mid- and long-term with further global warming, especially in places already exposed to high temperatures, along coastlines, or with high vulnerabilities." IPCC's observation is particularly critical for Egyptian cities with a high congruence of climate change risks and urban densities. Nearly 95-97% of the country's urban population is concentrated in the Nile Delta, and spreads along the banks of the Nile River, Mediterranean coastal belt, and the Suez Canal. These are among the key hotspots for multiple climate risks in Egypt.

Egypt faces a multitude of climate change risks, including high temperatures and associated heat stresses, variability in precipitation, increased frequency of extreme weather events (along with associated flooding), and water scarcity risks. Further, Egypt's coastal areas face coastal flooding and SLR risk, detailed in the following chapters, because of rising global temperatures and the subsequent melting of glaciers and ice sheets. The Nile Delta is one of the three extremely vulnerable mega-delta hotspots that will be directly affected by 2050, according to the IPCC.[10]

Major Egyptian cities are increasingly exposed to varying levels of climate hazards and chronic stresses including flooding, rising temperatures and prolonged heat stresses, air pollution, desertification, SLR, and land subsidence. The climate risk vulnerability assessment conducted for this report by the World Bank team and covering Eygpt's 14 major cities highlighted that a major proportion of the population in these cities (80-100%) is exposed to at least one major climate risk. A substantial fraction is facing more than one such risk (see Figure 5). Importantly, unplanned spatial expansion that does not take climate hazards into consideration is leading to increasing vulnerabilities in cities. Unless current spatial planning and expansion processes are informed by and sensitive to climate risk, resource efficiency, and sustainability, climate risk exposure in cities is expected to increase at an alarming rate. Egypt's more recently built cities[11] face similar climate risks but exhibit relatively lower levels of population vulnerability due to lower population densities and occupancy levels.

Figure 5: Population exposed to climate change hazards across key cities



Source: Climate risk assessment conducted by the team across 14 cities using World Settlement Footprint Landsat 5/7'; SSBN arc second (90) Global Hazard Data (World Bank License)

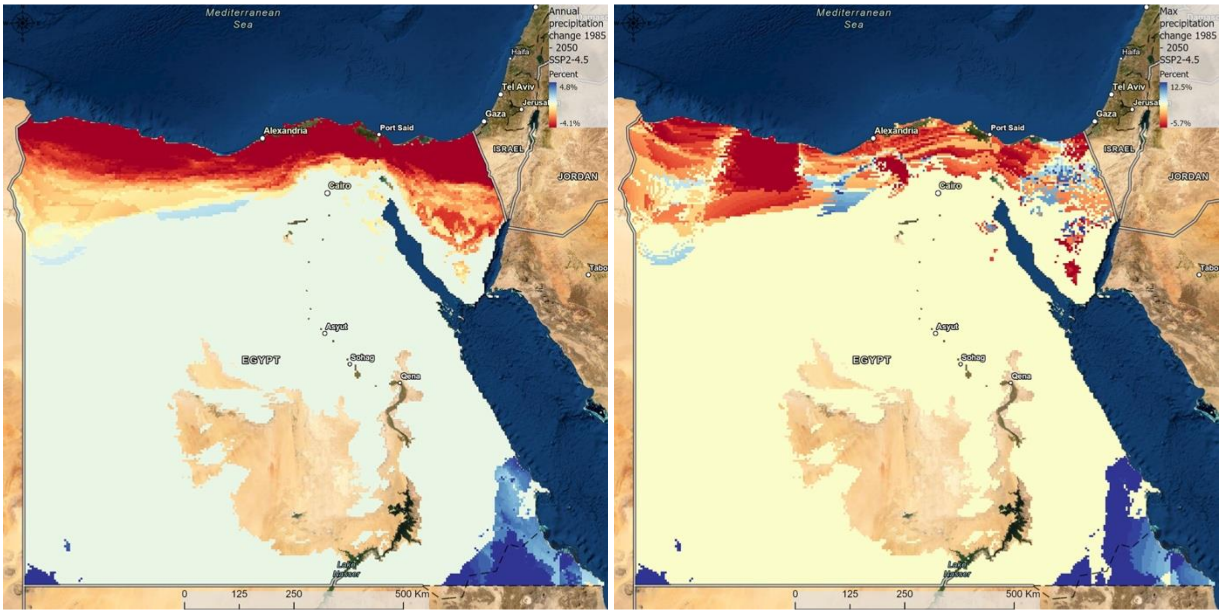
Egypt's unique urbanization patterns and the externalities associated with unsustainable urbanization trends further amplify the climate change impacts on and vulnerabilities of its citizens.

[10] IPCC Fourth Assessment Report, Megadeltas: Their vulnerabilities to climate change.
[11] Based on analysis of six new cities (New Cairo, 6th of October, 10th of Ramadan, New Damietta, New Minya, Borg Al Arab)

2.1. Flooding

Climate change is anticipated to result in significant variability in precipitation across Egypt, with annual rainfall volume changes ranging from 4.1% lower to 5% higher (using 1985 as the baseline year and projecting out to 2050). Across the same period, climate change is expected to result in variability of extreme rainfall events, with changes ranging from -5.7% to +12.5%. This variability would result in more frequent droughts—and subsequent water security risks—as well as frequent flooding. For coastal cities, flood risk would be further amplified because of the combined effect of variable precipitation and SLR.

Figure 6: Precipitation changes with climate change

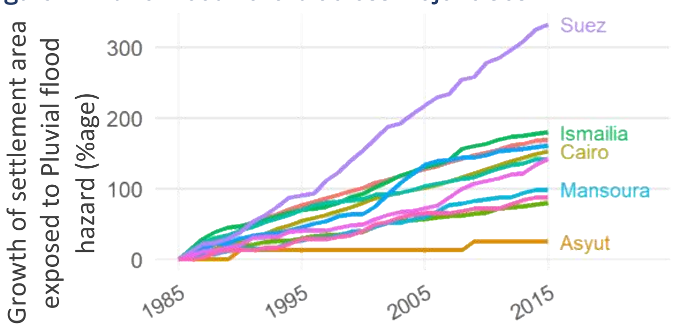


Source: Authors' assessment: Created using the results of the simulations of the following 8 General Circulation Models (BCC-CSM2-MR; CanESM5; CNRM-CM6-1; CNRM ESM2-1; IPSL-CM6A-LR; MIROC6; MIROC-ES2L and MRI-ESM2-0) that were conducted as part of the Coupled Model Intercomparison Project Phase 6 (CMIP6) (Eyring et al. (2016): Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9). The climate projections were statistically downscaled and calibrated with WorldClim v2.1 (Fick, S.E. et. all (2017) WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology

Pluvial flooding poses a major threat to Egyptian cities due to inadequate adaptive systems for flood resilience. The number of pluvial floods (such as the major floods in 2015 that led to significant damages) has increased in recent decades. The ability of cities to manage and mitigate the impacts of such extreme events has been severely constrained by persistent gaps in the coverage and adequacy of adaptive systems (including urban stormwater infrastructure) vis-a-vis precipitation load requirements as well as service delivery issues (such as poor operations and maintenance (O&M), poor investment and asset management planning, and lack of early warning systems).

The detailed climate risk assessment of Egypt's 14 major cities indicated varying levels of exposure to pluvial flooding risks, with some cities expanding rapidly into flood-prone areas. Across the 14 cities, settlements overall grew by 94% between 1985 and 2015, whereas the number of settlements exposed to pluvial flood hazard increased by 156%, totalling 78 km² in 2015. Cities in Nile Delta—El Mahalla El Kubra, Kafr El Dawwar, and Mansoura—are exposed to

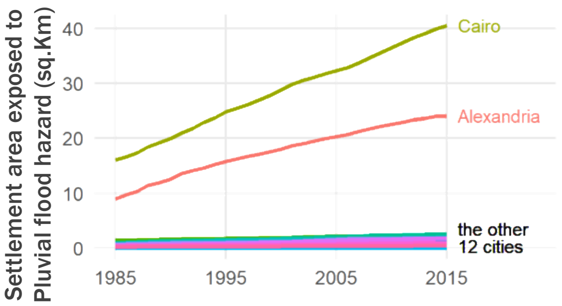
Figure 7: Pluvial flood hazard across major cities

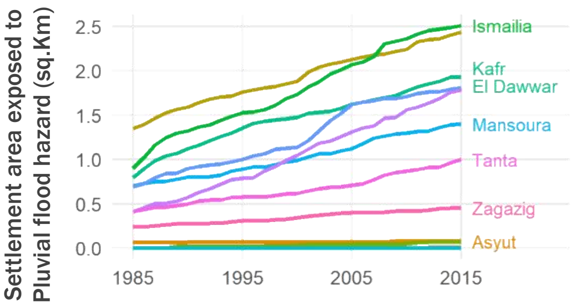


Source: Climate risk assessment conducted by the team across 14 cities using World Settlement Footprint Landsat 5/7'; SSBN arc second (90) Global Hazard Data (World Bank License) flood risks, with dispersed hotspots across the city. Aswan's southern areas have the highest probability of pluvial flooding. In Cairo, the built-up area exposed to pluvial flood hazard rose from about 18 km^2 in 1985 to 40 km^2 in 2015, while in Alexandria it increased from 9 km^2 to 24 km^2 over the same period. The spatial concentration of industrial and economic centers in cities results in increased socio-economic costs due to exposure to such pluvial flooding risks. In recent decades, although the warming climate has caused a decline in rainfall, the lack of risk-informed urban expansion has led to an increase in overall flooding.

The rapid growth of Egypt's urban population has led to unregulated development and unplanned urban expansion, leading to increased climate change vulnerabilities. The analysis of the 14 cities highlighted that urban expansion has led to an overall decrease in green spaces—to the tune of ~8.6% or 43,000 hectares—resulting in the densification of impervious area. Given the variability in the intensity of precipitation as well as the frequency of extreme precipitation events, the lack of local resilience practices in urban infrastructure and service delivery could amplify the existing impacts, in turn threatening the livability and productivity of Egyptian cities. Limited access to infrastructure in informal settlements puts the poorest at high risk of climate change impacts. Mismanaged solid waste is also a major contributing factor for increased vulnerability to urban flooding because it causes blockages in the urban drainage system. While fluvial flood risks have decreased thanks to upstream flood defenses and river flood management, the climate variability of the Nile River Valley could compound the hazard impact of flood events for cities.

Figure 8: Area exposed to pluvial flood risk hazard





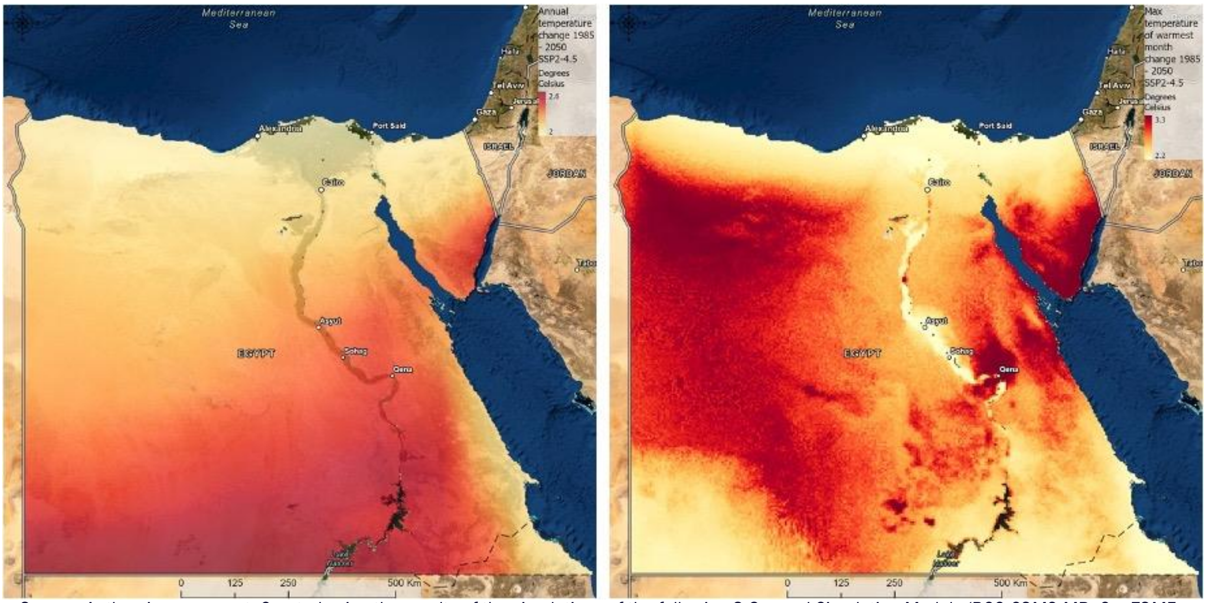
Source: Climate risk assessment conducted by the team across 14 cities using World Settlement Footprint Landsat 5/7'; SSBN arc second (90) Global Hazard Data (World Bank License)

If current patterns of urban expansion into flood-prone areas continue without risk-informed urban planning and infrastructure development, an additional 1.1 million people across major cities will be exposed to flood hazards by 2030. The urban expansion modelling for the 14 cities suggests that by 2030, the population exposed to 1-100 years and 1-10 years return period flooding event will increase by 35% and 72% respectively. While not factored into the above estimation, variations in the intensity and variability of flooding, lack of local flood resilience systems, lack of nature-based solutions (NBS), and the depletion of green cover/natural forests (due to urban expansion) will further contribute to increasing flood hazards across cities. Fluvial flooding hazards also show an upward trend and are closely correlated with the factors described above. However, the scale of fluvial hazard will also depend on the adequacy of upstream protection works and urban stormwater management systems.

2.2. Heat stresses

Climate change is expected to increase mean temperatures and heat extremes in an already dry, arid environment across Egypt. Temperatures have already increased over the past decades (0.53°C per decade across the past 30 years) and climate change will result in an increase of extreme temperatures in the range of 2.2-3.2°C by 2050 (as compared to 1985), while the annual mean temperature will rise by 2-2.6°C (see Figure 9). Urban heat islands across cities as well as rising emissions and pollution will intensify the effect of consequent heat stresses, acutely affecting the livability and productivity of Egypt's cities while amplifying desertification and water security risks.

Figure 9: Temperature changes with climate change



Source: Authors' assessment: Created using the results of the simulations of the following 8 General Circulation Models (BCC-CSM2-MR; CanESM5; CNRM-CM6-1; CNRM ESM2-1; IPSL-CM6A-LR; MIROC6; MIROC-ES2L and MRI-ESM2-0) that were conducted as part of the Coupled Model Intercomparison Project Phase 6 (CMIP6) (Eyring et al. (2016): Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9). The climate projections were statistically downscaled and calibrated with WorldClim v2.1 (Fick, S.E. et. all (2017) WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology

Egyptian cities are experiencing a consistent increase in mean surface temperatures and prolonged heat waves driven by urban heat island (UHI) effects, with a particularly acute impact on urban built environments and economic productivity. Surface temperatures in most of Egypt's major cities are reaching extremely high levels, especially in the summer, with ~90% of the population living in areas with surface temperature of more than 40°C. In cities such as Aswan, Asyut, Cairo, Port-said, and Suez, more than 95% of the population experiences high temperatures of more than 40°C. On the higher end of the extreme, Aswan and Cairo see staggering temperatures of over 45°C.

Pollution is closely correlated with heat stress, contributing to degraded living standards, additional stress on natural resources, and increasing climate change impacts. Notably, in the large cities of Cairo, Port Said, and Suez, more than 75% of each city's area shows PM2.5 concentrations above 10 μg/m3. For the most part, PM2.5[12] concentrations vary slightly within cities (ranging between 5 and 15 μg/m3), but cities like Zagazig and Faiyum are uniformly exposed to heavier pollution (≥10 μg/m3). In 2017, the cost of the negative effects of air pollution on health in the Greater Cairo area alone was estimated to be about 1.4% of Egypt's GDP.[13]

Heat hotspot analysis in major cities confirms that heat stresses are accentuated by the emerging urban form, urban infrastructure gaps, lack of green spaces, UHI effects of the built environment, emissions, and population density. Consequently, the built environment in major cities experiences much higher surface temperatures[14] than peripheral areas. Areas developed before 1985 in cities including El Mahalla El Kubra, Kafr El Dawwar, and Zagazig emerged as heat hotspots with the highest surface temperatures, while in other cities such as Mansoura and Tanta, more newly developed areas are emerging as heat hotspots. A few cities like Suez are facing consistent rising temperatures across the

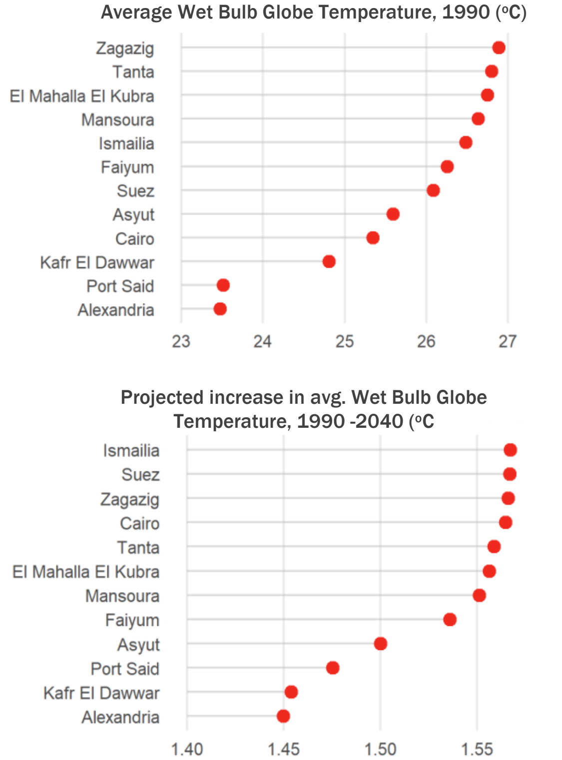
[12] PM2.5 particles are of concern because their small size allows them to travel deep into the cardiopulmonary system. According to the WHO, PM2.5 concentration should not exceed 10 μg/m3, which is associated with an 8% increase in long-term mortality.

[13] Larsen, Bjorn. 2019, "Egypt: Cost of Environmental Degradation: Air and Water Pollution," The World Bank.

[14] Data availability on UHIs and their impact on livability remains a key challenge, hence global databases on surface temperatures have been assessed to understand the intensity heat stresses in 14 major Egyptian cities.

entire city. The relationship between land cover and temperature remains unclear, however. Thanks to the Nile providing relief from the heat, urban areas in Cairo and Luxor, for instance, are cooler than rural outskirts in the deserts.

Figure 10: Heat wave stresses in key cities



Source: Climate risk assessment conducted by the team using Centre for International Climate Research's ClimINVEST database.

Intense and prolonged heat stresses are putting enormous pressure on natural resources (such as water) and contributing to increasing energy needs for cooling, leading to a vicious cycle of increasing GHG emissions that in turn will hinder the transition to low-carbon RCP (Representative Concentration Pathway) scenarios. The heat wave magnitude index daily (HWMId) shows that hotter cities are likely getting hotter: the three cities with the highest HWMId[15] in 1990 (Asyut, Suez, and Zagazig) are also the ones that may see the worst intensifications in heat waves by 2040. By contrast, the northern coastal cities are predicted to avoid the worst heat waves, although they are becoming warmer as well.

Excessive heat is closely linked with increasing health risks and reduced labor productivity.[16] Empirical evidence suggests a significant drop (26.1%) in productivity as temperatures increase from current levels under the RCP 8.5 climate scenario.[17] Further, heat stresses could result in the loss of 134,000[18] working hours annually by 2030, placing Egypt among the top five most impacted countries in Africa and the top two among Arab countries.

2.3. Sea-level rise and coastal flooding

Egypt's coastal areas are facing increasing risks due to SLR, extreme flooding, coastal erosion, land subsidence, and salinity intrusion—primarily due to warming oceans and the melting of glaciers/ice sheets that are driven by rising temperatures. Egypt has a vast coastal zone spanning over 3,000 km and supporting a diverse set of land use and economic activities that contribute significantly to Egypt's GDP. More specifically, the coastal zone includes i) the North Coast, comprising about 1,050 km of the Mediterranean coast with agriculture, grazing and tourism, ii) the densely populated Nile Delta with industry and intensive agriculture, and the Sinai Peninsula with small-scale agriculture, fishing and tourism; and iii) the Red Sea Coast extending up to 1,850 km, connecting the Mediterranean Sea in the north with the Indian Ocean in the south. Eighty-six percent of the Red Sea coastal area is vulnerable to inundation by SLR. SLR threatens urban infrastructure and industrial and agriculture production through storm surges and flooding.

Local SLR has been consistently rising across the past decades. Sea levels in Egypt rose by an average of 1.8 mm annually until 1992, by 2.1 mm annually between 1993 and 2012, and 3.2 mm annually thereafter. SLR modelling for Egypt shows that sea levels are expected to rise in the range of 1 to 6

[15] The heat wave magnitude index daily (HWMId) merges the duration (days) and the intensity (daily maximum temperature) of prolonged extreme temperature events into a single numerical index.

[16] Parsons K. (2014) *Human thermal environment. The effects of hot, moderate and cold temperatures on human health, comfort and performance*. 3rd edition. New York: CRC Press.

[17] Lee, SW et.al: *Effects of climate change-related heat stress on labor productivity in South Korea*. Int J Biometeorol 62, 2119–2129 (2018). https://doi.org/10.1007/s00484-018-1611-6

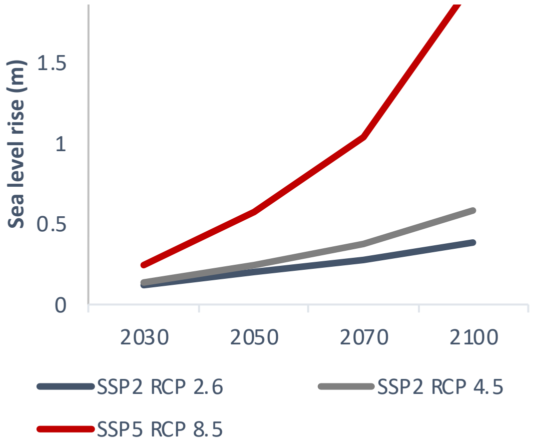
[18] ILO (2019) *Working on a warmer planet: The impact of heat stresses on labor productivity and decent work*

mm/year along the Mediterranean, the Nile Delta and the Red Sea coastal zone. Physical impacts of SLR include i) coastal erosion for exposed sandy beaches, with high potential for shoreline retreat, ii) flooding of coastal stretches during storm surges as observed in low-lying areas of the Nile Delta, iii) the acceleration of saltwater intrusion and the corresponding increase in groundwater salinity, and iv) siltation risk for harbors, navigation, and drainage channels.

The Nile Delta plays a crucial role in the Egyptian economy (supporting 40% of country's total agriculture production, 50% of fish catch, and 60% of industrial production) and faces a combined risk of SLR and land subsidence. The Nile Delta is particularly vulnerable to SLR—the IPCC has named the Delta as one of the world's three "extreme" vulnerability hotspots for SLR. There is a high risk of inundation as one-fifth of the delta is below mean sea level, a situation that is only worsening due to gradual subsidence. Several studies estimate the risk of inundation in the Nile Delta as ranging from 0.5 mm/year in the west to 4.5 mm/year in the east (Stanley, 1997). This means that 12,000 km^2 out of the total 20,000 km^2 of the Nile Delta is susceptible to inundation from SLR, which may cause extensive flooding that would displace millions of people and disrupt livelihoods. Published literature and a recent World Bank assessment[19] indicate that anticipated SLR may result in the submersion of between 12% and 32% of the Nile River Delta. SLR in the Nile Delta threatens urban infrastructure and industrial and agriculture production through storm surges and flooding, with projected annual damages and losses of between $2.1 billion/year and $14.8 billion/year. On the Red Sea coast, the risk of SLR is expected to grow for the coastal flats, estuaries, and bays where the economic activity of urban areas, harbors, and resorts is concentrated. The damage to coral reefs from warming sea waters is expected to trigger stronger wave action along the coast and increase the impact of SLR.

Projections based on the DIVA model[20] indicate that the magnitude of future SLR for Egypt's coastal zone could be as high as 2 m by 2100 under high SLR scenarios (RCP8.5 and SSP5). The SLR[21] modelling under low, medium and high SLR scenarios corresponding to 2030, 2050, 2070 and 2100 show that SLR risk is less than 0.5 meters under the low SLR scenario, between 0.5 and 1.0 meters under the medium SLR scenario and exceeds 1 meter beyond 2050 under the high SLR scenario, potentially reaching 2 meters by 2100. Consequently, the coastal zone area subject to an extreme SLR flood event (1 in 100 years) range between 10,000 km^2 and 20,000 km^2 under low SLR, 18,000 km^2 to 20,000 km^2 under medium SLR, and 20,000 km^2 to 25,000 km^2 under high SLR scenarios over the period 2030 to 2100. This implies that the area subject to extreme SLR flood events is expected to double under medium and high SLR scenarios and remain at elevated levels across the decades until 2100, a finding with significant implications for emergency recovery costs following extreme flood events as well

Figure 11: SLR projections for climate scenarios



Source: Team's assessment using DIVA model based on DINAS-COAST database and the model updates.

[19] World bank Egypt's Rise benchmarking study (2021)

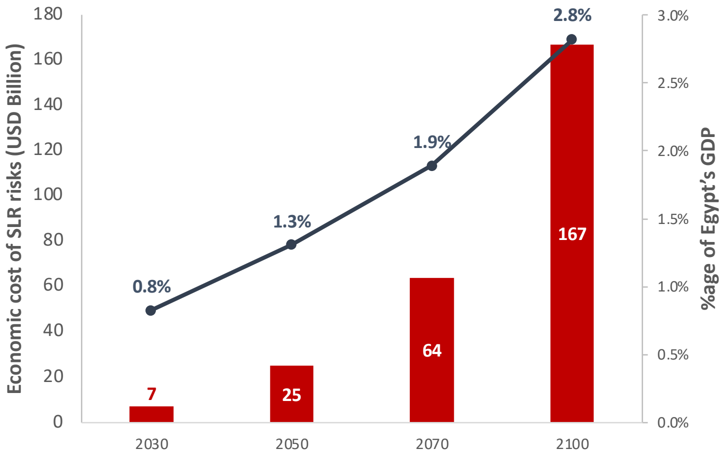
[20] DIVA (Dynamic Interactive Vulnerability Assessment model is an integrated coastal modelling framework to assess the biophysical and socioeconomic consequences of SLR and associated flood damage under different physical and socio-economic scenarios. DIVA model with its DINAS-COAST database (Vafeidiset et al 2008, Hinkel et al. 2013) and the model updates (Lincke and Hinkel 2018, Jeverejva et al 2018 and Brown et al 2021) is considered to estimate the climate change induced SLR impact on Egypt coastal zone.

[21] The SLR risk is based on combinations of representative concentration pathways (RCP) and socioeconomic pathways (SSP). The RCPs seek to assess the impacts of greenhouse gas emission concentrations in the atmosphere with as a result of anthropogenic activities. In the DIVA model cost of protection is estimated based on RCP 2.6, RCP4.5 and RCP 8.5 to represent low, medium and high SLR risk, respectively. The socioeconomic pathways (SSP) reflect evolution of gross domestic product (GDP) of a country in the absence of climate policy (Riahi et al 2017). The two SSPs - SSP2 (middle of the road) and SSP 5 (fossil fuel development – taking the highway) have been adopted in this analysis.

as one that underscores the importance and urgency of coastal protection as part of long-term coastal zone planning and management over several decades.

Without a sustained focus on coastal adaptation, the costs of SLR flood damage are expected to increase significantly, doubling each decade. As economic growth and asset values trend upward, so do the damage incurred by floods and the costs of protection. Earlier studies show that the costs of inundation due to SLR by the year 2100 are expected to increase. For example, studies show that the cost of SLR increases globally by 2100 as temperatures rise (Jevrejeva et al 2018, Brown et al 2021). The costs of SLR flood damage are expected to grow in tandem with economic growth over the long term, while protection costs materialize in the near term. Under the medium SLR scenario (RCP4.5, SSP2) and assuming the continuation of adaptation measures implemented in the past, annual SLR flood damage costs are estimated[22] to reach US$7 billion by 2030 (equivalent to ~1% of Egypt's GDP) and to increase significantly to US$167 billion by 2100 (equivalent to ~3% of Egypt's GDP). Given the upward trends in economic growth and asset values, annual SLR flood damage costs in 2100 are expected to be more 20 times those of SLR damage costs estimated for 2030 under the medium SLR scenario. For a high SLR scenario, the economic damages from SLR will increase even further. The projected increase in SLR flood damage costs points to the need for investment in additional coastal protection measures and maintenance of existing protection measures—to adapt and improve the resilience of coastal economy over several decades.

Figure 12: Projected damages for SLR RCP4.5, SSP2

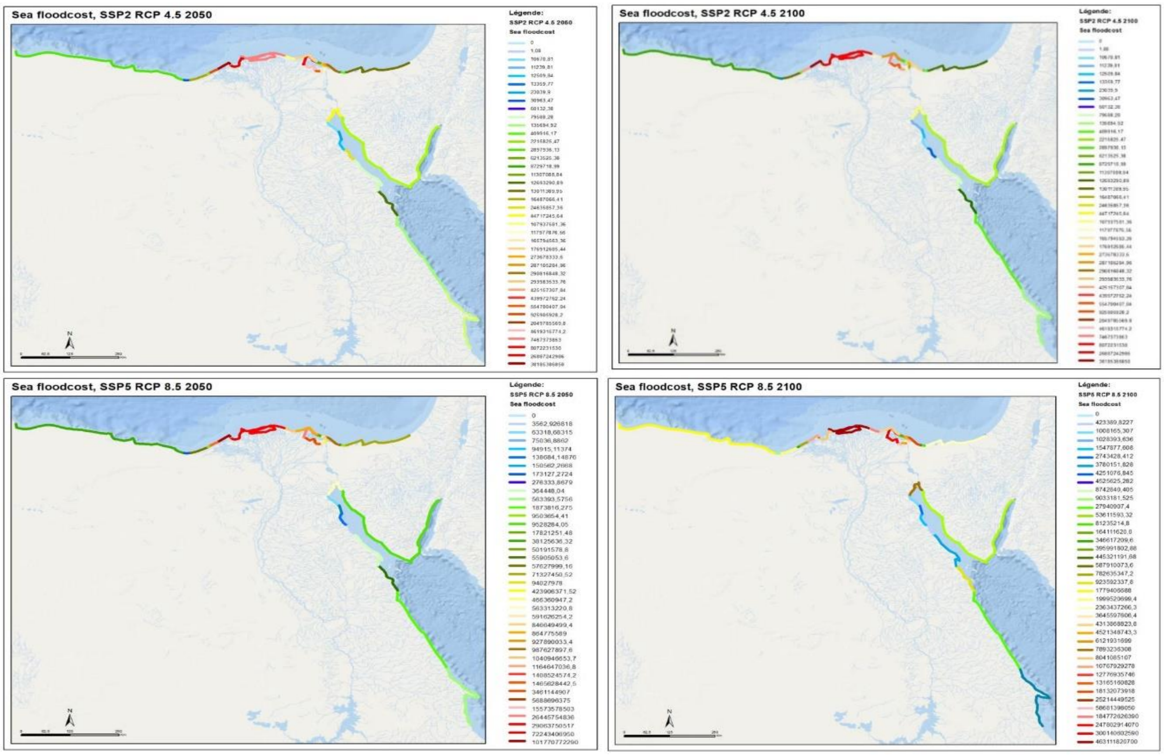


Source: Team's assessment using DIVA model based on DINAS-COAST database and the model updates. The estimates are conducted for middle SLR scenario i.e. SLR RCP 4.5, SSP2

The spatial concentration of major cities along the Mediterranean coast and in the Nile Delta accentuates the intensity and direct economic impact of coastal risks (from SLR, subsidence, saltwater intrusion, and coastal storms). In the absence of additional coastal protection measures, the Nile Delta is at risk for high damage. The segment-wise mapping of flood damage cost (see Figure 13) of projected SLR shows that i) the Nile Delta is subject to the highest expected damages from SLR under low, medium and high SLR scenarios, ii) the red, brown and orange color codes of the coastal segments indicate high projected flood damage costs in the Nile Delta followed by the North Sinai coast on the Mediterranean, iii) the projected flood damage costs of the Mediterranean coast are larger than the projected flood damage costs of the Red Sea coast in future decades, and iv) the SLR risk to the Red Sea coastal zone is concentrated in the middle and the southern part of the coastal zone between 2050 and 2100. The damage pattern is attributed to high economic activity and urban densities in the Nile Delta and along the Mediterranean coast. Most of the major Egyptian cities are concentrated in the Nile Delta or along the Mediterranean coast and are directly exposed to coastal risks related to SLR, as discussed above; major coastal cities such as Alexandria, Port-Said, Ismailia, and Suez face the highest level of climate and economic risks. About 45% of the population in Alexandria is currently living below mean sea level and if sea levels rise by two meters, northern and eastern Alexandria will be almost fully inundated.

[22] Estimated using DIVA model.

Figure 13: Segment-wise damage cost mapping for Egypt for climate scenarios



Source: Team's assessment using DIVA model based on DINAS-COAST database and the model updates.

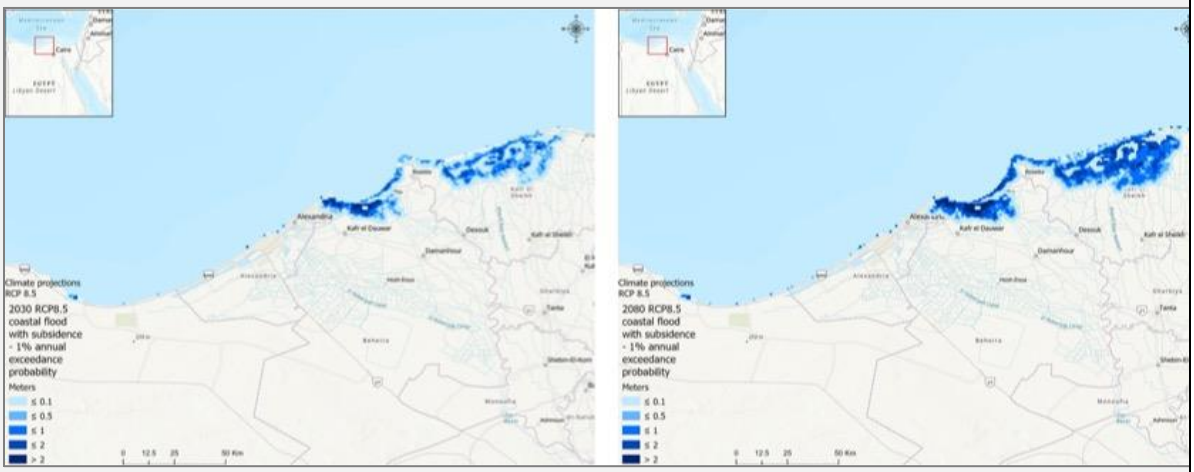
A combination of coastal risks (from SLR, subsidence, and storm surges) and other climate hazards (such as pluvial and fluvial flooding) not only impact cities directly but manifest into a broader and intense territorial impact. Specifically, i) coastal storm occurrence generally correlates to the types of storms that cause pluvial events, where low-lying areas can be impacted via coastal surges, and ii) SLR and land subsidence are closely correlated with land erosion in potentially vulnerable areas, exacerbating the overall impact. The impact of coastal and land erosion is extreme for coastal cities and, in combination with land subsidence, further exacerbates the impact of coastal and pluvial flooding, particularly for the Northeast part of Alexandria city.

Box 1: Flood risk in Alexandria

Alexandria is Egypt's second-largest city (5.18 million residents) and a key center for tourism and other economic activities along the Mediterranean coast. It faces combined flooding risk from pluvial flooding, fluvial flooding, and SLR-driven coastal flooding. With about 45% of its population currently living below mean sea level, Alexandria is highly vulnerable to climate change. The floods that hit the city on October 25-26, 2015, have been described as "the worst in Alexandria over the past decades in terms of the number of people affected and the amount of economic damage" (Egyptian Streets, 2015). Those floods were responsible for seven deaths in the city, around US$10 million in direct damages to private property, and around US$27 million in business losses. At least 30% of the city was flooded, with water depths ranging between 0.5 m and 1.0 m, and the power supply was interrupted or shut down for up to ten days. As a result, economic activity in many parts of the city came to a standstill for up to two weeks, some industrial activity was halted, and tourism was interrupted. During the 2016-17 winter season, Alexandria was exposed to a storm with strong westerly winds up to 83 km/hr and 4 m sea waves. This led to moderate damage to beaches and tourist facilities overlooking the Sea Corniche.

Alexandria’s rainy season (which starts in late October and ends early February), averages 18 rainfall events and the city receives about 200 mm of rain per year, on average. According to Zevenbergen et al. (2016), on October 25-26, 2015, the intense rainfall measured at the Ras El Teen and Abu Qir meteorological stations reached 40 mm. However, rainfall data from the Tropical Rainfall Measuring Mission (TRMM) showed that for both the October 25 and November 4 rainfall events, rainfall was as high as ~60 mm. This disparity highlights the uncertainty and variability of precipitation measurements. The October 2015 pluvial flood event could only be coarsely estimated by extrapolation to be a once in 50 years event. Estimates suggest that rainfall between 20 mm and 32 mm is expected at the stations once every two years (i.e., for 2-year return period rainfall). However, due to gaps in existing drainage systems, Alexandria can flood (to a minor extent) with as little as 20 mm of rain. Projected SLR under various climate scenarios (see Figure 14) further adds to Alexandria’s flood risks.

Figure 14: SLR risks for Alexandria for 2030 and 2080 - RCP 8.5



Source: World Resource Institute, Aqueduct tools

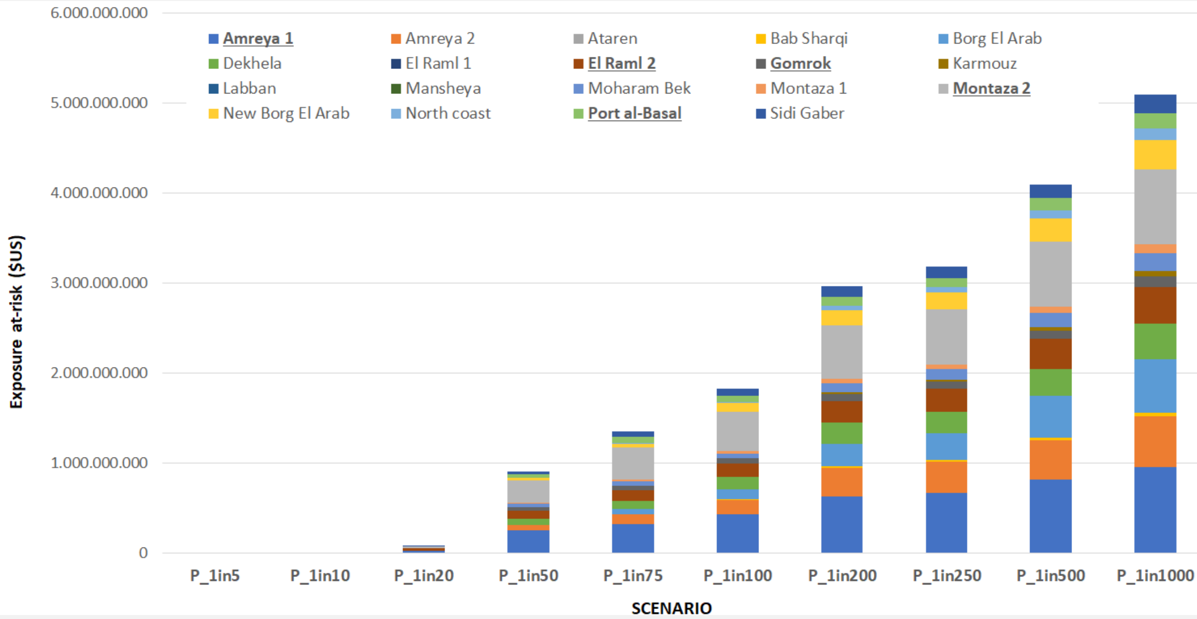
Macro estimation of the flood risk based on global data sources[23] for Alexandria suggests that the total Exposure-at-Risk (EAR—expressed as a percentage of the total replacement value of all buildings in Alexandria) value is US$46.6 billion. The summary below provides more detail in terms of specific types of flood risks.

- Pluvial flooding: EAR as high as 10.9% for pluvial flood events in Alexandria for extreme rainfall events. The costs exhibit a high range due to high variability in rainfalls. Figure 15 provides the EAR due to pluvial flooding under the current climate for various return periods, by municipality. Of Alexandria’s 19 municipalities, those with the highest pluvial EARs are: Montaza 2, El Raml 2 and Amreya 1, followed by Port al-Basal and Gomrok.
- Fluvial flooding: Additional flooding risk from fluvial flooding during similar return periods ranges from negligible to 3.2%, and takes into consideration upstream flood defenses and river flood management. The major damming along the Nile has changed the flooding pattern away from fluvial and toward pluvial flooding.
- Coastal flooding: The EAR from coastal flooding ranges from 22.7% to 30.1% of the total building exposure, while the underlying flooded surface ranges from 20.6% to 27.2% of the total area in the 24 coastal flood scenarios. Municipalities with the highest EARs for coastal flooding are El Raml 2, Port al-Basal and Karmouz, followed by Mansheya, Labban, Sidi Gabar, Moharam Bek, and Montaza 2.

[23] The assessment of the scale of flood risk hazard and the subsequent EAR (Exposure-at-risk) for Alexandria has been conducted based on global flood layers such as Climate Central dataset (2020) and Fathom dataset. Buildings’ built-up floor area exposure and replacement value has been estimated based on the 2019 WSF-3D Structure raster layers with 90 m cell resolution. The scenarios are based on the Fathom scenario that model the impact of each of the varying return periods of 5, 10, 20, 75, 100, 250, 500, 1000 years. Fluvial and Pluvial scenarios from Fathom dataset, consider climate current change trends, while coastal risk considers RCP8.5 scenario, in 50th and 95th percentile.

Economic losses from disrupted services, mobility, and industrial productivity; socio-economic costs (from diseases, health costs, increased mortality); and flooding of heritage buildings and socio-economic infrastructure (e.g., schools, hospitals) further add to the cost of flooding for Alexandria. Challenges such as the inadequacy of large-scale modelling (e.g., global flood models), lack of robust local/city level flood maps, lack of historical data, rapid changes in elevation, and a piecemeal approach to the implementation of corniches and other coastal defenses, mean that a more exhaustive primary data-based analysis is necessary to fully understand the scope of risks faced by Alexandria.

Figure 15: Exposure-at-Risk for Alexandria for high pluvial flood events



Source: Team's assessment using global flood layers such as Climate Central dataset (2020), Fathom dataset and 2019 WSF-3D Structure raster layers with 90 m cell resolution

2.4. Resource stresses

Resource stresses resulting from inefficient resource utilization and service delivery systems across Egyptian cities further amplify the vulnerability to climate change, impacting the country's economic performance, productivity, and development potential. Most of Egypt's big cities suffer from unmanaged urban expansion as well as constrained urban infrastructure and service delivery systems, leading to depletion of natural land cover, air pollution, water pollution, and land pollution from inadequate waste management. Cities lack sustainable and resource-efficient approaches to deliver services and address inadequacies. Such approaches would include risk-informed spatial and land use planning, treated wastewater recycling and reuse, and resource recovery and recycling from waste.

2.4.1. Land as a resource

Unplanned and unregulated spatial urban expansion is leading to increased desertification, a rapid decline in arable land, and inefficient land use management in urban and peri-urban areas. Arable land, a major resource constraint[24] for Egypt, is decreasing at a rate of ~2% per decade, as desertification intensifies across the country and built-up areas expand in and around cities. Weak spatial planning systems and the absence of integrated, resource-efficient territorial planning and development approaches is leading to i) the conversion of arable lands into built-up areas, ii) a growing number of unplanned settlements, iii) land degradation, and iv) loss of land to construction activities[25] and the skimming of fertile soil for brickmaking. Across the 14 major cities, arable land (both agricultural and natural green areas) has declined at a much faster rate across the past two decades than previously,

[24] Arable land is 7.2% of Egypt's total land area
[25] Egypt loses about a hectare of fertile land to construction alone every hour

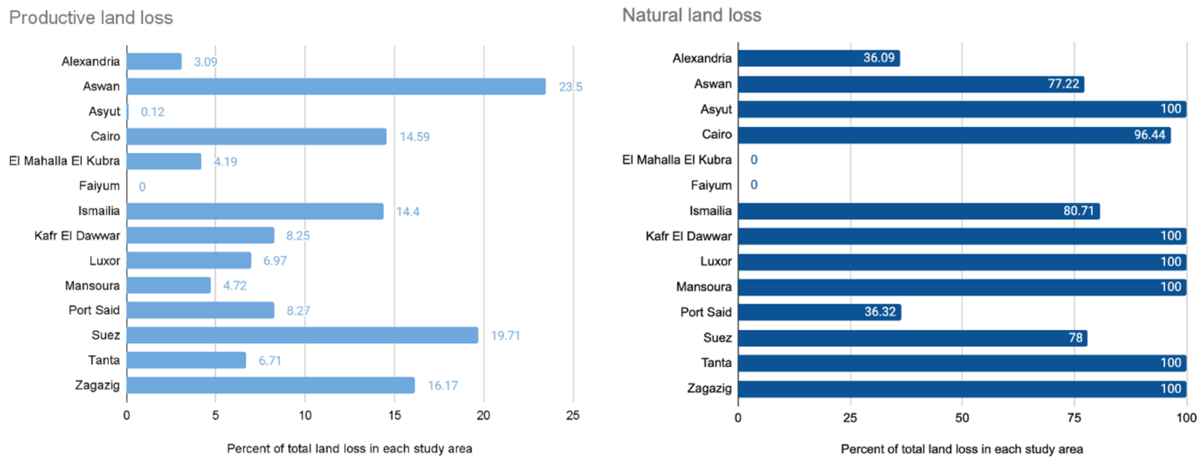
with an overall decrease of ~8.6% or 43,000 hectares. Asyut and Aswan have seen the highest decrease in the range of 26-31%, followed by an 18-19% decrease in Cairo, Suez, and Zagazig and a 12-14% decrease in Mansoura, Port Said, Ismailia, Kafr El Dawwar, and Tanta between 2000 and 2015.

Business-as-usual urbanization patterns that do not focus on compact growth illustrate a continued trend of inefficient land resource utilization and the depletion of natural and productive land. Urban growth and expansion modelling across the 14 major cities suggests that the absence of a compact growth focus will lead to a ~900 km² additional land footprint[26] requirement by 2030. Unmanaged urban expansion at this scale is anticipated to cause:

- Loss of 138 km² of natural land[27] that is critical for cities' adaptive capacity against climate-driven variability and changes in weather patterns (flooding, emissions, pollution, heat stresses). Approximately 50% of such natural land loss is projected to occur along the Northern Coast due to strong economic growth and the urbanization potential of cities such as Alexandria and Port Said. Further, 40% of such natural land loss is projected to occur in cities concentrated in the interiors of the Nile Delta.
- Loss of productive/agricultural land[28] to the tune of 251.24 km², resulting in a decrease in agricultural productivity and the loss of arable land, both of which would lead to wider negative socio-economic externalities. Approximately 53% of this productive land loss is projected in the cities concentrated in the interiors of Nile Delta, while 34% is projected in the cities along the Northern Coast.
- Additional productive land and natural land losses due to coastal erosion (SLR, salt water erosion, siltation in Nile Delta) will further stress Egypt's adaptive capacity.

For certain cities, the results of the BAU scenario by 2030 are even more acute. As summarized in Figure 16, out of the 14 major cities, two will have lost more than 35-40% of their natural land area, four cities will have lost around 75-80%, and seven cities will have lost more than 90% of their natural land area.

Figure 16: Anticipated loss of natural and productive land with unmanaged urban expansion by 2030



Source: Urban Performance tool results

This urbanization pattern would amplify climate change-induced floods and heat stresses while nullifying the emission reduction potential of natural GHG sinks. This is particularly concerning because

[26] Urban footprint refers to the total built-up area of a city or urban area, including streets, open space, and inner vacant land

[27] This indicator accounts for the area of land predicted to change from a woody tree, shrub, or other vegetation into urban or agricultural land, between the base and the horizon year

[28] This indicator accounts for the area of land predicted to change from agricultural uses to urban human settlements, between the base and the horizon year. Productive land consumption is calculated as the area that was agricultural land in the base year and transformed into other land uses in the horizon year

unmanaged urban expansion and underleveraged urban densifications drives urban mobility needs, resulting in increased GHG and vehicular emissions, which contribute to air pollution and amplified heat stresses. Elevated levels[29] of air pollution from vehicular emissions across cities is one of the key environmental and health hazards currently degrading livability standards and increasing climate change impacts.

Unmanaged urban expansion has a major detrimental impact on the climate change resilience and adaptive capacity of Egyptian cities, service delivery, and agriculture productivity in the country. Avoiding or minimizing this impact requires urgent action to integrate land-use planning and management to conserve natural resources through well-planned, resource-efficient urban and territorial planning mechanisms.

2.4.2. Water as a resource

Water security poses a key challenge for Egypt's economic and development trajectory. Egypt, already among one of the most water-stressed countries in the world, faces increasing water security risks from climate change (high variability in overall water resource availability, saltwater intrusion from SLR, etc.) as well as a growing population. Egypt's current annual share of water is 570 m^3 per capita, placing the country well below the international threshold for "water scarcity" and close to the "absolute scarcity" threshold of 500 m^3 per capita per year. The water stress levels were around 117% in 2017, levels that are very close to "absolute water scarcity" of 500 cubic metres of water per person per year as defined by the United Nations, and estimates[30] suggest that the country could run out of water by 2025 if business as usual continues.

Egypt is currently dependent on water availability from the Nile River, but climate change has introduced a high degree of uncertainty around the timing and volume of that water. The Nile River accounts for about 95% of freshwater resources in Egypt, but annual water allocations are constrained by Nile water-sharing agreements and upstream developments (such as the Grand Ethiopian Renaissance Dam-GERD). Higher temperatures, increased evapotranspiration (ET), and highly variable precipitation in the Nile Basin induced by climate change will significantly affect Egypt's water availability. The global models recognized by the Intergovernmental Panel on Climate Change (IPCC) consistently predict increased temperatures in the Basin but show a wide range of possible precipitation changes. In the coming century, the variability of the region's rainfall is projected to increase, with the potential to change the Nile flow into Egypt by up to 50%, resulting both in more frequent drought years and more frequent high-flow years, as well as an increase in the frequency and intensity of flash flooding in Egypt's coastal areas.[31,32] These changes in Nile flow will be further complicated by impacts from upstream development in the Nile River Basin.

Climate change impacts from SLR and heat stresses further add to the growing water security risks: Saltwater intrusion due to SLR risks (refer to SLR risks above) poses water salinity risks to groundwater as well as the Nile Delta. In addition, extensive and unplanned groundwater extraction (which almost trebled across three decades—from ~1.5 BCM per year in 1981 to 4.6 BCM per year in 2010),[33] is resulting in the depletion of available groundwater resources. In addition to increasing temperatures resulting in increased evapotranspiration, heat stresses will lead to increased water demands for cooling

[29] Average PM2.5 levels are almost nine times higher than the WHO guidelines. Notably, in the large cities of Cairo, Port Said, and Suez, more than 75% of each city area shows PM2.5 concentrations above 10 µg/m3.

[30] UNICEF (2021): Water Scarcity in Egypt

[31] Siam M. S. and E. A. B. Eltahir (2017) Climate change enhanced interannual variability of the Nile River flow. Nature Climate Change vol 7

[32] Niang, I., O.C. Ruppel, M.A. Abdrabo, A. Essel, C. Lennard, J. Padgham, and P. Urquhart, 2014: Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265.

[33] M. B. Mabrouk et.al (2013): A review of seawater intrusion in the Nile Delta Groundwater system

and drinking purposes, resulting in a vicious circle of increased water demand and reduced water availability across Egyptian cities—unless the GoE takes steps to curtail these trends.

In the context of prevailing water security risks, major Egyptian cities suffer from critical water supply service delivery gaps and lack a resource-efficient approach. Urban water supply services across Egyptian cities suffer from high transmission and distribution (T&D) losses—about 29%. Although access to drinking water has improved over the years, service delivery is negatively affected by ageing networks, the deterioration of water reservoirs, and leakages in groundwater and networks systems, among other factors. Further, water consumption patterns across cities are marked by suboptimal efficiency, resulting in high per capita water use levels. Currently, the water supply norms for Egypt remain as high as 400-450 liters per capita per day (lpcd) in large cities such as Cairo and Alexandria—as a point of comparison, that is more than twice the norms in Jordan, Morocco, and Tunisia (168, 155, and 159 lpcd, respectively). Business as usual projections aligned with urban growth across the 14 major cities suggest a 35% increase in drinking water demand by 2030 unless current levels of water consumptions are curtailed. Meeting this increased demand may not be sustainable given the water security risk across Egypt. Continued service delivery gaps, water losses/leakages, and growing non-residential demand for water from economically important activities across these cities will compound the anticipated water stress. While desalination is one option to meet the water demands of growing urban populations in existing cities and new cities, in the absence of plans to ensure the financial and operational sustainability of such projects, desalination could result in a further exacerbation of declining service delivery levels.

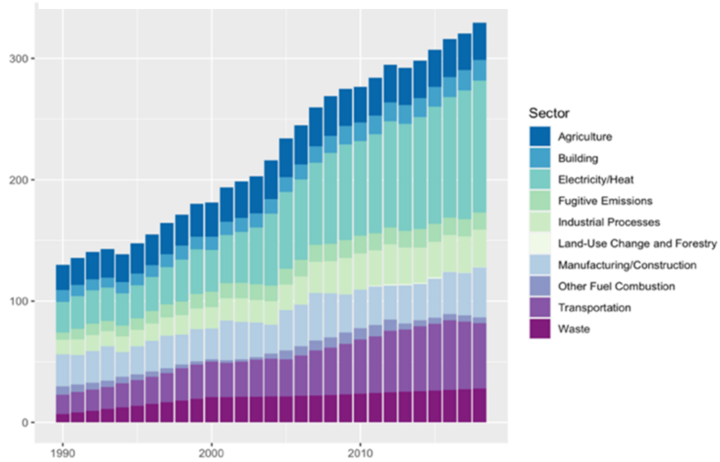
Low efficiency in the treatment of wastewater and limited wastewater circularity across Egyptian cities puts additional strain on already scarce resources. While wastewater recycling can significantly reduce water security risks from climate change, only 1.7% of generated wastewater[34] in Egypt is treated to tertiary standards, recycled, and reused, suggesting very limited progress in building the basis for a circular water economy in cities.[35] Much of the reuse of drainage water happens informally in agriculture and without sufficient treatment. Mismanaged wastewater contributes to water pollution, increases the risks of urban flooding, and degrades fertile land. Most of the major cities currently lack adequate infrastructure capacity and management systems (such as a sound network and adequate treatment facilities) for the management, recycling, and reuse of wastewater. Many informal settlements lack even public network connectivity. Of the ~5 billion m^3 of total wastewater generated in 2015, almost 26% of untreated wastewater was released into natural bodies of water, while only ~1.7% underwent tertiary treatment and was reused. These data points represent missed opportunities to use water resource circularity to manage water stresses. Egypt's water treatment systems suffer from suboptimal treatment technologies and efficiencies, particularly in the face of rapid urbanization, increasing amounts of trade effluents as well as industrial pollution and the resulting heavy metal contamination in water resources. Additional wastewater stresses from the lack of storm water management services that are separate from wastewater services put an additional strain on already deteriorating wastewater services (while also posing flooding risks to cities). Untreated/partially treated wastewater is also a source of key anthropogenic GHG emissions such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

[34] Hany F. Abd-Elhamid et. al: Safe Reuse of treated wastewater for agriculture in Egypt (2018)
[35] Several studies funded by the Egyptian Ministry of Higher Education and Scientific Research focus on the improvement of solid waste and wastewater recycling, including *Polishing of secondary treated wastewater using nano-ceramic hybrid PET waste plastic sheets. Desalination and water treatment*, 2021; 217: 214–220, *Three-dimensional, flow-through silver-magnetite nanocomposite–modified reactive electrochemical system with slow silver ions release for efficient bacterial disinfection of sewage*. Journal of Environmental Chemical Engineering, 2022; 10, 106985., and *Combining chemical coagulation processes and innovative aerobic reactor for the treatment of de-hairing wastewater*, Waste and Biomass Valorization, (2021); 12:2557–2564.

3. GHG Emissions in Cities

Egypt's economic growth is still coupled with emissions growth, as reflected in total GHG emissions from 1990 to 2019, which grew 163% in absolute terms and 47% per capita.[36] In just the ten years between 2005 and 2015, emissions increased by about 31%, from 248 MtCO2e in 2005 to 325 MtCO2e in 2015. The GoE estimates that in 2015, the Energy sector, which includes transport and industry emissions (65%) and Industrial Processes and Product Use (IPPU - 12%), together represented 77% of emissions,[37] while ~8% was contributed by the waste sector. Egypt's contribution to global emissions remains low at around 0.6%.[38]

Figure 17: Egypt's GHG emissions trajectory



Source: Authors' elaboration based on Climate Watch Historical Country GHG Data (1990-2018), WRI, 2022

Cities contribute to more than 80% of Egypt's direct CO_2 emissions.[39] Emissions from cities have increased more than tenfold across the past five decades, from 18 million tons to 182 million tons.[40] Emissions from urban areas[41] more generally have increased from 57% of the total in 1970 to 74% in 2015, with CO_2 emissions from urban areas increasing from 18 million tons in 1970 to 182 million tons in 2015 (see Figure 18). CO_2 emissions have increased at almost 2.4 times that of the urban population increase, indicating a relatively steeper increase in per capita urban emission intensities over time. Per capita emission intensities in cities have quadrupled over 1970-2015, increasing from 0.57 tons annually in 1970 to 2.43 tons annually in 2015—driven by economic activities, rising incomes, and changing consumption patterns. Similarly, the share of methane emissions from cities has increased from 38% to 57% over the period 1970-2015—tripling from 465,000 tons in 1970 to 1.4 million tons in 2015.[42] Coupled with urban growth, emission-intensive city systems and policy choices in buildings, urban mobility, solid waste and wastewater management, and urban land use are driving GHG emissions. The stock of existing residential and public buildings—approximately 21 million units—accounts for 17.42 MtCO2e emissions annually. Egypt requires an additional 4.4-4.5 million housing units by 2030 as well as non-residential construction (e.g., offices, hospitals, schools, hotels, etc.). Under a business as usual approach, these new buildings will contribute to increasing emission intensities in cities.

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[36] In 1990 emission were 134 Mt CO2eq and 2.38t CO2eq per capita; in 2019 emissions were 352 Mt CO2eq (~163% increase from 1990) and 3.51t CO2eq per capita (~47% increase from 1990). Climate Watch. 2022. Washington, DC: World Resources Institute.

[37] Egypt's Biennial Updated Report (2018)

[38] Egypt's Biennial Updated Report (2018)

[39] Calculations using EDGAR emissions data combined with information on urban extents. Crippa et al., 2021. "Global Anthropogenic Emissions in Urban Areas: Patterns, Trends, and Challenges." EDGAR data is a global dataset and is based on based on mapping of emitting activities and corresponding emissions factors that are in line with IPCC guidelines. The EDGAR data provides emissions of GHGs and air pollutants for all anthropogenic emitting sectors, following the IPCC categories, namely 'energy-industry' (which includes the combustion in the power and non-power generation industries, fugitive emissions, fuel production, refineries and transformation industries), 'residential' (which includes small scale combustion), 'transport' (which includes both road and non-road transport), 'waste' (which includes solid waste disposal and waste water treatment) and 'other' (which includes all emissions not included in the other categories such as industrial process emissions (e.g. cement production, iron and steel production, non-metallic minerals production, non-ferrous metals productions, chemicals production), solvent use, indirect emissions for N2O, etc.). EDGAR data provides Scope 1 emissions spatially across types of settlements. City emissions are aggregated overlaying information on urban settlements with the EDGAR data.

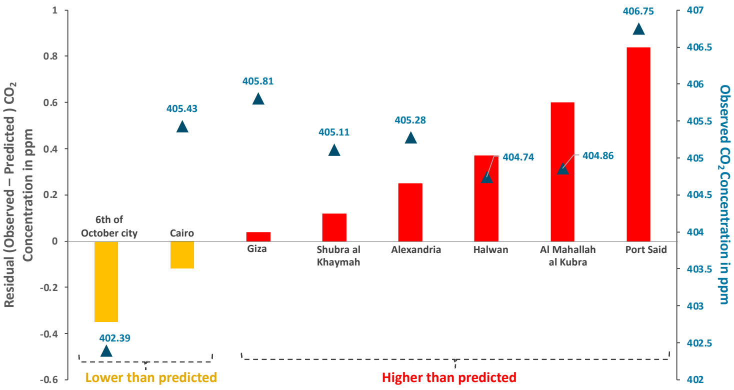
[40] EDGAR emissions data: Crippa et al., 2021. "Global Anthropogenic Emissions in Urban Areas: Patterns, Trends, and Challenges." Emission numbers correspond only to urban centers.

[41] Urban centers, dense and semi-dense urban clusters.

[42] EDGAR emissions data: Crippa et al., 2021. "Global Anthropogenic Emissions in Urban Areas: Patterns, Trends, and Challenges." Emission numbers correspond only to urban centers.

The concentration of CO_2 emissions across Egyptian cities also varies compared to modelled expectations,[43] indicating a differential between cities' performance on emissions. The actual accumulated CO_2 concentration observed in eight Egyptian cities ranges between 402.39 ppm and 406.75 ppm.[44] The range is due to differences in cities' socio-economic and geographical characteristics. When these observed CO_2 concentrations are compared against expectations modelled based on those characteristics, however, there are differences in both the upward and downward directions (see Figure 18).[45] The cities to the right of Figure 18 emit more CO_2 than would be expected based on their characteristics, likely indicating a lack of decarbonization efforts and a corresponding opportunity to reduce emissions. Egyptian cities such as Port Said and Giza fall in the 90th percentile of 99 cities in the MENA region, indicating that the observed levels of CO_2 concentration for these cities place them among the ten cities in the MENA region with the highest CO_2 concentrations. The ability to decarbonize will be one factor in the competition across cities to attract people and investments.

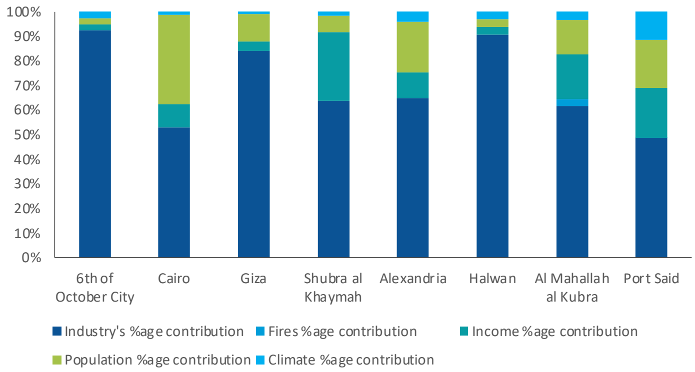
Figure 18: CO_2 concentrations across Egyptian cities



Source: Authors' elaboration based on data based on World Bank's Urban CO2 Emissions: Global Analysis with New Satellite Data (2021).

CO_2 concentrations[46] in cities are driven by the spatial concentration of industrial and residential activities[47]—differences in income levels and population densities also play a key role. Rising income levels and high population densities are contributing to the increase in CO_2 concentrations in all of Egypt's major cities. In cities including Cairo, Alexandria, and Port Said, CO_2 concentrations are greater than 405 ppm (a threshold representing the 75th percentile of 99 cities modelled in MENA). In Cairo, ~36% of CO_2 concentration is driven by population and population densities while another 10% is driven by income levels. Similarly, in the key coastal cities of Alexandria and Port Said, 19-20% of CO_2 concentration is driven by population densities, while in Shubra al Khaymah, the fourth largest city of Egypt, ~28% is driven by income levels. The 6th of October city's heavy concentration of industrial zones are the primary driver of its emissions. As a point of comparison, in a lower middle-income country such as India, only 9% of emissions in the city of Delhi are driven by rising incomes. In the world's

Figure 19: Contributors to CO2 concentration



Source: Authors' elaboration based on data based on World Bank's Urban CO2 Emissions: Global Analysis with New Satellite Data (2021).

[43] World Bank (2021), Urban CO2 Emissions: Global Analysis with New Satellite Data. The global analysis of gridded emission in cities by the World Bank compares CO2 concentrations observed from satellite data with predicted CO2 concentrations from a model, between 2014 to 2020, for 1,236 cities (with populations over 500,000) in 138 countries. It shows the difference between observed and predicted CO2 concentration in parts per million in a few Egyptian cities.

[44] These values do not include the emissions accumulation from carbon intensive buildings and waste sector and hence the actual CO2 concentrations could be even higher.

[45] The difference between the observed and predicted concentrations

[46] Susmita Dasgupta et.al, Urban CO2 Emissions: Global Analysis with New Satellite Data, World Bank (2021)

[47] The contributions of key categories: Industry (power plants, steel mills, refineries, cement plants); Fires (carbon emissions from agricultural and forest burning); Income (non-industrial CO2 sources that are correlated with income); Population (population and population density); and Climate (heating degree days), in predicted CO2 concentrations were assessed in the global study quoted earlier.

largest megacity—Lagos, Nigeria—only 4% of emissions are driven by incomes. It is therefore evident that rising income levels and changing consumption patterns in Egyptian cities are leading to an increase in the emissions intensity of the urban economy. Appropriate policies must therefore be designed to change behavior in the direction of low carbon development.

3.1. Drivers of cities' contributions to GHG emissions

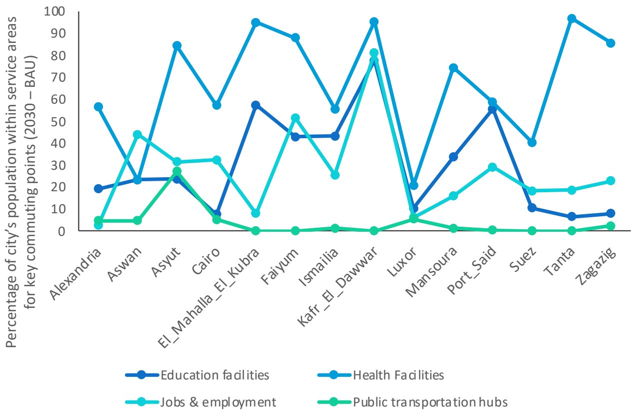
Emission-intensive city systems and service delivery choices play a defining role in the coupled growth of GHG emissions with urbanization. The adequacy and efficiency of existing practices across green/energy efficient buildings, urban mobility models, solid waste and wastewater management, and green areas/NBS play a key role in the net GHG contribution of population centers. Egyptian cities exhibit suboptimal performance in adopting low-carbon solutions across most of these critical sectors.

In 2018, the road transportation sector contributed 16.4%, or ~54 MtCO2e, of Egypt's GHG emissions, with emissions from urban mobility systems representing a primary driver of the GHG footprint. Unmanaged urban expansion and the lack of efficient urban public transport systems leads to increased dependence[48] on private vehicles and commuting distances in cities, resulting in increased vehicular emissions, congestion, air pollution, and GHG emissions. The negative externalities of poor public transport systems, unsafe mobility, and limited penetration of EVs in urban transport systems go beyond GHG emissions to also impact public safety and livability. For example, air pollution levels in Greater Cairo are among the highest of all global cities, imposing a toll on the health of its inhabitants. Even within the MENA region, which leads the world in rates of morbidity and mortality due to ambient air pollution (AAP), Egypt has the highest rates. More than 150 per 100,000 people died prematurely in Egypt due to AAP in 2019.[49]

In the case of EVs, governments can play an essential role in providing public charging infrastructure to enhance EV penetration and the quality of service delivery for private and public mobility across cities. In Egypt, however efforts to leverage this government role at the local level have been limited. Looking beyond EVs, an overall limited focus on compact cities, a lack of non-motorized/shared micro-mobility options, and increasing spatial expansions/urban sprawl have led to growing emissions due to strong linkages between spatial expansion patterns and public transport systems.

Lack of coordinated land use and transport decisions can affect livability, reduce connectivity—impacting access to jobs—and can also lead to increased emissions. Proximity to public transportation, which is another key element of the urban form, remains a challenge in all cities. In Asyut 22% of the population lives within walking distance of a bus stop, but in the rest of the cities, this percentage remains lower than 8%. The poor accessibility of key critical services (such as education facilities, hospitals, jobs and employment centers, public transportation hubs/bus stops, etc.) strongly correlates with increased uptake of private motorized vehicles.

Figure 20: Percentage of cities' population within service areas (Education and Health facilities, Jobs and Public Transportation) for key commuting points



Source: Authors' elaboration of the results of the Urban Performance tool results

[48] Over recent decades, there has been a marked increase in the number of cars per household (+ 220%) and increase in transport mobility (+ 77%) which, together with the sharp population increases, has resulted in a spectacular increase in the number of trips (+ 213%) and a marked increase in congestion levels and travelling times, depending on the geographic areas.

[49] World Bank, n.d. "Blue Skies, Blue Seas. Air Pollution, Marine Plastics, and Coastal Erosion in the Middle East and North Africa. Draft."

Across the major cities, current urban expansion patterns are expected to lead to a 24% increase in the per capita daily mobility footprint by 2030. An urban growth modelling assessment[50] across the key cities found that the annual mobility footprint will increase by ~15,480 bn vehicle km traveled (VKT) by 2030, with travel distances increasing from 13.6 km/capita/day to ~17 km/capita/day. An increase of this scale will drive GHG emissions, congestion, and air pollution unless Egyptian cities shift to more sustainable, green, and efficient urban mobility systems and integrate compact city development principles through efficient and integrated urban planning. BAU projections for 2030 suggest that density is expected to increase in just two of the 14 cities. In the remaining 12 cities, density is expected to drop from 316 to 273 inhabitants per hectare, on average. Suez represents the most significant drop in the projections, with an expected change from 168 to 49 inhabitants per hectare. A reduction of this magnitude could potentially increase dependency on private vehicles (5%), increase VKT (6%), and increase the emission of pollutants (3%). Such unmanaged urban expansion will further result in declining performance on proximity indicators—for instance, in the city of Alexandria, the proximity to health facilities decreases by 10% in 2030 as compared to proximity in 2021.

Residential and public buildings account for 17.42 MtCO2e[51] annually (2019), but there is a rather limited focus on developing green buildings, promoting captive green energy applications, and inculcating urban energy-efficiency practices. As a result, this core aspect of city systems continues to drive GHG emissions and contribute to cities locked-in emissions. As temperatures and heat stresses increase due to climate change and income levels rise, driving a higher dependence on—and ability to pay for—energy-intensive demands for cooling, emission intensities are expected to increase.

The scale of urbanization and need for affordable housing across Egyptian cities present an opportunity to integrate green building principles. Currently, 21 million units of Egypt's existing residential and public building stock have a limited or no focus on green building. Given high population growth and rapid urbanization, by 2030, Egyptian cities will require an additional 4.4-4.5 million residential units as well as 23-24 million m^2 of commercial buildings (offices, hotels, retail establishments, etc.). If these additional unites are constructed without a low carbon and green focus, they will continue to increase the per capita energy consumption and emissions footprints of cities. Around 5.2% of Egypt's urban population lives in informal establishments[52] that require an additional 415,000 affordable housing units, presenting opportunities for government to align affordable housing and efforts to reduce cities' carbon footprints. A large body of literature, including from the IPCC and the International Energy Agency (IEA), suggests that integrating green building and urban energy efficiency as part of cities' systems presents significant, economical potential for mitigating GHG emissions as well as optimizing resource-dependent emissions intensities. A recent study by the International Finance Corporation (IFC)[53] underscored the need to renovate between 3% and 5% of the existing global building stock every year until 2050 to put the buildings sector onto a 1.5°C-compatible pathway.

The waste sector contributed ~8%[54] of Egypt's GHG emissions in 2019, due to the lack of adequate municipal solid waste (MSW) management systems in cities. Of the 21-22[55] million tons of MSW generated annually in Egypt, 80% is dumped, burnt, or littered, while less than 12% is treated and recycled. Such high levels of mismanaged solid waste lead to significant volumes of GHG emissions from untapped methane and black carbon, while also contributing to air pollution, resource degradation, and the subsequent amplification of climate change impacts (as detailed previously). Low levels of recycling

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[50] The assessment has conducted as part of this study using Capsus' Urban Performance tool.

[51] Including both embedded carbon and energy consumption. WRI's climate watch data tool https://www.climatewatchdata.org/ (lasted accessed September 30, 2022)

[52] Egypt's 2021 Voluntary National Review, Ministry of Planning and Economic Development.

[53] IFC (2021) Green buildings: A finance and policy blueprint for emerging markets

[54] 2019 data from Climate Watch Historical GHG Emissions. 2022. Washington, DC: World Resources Institute. Available online at: https://www.climatewatchdata.org/ghg-emissions. Official estimates from Egypt's First Biennial Updated Report (BUR), indicate that in 2015, the waste sector contributed to 8% of the total GHG emissions.

[55] Data is from 2016 and covers MSW from both urban and rural areas in Governorates.

represent a lost opportunity to tap into resource recovery and the circularity potential of waste. The low number of energy recovery applications from waste (bio energy, waste to energy) highlights two additional missed opportunities for potential climate change benefits: i) tapping methane from waste (methane is a key GHG with 25 times the global warming potential of CO_2) and ii) replacing fossil fuel usage with electricity, bio-CNG (compressed natural gas), bio-methane, etc that can be generated from waste. The organic content (56%) in the amount of mismanaged waste has a bio-energy resource potential of ~650 million Nm3/annum of biogas that is currently unrecovered and is lost. This is a missed opportunity considering the increasing energy demand with urbanization.

Poor recycling levels and lack of plastic circularity have a wider climate change impact given the growing fossil fuel resource footprint of global plastics manufacturing. The fossil fuel resource footprint of global plastic production has tripled since 1995, contributing 1.7 GT CO_2 in 2015. Even as the use of renewable energy grows, fossil fuels are increasingly used to meet the growing demand for plastics. And these plastics are ending up in the oceans. Egypt, unfortunately, contributes significantly to marine litter, due to its high level of mismanaged waste with high plastic content (13% of mismanaged waste meets this criteria), long coastline, and the concentration of urban clusters in Nile Delta.[56] The 0.25 million tons of marine plastic waste that Egypt contributes annually to the Mediterranean Sea is followed only by Turkey (0.11 million tons annually). Egypt's annual contribution is projected to grow to 0.5 million tons by 2025.[57] Due to poor municipal waste management systems that fail to recycle and implement plastic circularity systems, ~51 million tons of mismanaged plastic will be produced, which can further increase Egypt's contribution to marine litter. Growing evidence suggests that plastic pollution (and microplastics) interferes with the absorptive capacity of soils and the world's ocean as natural carbon sinks by disrupting the growth of algae and other flora and fauna that sequester carbon.

Given that waste generation trends are coupled with economic growth, Egypt's limited infrastructure will lead to significant amounts of mismanaged solid waste and plastics. As waste generation increases in tandem with Egypt's economic and per capita income growth, the waste generation in the 14 major Egyptian cities is anticipated to increase by 68%, from ~12 million tons annually in 2021 to ~21 million tons in 2030. This significant jump is due to the combined effect of urban population increases in these cities as well as the increase in per capita waste generation rates driven by income growth. Given existing service delivery levels and the abovementioned forecast of waste volumes, the BAU scenario suggests that the total volume of mismanaged waste between 2021 and 2030 will be approximately 135 million tons.

For cities that have developed in carbon-intensive way, with inefficient building and a high dependence on individual cars, the decarbonization process will be challenging as it requires a significant level of investment to develop public transit and retrofit buildings. These cities and may find it difficult to attract financing. These anticipated challenges underscore the need to align further urbanization with a low-carbon cautiousness that can lead to low-GHG emission pathways in the coming decades. This is particularly true in the context of Egypt, where urbanization by 2050 is anticipated to add as many new city dwellers as currently exist, cities represent key GHG contributors from a spatial perspective, and cities face significant climate change vulnerabilities (such as heat stresses) that are closely correlated with GHG emissions.

[56] Losses from plastic pollution are estimated at €641 million per year for the Mediterranean, including up to €268 million in tourism, €235 million in the maritime industry, and €138 million in fisheries. Dalberg (2019). "Stop the Plastic Flood: How Mediterranean Countries Can Save their Sea." Report for the Worldwide Fund for Nature (WWF), Gland, Switzerland.

[57] Dalberg (2019). "Stop the Plastic Flood: How Mediterranean Countries Can Save their Sea." Report for the Worldwide Fund for Nature (WWF), Gland, Switzerland.

4. Urban Institutional Systems and Financial Sustainability

4.1. Institutions and planning systems

The existing institutional system in Egypt remains highly centralized, very hierarchical, and extremely fragmented. Egypt's constitution recognizes that public administration needs to be organized at different levels to be closer to the people. The constitution defines multiple levels of public administration, including local administrative units, as legal institutions—governorates, cities, and villages. The empowerment of local administrative units is ensured in Articles 176 and 177. Beyond legal and administrative autonomy, the constitution further clarifies that each local administrative unit should have an independent budget and acknowledges the right of local administration units to collect their own revenues. However, the current structure[58] and functioning of the territorial administration is not well-equipped to meet emerging development needs. While Egypt's population has grown ten-fold over the past 100 years, the number of governorates and their operational modalities have not evolved significantly, despite reform efforts. Governorates still do not have adequate capacity for planning and delivering public services efficiently. At the sub-governorate level, local administrative units have yet to become organizational entities with their own distinct responsibilities and independent budgets. The institutional weaknesses, fragmented governance framework, and limited autonomy of local administrations—both at the governorate and local level—have created a significant gap between the public sector and the people it seeks to serve.

In practice, there are no separate legal, administrative, or budgetary local administration entities below the governorate level. While the Central Authority for Organization and Administration (CAOA) formally classifies district-level administration units as administrative entities that are separate from governorates, in practice, district offices act as sub-divisions of their respective governorates. In fact, district offices are reflected as cost centers within their governorate's Diwan (provincial) budget.

Consequently, at the local level, service delivery involves multiple institutions, with fragmented accountability and limited financial resources. In terms of urban service sectors, power and responsibility are divided between the federal government, special authorities, and local administration units, but a clear unifying legal framework is missing.[36] In practice, the *de facto* assignment of powers and responsibilities over sectoral functions is characterized by a lack of local control over financial resources. While the Ministry of Local Development has organized six local development programs,[59] at the governorate level.[60]. n important challenge for these programs is that the functions the Ministry has assigned to them are not results-oriented; the list of development projects do not effectively link public sector objectives (social development; economic development; environmental improvement, etc.) with the local development programs. The current assignment of functions focuses almost exclusively on local infrastructure development. As a result, the current system creates a disconnect between the planning and development of infrastructure and the planning and delivery of recurrent local services that will be needed to support that infrastructure and its users or residents. Outside of the local development sector, the current situation is even less clear. Sector line ministries and their service directorates do not have clearly distinguished areas of responsibility for investment planning. As a result, service directorates undertake investment planning in the absence of any assurance that the respective line ministry will

[58] Currently, Egypt's territorial-administrative structure is legally structured based on five hierarchal levels or categories of Local Administrative Units (LAUs): Governorates (muhafaza), Rural Districts (markaz), cities, urban district (hay), and local administration unit at the village level.58 Authority is exercised by and through governors and heads of LAUs appointed by the central government. Egypt's 27 Governorates sit at the apex of the sub-national administrative hierarchy and constitute the main local administration and service delivery units in Egypt.

[59] (1) urban and rural development; (2) Environment improvement; (3) Local economic development; (4) Roads and Transportation; (5) Support local services; and (6) Local administration and technical support

[60] (1) urban and rural development; (2) Environment improvement; (3) Local economic development; (4) Roads and Transportation; (5) Support local services; and (6) Local administration and technical support

approve the plans, or if they will simply "absorb" sub-national plans into national plans. The bottom line is that governorate-level service directorates do not appear to have well-defined, devolved decision-making powers for specific aspects of their sectoral mandates.

Existing planning systems at the local level lack the integrated approach that is critical for climate-smart spatial development and for integrating climate sensitivity into city planning and management (covering spatial, land-use, infrastructure, economic development, and investment/financial dimensions). Integrated local and sub-national climate-smart planning systems are critical for integrating climate sensitivity into spatial planning and development, developing green public spaces and blue infrastructure, pivoting toward green buildings, improving connectivity and mobility, and enhancing city competitiveness. While local service delivery plans and local sectoral investment plans are currently prepared through a bottom-up approach, there is no meaningful decision-making power at the subnational level, forcing local administrations to rely on decisions made by officials at the higher level. In practice, the system works as follows. The general bureaus and the sectoral directorates in each governorate submit their annual investment "plans" to their respective ministries. Each ministry then selects investment plans to be included in its unified sectoral plan and submits it to the Ministry of Planning and Economic Development. As for the governorates' other directorates and general bureaus, their requests for investment budgets are created in the absence of an agreed-upon developmental vison or plan for the governorate. This fragmented investment planning process results in weak linkages between the national socioeconomic plan and sub-national plans. The country's overall socioeconomic development plan is, therefore, implemented with limited synergies between different sectors from a spatial/regional perspective. It is vital that the planning process at the sub-national level is integrated, climate-risk informed, emission-sensitive, and well-resourced to ensure that priorities (ideally those that drive sustainable, resilient, and inclusive development) are identified and implemented in a focused manner.

Cross-cutting constraints in Egypt's land governance ecosystem impact land-use planning and management for urbanizing cities. Public land, which accounts for over 90% of Egypt's surface area, is managed through a complex system of laws and by several institutions with confusing mandates , which muddies the process of both protecting this land and allocating it for development purposes. Urban land-use planning and administration systems are very centralized and bureaucratic, and this—combined with the lack of access to proper private land registration—has pushed more than 60% of the Egyptian economy into informal markets and slums. Land governance suffers from key constraints stemming from the multiplicity of government institutions (most of which suffer from limited capacity), opaque systems, and the lack of clear regulations and by-laws for land valuations, land ownerships, land tenures, land readjustment, and land pooling for urban expansion. Further, the challenges in land governance, when paired with those facing planning systems, result in disconnect between land use changes that are needed for balancing the economic and development infrastructure with the actual needs. These challenges also hamper the implementation of any local land use changes for climate risk mitigation, green zoning, redevelopment, etc. Land and property markets that could be used to tap land-based financing remain unregulated and subject to a constrained supply and demand system driven by a myriad of individual intermediaries (mainly informal brokers acting as sole actors).

The Government of Egypt has begun to make some progress in improving aspects of local public administration and its functioning. Examples include i) the development of a formula-based allocation of capital budget ceilings for governorates and districts; ii) new legislation[61] for local administration, socio-economic planning, and strategic (or spatial) planning, all of which contribute to empowering local level administrative units and making them more effective, iii) the enactment of regulations and laws that

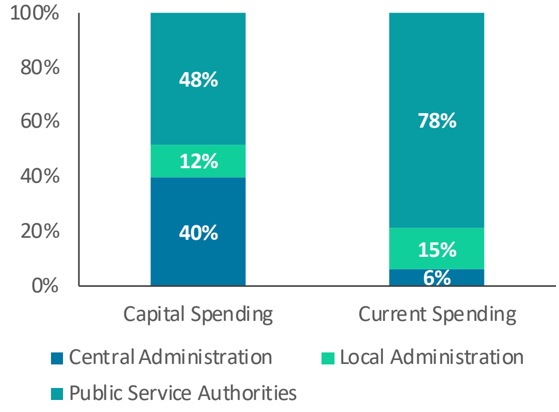
[61] (i) a new local administration bill to replace the current local administration law No. 43/1979; (ii) a new planning bill to replace the current law No. 70/1973 governing the preparation of the National Socio-economic plan; and (iii) amendments of the building law No. 119/2008 to enhance the process of undertaking strategic and urban plans.

strengthen local administrative authority,[62] iv) the implementation of national and presidential programs that focus on local and urban development challenges and service delivery issues, and v) the implementation of pilot programs to test innovative approaches to local-level investment planning, asset management, own-source revenue administration, service delivery automation and streamlining, citizen engagement and participation, and transparency. While these (and other) actions represent important moves in the right direction, significant capacity and resources are needed to enable implementation of such laws and make a meaningful shift toward spatially integrated, resilient, and climate-smart urban services.

4.2. Fiscal sustainability and access to financing

The financial resources that local administration units need to undertake urban investments and provide sustainable services remain limited. Local administration units[63] in Egypt have a relatively narrow scope for public investments, limiting their ability to sustainably finance the priority investments needed for climate-resilient and low carbon infrastructure development and service delivery. For context, total local public investment spending in Egypt is very limited—amounting to approximately 12% of total public capital expenditure and about 0.33% of GDP. Governorate jurisdictions in Egypt typically include both urban and rural areas—but unlike similar sub-national governments in many other countries, they do not make significant investments in vital sectors. This partly explains the relatively small spending footprint of local administration units in Egypt when compared to local administrations or local governments in other countries. Almost fifty percent of total government staff are posted at the local level, and yet that level only receives 15% of budgetary resources, meaning that local administrations are substantially underpowered, lacking the financial resources to leverage their human resource potential to deliver effective public services.

Figure 21: Administrative distribution of current and capital spending (FY16)



Source: Authors' elaboration of the data from World Bank's Modernizing Local Administration in Egypt: A Roadmap for Fiscal Decentralization (2021)

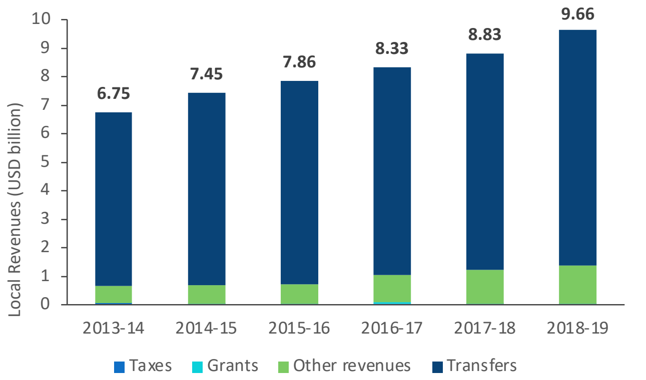
Local administration spending in Egypt is dominated by recurrent spending. Recurrent spending averaged 93.0% of total spending in FY2009-16, while capital spending was low, averaging 7.3% across that same period and trending further downward in more recent years. In the Egyptian annual budget process, the recurrent and capital budget formulation processes are not well-aligned. During the budget formulation process, recurrent and capital expenditure planning is led by different ministries at the central level, with the Ministry of Finance responsible for formulating the recurrent budget and the Ministry of Planning for the formulation of capital expenditures, including local investment resources. Recurrent and capital funds also follow different institutional routes to (and at) the subnational level. While recurrent resources are provided to all governorate directorates (i.e., Diwan and sectoral directorates), the vast majority (80+ percent) of local investment funds reach the local level through the Governorate Diwan. As a result, the Governorate Diwan tends to be a capital-focused entity, whereas sectoral directorates at the governorate level focus almost of their efforts on the recurrent provision of sectoral services.

[62] Parliament has approved several laws that will have a direct impact on regulating service provision and the role of the local government in enhancing local economic development, among which are: (i) law No. 150/2020 to regulate street parking; (ii) law 154/2019 to regulate shops; (iii) law No. 92/2018 to regulate mobile food carts; Law No 208/2020 to regulate advertisement in public roads, among others

[63] Central Administration Units (CAUs): typically related to general ministry offices, central departments, national research centers and institutes, national authorities, and agencies and supreme councils. Public Service Authorities (PSAs): provide services to the public on a non-market basis.

The revenues of local administration units (LAUs) are predominantly dependent on ad hoc fiscal transfers from the central government to meet the service delivery financing needs. Egypt delivers one of the highest levels of intergovernmental fiscal transfers to local institutions, as compared to peer countries in MENA region. The revenues of LAUs are made up of shared revenue from central taxes, transfers, and local own-source revenues (OSR). A major fraction (86% in 2018/19) of local administration funding is provided by the central government through fiscal transfers. The share of national taxes allocated to LAUs has been declining for some time; as of 2018/19 it has been almost negligible. Fiscal transfers to LAUs between 2013/14 and 2018/19 increased by 36% (~7.2% per annum), but with inflation running at an average of 13.8% per annum over the same period, transfers from the national government are not keeping pace with inflationary increases. In recent years, the GoE has taken steps to introduce a formula-based approach to allocating resources to governorates (and setting an indicative ceiling for districts) that would allow LAUs to plan their infrastructure and recurrent services within the context of a hard budget constraint, but it has not yet been scaled up.

Figure 22: Revenue sources for LAUs



Source: Authors' elaboration of the data from World Bank's Modernizing Local Administration in Egypt: A Roadmap for Fiscal Decentralization (2021)

OSR mobilization is constrained by outdated laws, centralization of taxes, and a limited focus on ensuring the financial sustainability of service delivery, thereby limiting ability to leverage private sector financing as well. Local administrative units in Egypt have several own-source revenue streams,[64] but their mobilization remains subpar due to both outdated laws and the lack of incentives for local administrations to generate their own revenues. Globally, property taxes are a major source of local OSR for well-functioning cities. This is not the case in Egypt. Over the years, most taxes in Egypt have been centralized, leaving only vehicle taxes and local fees at the local level. As a result, local governments are very limited in their ability to levy and collect taxes. Moreover, user charges and the financial sustainability of urban service provisioning lack a clear focus. Land-based financing likewise, remain untapped due to cross-cutting regulatory challenges associated with land governance (highlighted above). LAUs are (appropriately so) not in a position to borrow, as their finances are an integral part of the national budget. Public-private partnerships (PPPs) can be an option for financing urban investments, but in the Egyptian context, a weak revenue base and fiscal health, lack of concessional financing sources, and limited capacity at the local level to design, structure and monitor complex PPP[65] transactions inhibit the leveraging of such financing. The overall management of OSR remains fragmented, with various departments responsible for administering specific fees and charges. The current predominance of manual and semi-automated revenue collection in Egypt further constraints OSR mobilization by creating loopholes for revenue leakages. In sum, limited revenue mobilization and constrained funding has made it difficult for local governments to develop and maintain necessary long-term urban infrastructure and existing services to meet the current and future urban needs for climate resilient, low-carbon cities.

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[64] These include rentals of state land, shares of quarry revenues, proceeds from the sale of goods and services, revenues from productive projects, rentals of governmental buildings, rentals of utilities, fines and penalties, optional donations, market revenues, housing unit rentals and other revenues

[65] Egypt's PPP Law No. 67 of 2010 permits authorities to enter into PPP contracts for all infrastructure and public services projects, to include the construction, financing, and maintenance of such projects.65 However, according to Egypt's 2020 Country Private Sector Diagnostic, very few PPP transactions closed in Egypt over the past few years and even lesser by sub-national and local governments.

5. Reimagining the Transition to Resilient and Low-carbon Cities

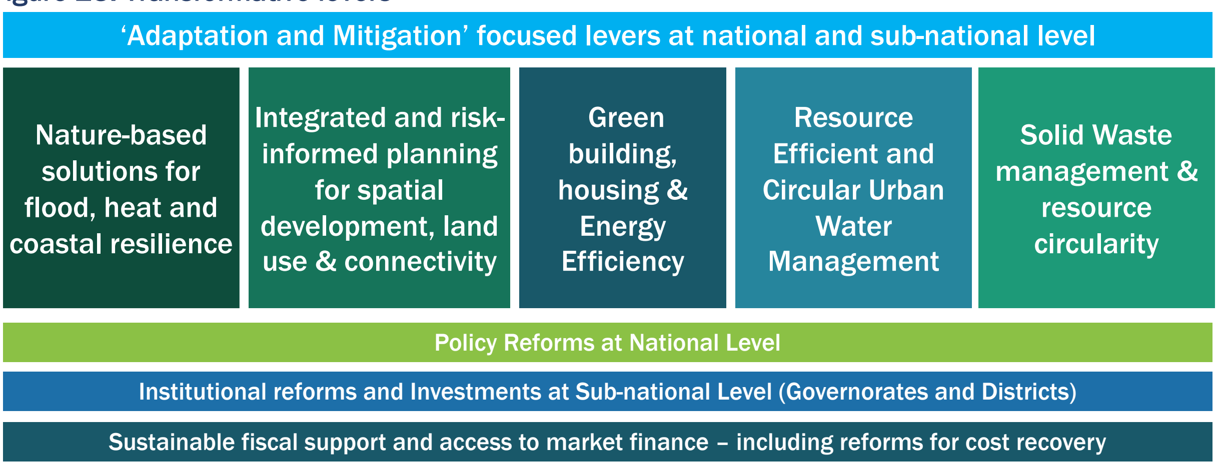
5.1. Strategic direction

Egypt's cities need to pivot toward a resilient, climate-smart, and resource-efficient urban development trajectory. This pivot will require a balanced, carefully calibrated approach centered around adaptation and mitigation and whose implementation is focused and spatially integrated across various city systems/services. The national government plays a key role in policy making, developing systems, and mobilizing resources that are critical for implementation of various transformative levers. At the same time, however, capable and empowered sub-national institutions within Egypt's multi-tier public administration system are fundamental to the country's climate action.

To enable Egypt's transition to a climate-resilient and low-carbon trajectory, its cities will need green, resilient, sustainable, and inclusive systems for urban infrastructure and service delivery, spatial and investment planning, and efficient land-use management. Adopting a "climate-resilient and low-carbon cities"-centric approach is necessary to i) mainstream a specific focus on cities for climate adaptation and mitigation interventions as part of sub-national governance, planning, and financing mechanisms, ii) embed climate risk sensitivity, emission sensitivity, sustainability, and resource efficiency into city planning, land-use, financing, institutional, infrastructure, and service delivery systems, and iii) strengthen linkages among sectors such as energy, transport, water, waste, and other municipal infrastructure in the development and implementation of strategies for a long-term transition at the local level. An initial focus on cities can also help accelerate progress toward ambitious national GHG mitigation goals and enhance livability and economic productivity.

This transition will require national reforms as well as the strengthening of institutional capacities and mobilization of adequate financial resources at the sub-national/local level. It is critical to strengthen the enforcement of national policies and shift to robust service delivery and urban infrastructure systems that reduce climate risk vulnerabilities as well as contribute to the country's GHG mitigation ambitions. Figure 23 below summarizes the transformative levers, detailed in subsequent sections in this chapter, that are available across various areas (policies, systems, and investments) to strengthen "Actions across urban systems:" Pillar 1 of Cities and Climate Change Framework (refer to the explanatory paragraphs following Figure 4) and "Enabling systems:" Pillar 3 of Cities and Climate Change Framework (refer to the explanatory paragraphs following Figure 4). These two pillars are crucial to transition Egyptian cities toward resilient and low carbon urban growth trajectories.

Figure 23: Transformative levers



5.2. Transformative levers across urban systems

5.2.1. Nature-based solutions for flood, heat, and coastal resilience

Mainstreaming nature-based solutions (NBS) as part of infrastructure and service delivery systems in cities today can help manage risks and enhance adaptive capacity against climate hazards and chronic stresses (heat, floods, coastal risks, air pollution). In cities, NBS serve as GHG sinks while also enhancing resilience to climate change hazards such as heat stress and flooding, contributing to clean air, and delivering as much as five times the cost effectiveness when compared to engineered solutions.[66] For example,[67] in the United States, across 52 coastal defense projects, nature-based solutions were estimated to be two to five times more cost effective at lowering wave heights and increasing water depths compared to engineered structures. Implemented well, nature-based solutions have significant potential to enhance urban cooling and livability, decrease air pollution levels, increase carbon absorption (GHG sinks), mitigate the destructive effects of floodwaters, and manage SLR. Five examples of NBS integration methodologies are described below.

- Urban areas can be cooled effectively through **increased vegetation** for shade and evaporative cooling and **the use of more reflective materials.** In newly built areas, streets and buildings can be oriented to maximize shade and airflow. Lowering temperatures in cities with mainstreamed penetration of NBS and green cover can also lower energy costs and prevent heat-related illnesses.
- Better land management with NBS to restore areas that should be protected is essential, especially in the context of desertification. In cities that receive little rainfall, natural ways to preserve vegetation can help manage water flows.
- Nature-based solutions can be deployed to assist with stormwater management, water treatment, and rainwater harvesting, contributing to the overall flood and water resilience across Egyptian cities.
- Guiding urban growth away from high-risk areas (such as flood-prone areas) can help minimize future damage and preserving natural land can help implement nature-based solutions.
- Increasing the area of green spaces and afforestation in all existing and new urban cities in a programmatic manner, with adequate accountability and resources, is necessary for mainstreaming NBS across Egyptian cities, thereby enhancing the adaptive capacity of cities against climate change stresses.

Enhancing resilience to coastal risks requires a comprehensive approach backed by a coordinated regional and local effort. Adaptation is the most viable long-term strategy to address the risk of SLR. Adaptation is estimated to reduce SLR flood damage costs by a factor of 10.[68] Early investment in adaptation is reflected in higher discounted benefits to costs over the long term. Similarly, the cost-benefit ratio of combining dikes and mangroves has been estimated to be 1.5 times higher than the ratio of dike-only protection,[69] which highlights the potential of NBS as an investment option to protect tourism infrastructure and urban areas on the Red Sea and Mediterranean coasts. The DIVA model simulation of Egypt shows that 37% of the most vulnerable coastline needs to be prioritized for protection. Therefore, it is reasonable to prioritize coastline protection investments based on three categories—about one-third of the coastline with high priority for protection, about one-third with medium priority, and about one-third with low priority. Adaptation to SLR generally falls into one of three categories: i) coastal protection through hard and soft measures, ii) accommodation through policies that enable adaptation to SLR, and

[66] Gregg et, al (2021): "Benefit Accounting of Nature-Based Solutions for Watersheds: Guide."

[67] Seddon Nathalie; Chausson Alexandre; Berry Pam; Girardin Cécile A. J.; Smith Alison and Turner Beth. 2020, "Understanding the value and limits of nature-based solutions to climate change and other global challenges," Phil. Trans. R. Soc. B3752019012020190120

[68] Jevrejeva et al 2018

[69] Naoko Kumano , Makoto Tamura , Tomomi Inoue , and Hiromune Yokoki, 2021. "Estimating the cost of coastal adaptation using mangrove forests against sea level rise", Coastal Engineering Journal, 63 (3) 263-74.

iii) retreat through a planned movement of assets or activities landward to minimize exposure to SLR.[70] Soft measures include leveraging NBS such as mangroves and other vegetative barriers, re-vegetation to stabilize seabed sediment, wetland restoration, dune stabilization with NBS, vegetative buffers, dune rebuilding with native palm and posidonia grasses, and conservation zones to preserve priority coastal habitats. While the combination of soft measures and NBS offers adaptation benefits for scattered coastal communities, agricultural lands, and aquaculture activities along the coastal zone, they also play a key role in enhancing the efficiency of hard measures in a cost-effective and ecosystem centric manner, leading to wider economic benefits for coastal communities. Such an integrated approach would require:

- A streamlined, prioritized implementation of Integrated Coastal Zone Management (ICZM) with clear institutional roles and responsibility allocations as well as defined funding and budgeting.
- Integration of the local development plans of coastal cities with regional plans, accompanied by the customization of local development plans to include local hazard levels and coastal flood risk mitigation/adaptation plans aligned with socio-economic importance of coastal cities.
- Scaling up the Egyptian government's mangrove planting efforts in the Red Sea Governorate, along with the private initiative led by HSBC Bank, WRI, WWF and a network of local partners through the Climate Solutions Partnership, as public private partnerships to promote investment in NBS throughout Egypt's coastal zone.

5.2.2. Integrated and risk-informed planning for spatial development, land use, and connectivity

Risk-informed spatial development to manage urban growth and sustainable land-use management can enhance efficiency in the use of land resources, while reducing climate vulnerabilities. Compact and climate risk-informed urban growth is fundamental to increase efficiency and sustainability considering the multiplicity of climate hazards and land resource constraints in Egypt. Urban growth modelling highlights that better managing urban expansion through transformative actions in the 14 major cities can result in the conservation of nearly 39,000 hectares of green areas, including agriculture land. These transformational actions would result in the conservation of permeable surfaces, which are key for flood management, but would also contribute to food safety by preserving prime agricultural land, as well as mitigating the heat stresses faced by Egyptian cities. Compact urban growth also requires prioritizing infill against brown-fill development to increase densities. With land being both a GHG source and a GHG sink, land-use practices across cities drive how the evolving urban morphology correlates with their resilience, especially considering the acute climate change risks of heat waves, urban heat islands, urban flooding, and desertification. To achieve better managed urban growth and land use, it will be necessary to update city-level, long-term detailed plans and strategic plans; strengthen legal frameworks; define functional roles for the multitude of public stakeholders; enable climate risk-focused land re-adjustments (including land pooling, expropriations, voluntary purchases), land registrations and land-related taxation; and strengthen building codes.

Building on existing capabilities, Egypt should invest in a more comprehensive flood risk management framework to reduce potential loss and damages to human lives and the economy. An effective management framework for flood risks requires a four-part approach: i) improved flood prediction and communication; ii) improved emergency response planning; iii) investment planning to reduce the risk of flood hazard; and iv) financial risk mitigation measures to protect assets where risk cannot be reduced. The existing flood early warning system could be enhanced specifically for flash floods by linking it to a satellite-based Flash Flood Guidance System (FFGS) that detects potential occurrence of flash floods using open-access and readily available information on precipitation, soil moisture, and topography. If coupled with vulnerability mapping and the use of innovative communication systems, the FFGS could be used to notify communities and concerned stakeholders of an impending flood event. Hazard

[70] Dronkers et al., 1990

assessment studies and identified investments in green and grey flood protection infrastructure are needed to reduce the risk of flood hazards for higher-risk areas.

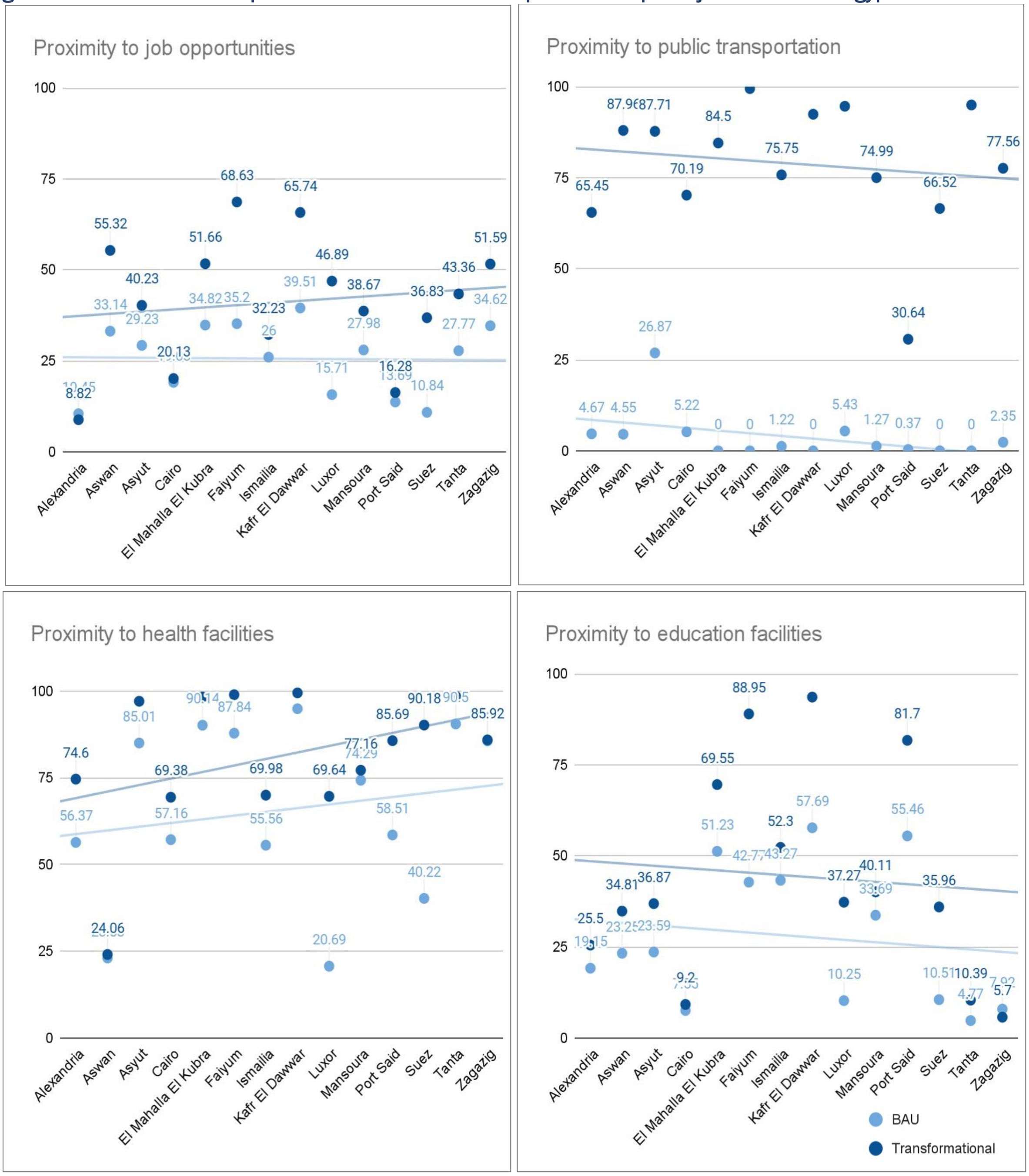
Green and efficient urban public transport systems, paired with managed spatial urban growth, are critical to reversing the increasing dependence on private vehicles and commuting distances in cities. A more extensive public transportation network would increase Egyptians' access to education, health facilities, and job opportunities. Ideally, services and infrastructure should be accessible within a 15- to 20-minute walking distance. This would decrease commuting times and encourage the use of public transport or non-motorized mobility. To enable modal shifts to public and non-motorized transport options, it is critical to address last-mile connectivity issues by configuring existing streets to support walking, biking, and high-frequency transit, and to provide space for businesses, schools, and institutions to safely operate. Relatedly, such a transformation would also require realigning lane disciplines to provide cycling lanes and pedestrian-friendly sidewalks along the most-transited routes. Demand-management strategies could also be brought to bear, by, for example, increasing prices in parking lots and limiting the number of available parking spaces. This combination of sectoral initiatives will promote walking, cycling, and commuting via public transport, as well as support the transition to resilient cities.

Modelled urban growth results across managed urban expansion and public transportation-focused transformative levers highlight significant improvement potential for balancing densities and enhancing public infrastructure across Egyptian cities. Improved proximity is highly relevant to Egyptian cities because it reduces air pollution and GHG emissions while also enhancing quality of life for and resilience of its citizens. As can be seen in Figure 24, an increased density with managed urban expansion and balanced focus on public transportation by 2030 results in these benefits in all cities:

- Shorter distances to education facilities, measured in terms of the percentage of the population that lives within 1,000 m walking distance of the nearest school.
- Higher percentage of the population living in proximity to health facilities, measured in terms of the percentage of the population that lives within 1,500 m walking distance of the nearest health center.
- Higher proximity to job opportunities, measured in terms of the percentage of the population within 1,000 m walking distance of urban areas with high job density. This is true across all cities except Alexandria, due to the densification process that occurs in central areas.
- A drastic improvement in the proximity to public transportation, measured in terms of the percentage of the population that lives within 400 m walking distance of a public transportation route.

Interventions to manage the urban form, improve connectivity, and enhance the sustainability of service delivery not only provide a path to strengthen resilience but also to contribute to emissions reduction. The way cities grow and how they are managed significantly influences their net emissions intensity. In addition to enhancing resilience to climate change hazards and contributing to clean air (refer to the previous sections), nature-based solutions serve as GHG sinks, providing an offsetting effect to cities' emissions. Similarly, integrating low-carbon and energy-efficiency levers such as energy-efficient technologies, pumping systems, efficient processes, etc., across infrastructure and service delivery choices in public transport, water supply, wastewater, and street lighting can result in dramatic GHG reductions while also lowering the fiscal burden on governments and citizens through reduced electricity bills.

Figure 24: Role of urban expansion and efficient urban public transport systems across Egyptian cities



Source: Authors' elaboration of the results of the Urban Performance tool results

5.2.3. Resource-efficient and circular water management

Rationalizing urban water use, enhancing the efficiency of urban water supply delivery systems, and reducing non-revenue/unaccounted-for water can help Egypt save over 2 billion cubic meters (bcm) of water annually. Improving urban water resources management is vital for ensuring water security in cities. Egypt's Sustainable Development Strategy 2030 has a target of reducing water losses to 15% from the current levels of about 29%. Rationalizing water usage and improving operational efficiency in the urban water supply systems in cities can help reduce inefficiencies in the use of water by households, firms, and industries. Targeted investment programs that facilitate water waste reduction, water treatment, recycling, and reuse, can help ensure water security for an expanding population. Significant investments should be made in the management of integrated urban water resources so that freshwater, wastewater, and storm water management systems work together to conserve groundwater, limit salinization, improve drinking water delivery, and build resilience (damage resistance and ensuring the continuity of supply) to climate risks and disaster events such as flooding. Reducing water losses to 25% and revising water supply norms to 80% of current levels could help Egypt save over 2.2 bcm of water in a year (over a third of estimated water production in 2050 for domestic consumption)—over and above the National Water Resources Plan (NWRP) target—through reduced demand and improved efficiency, thus making water available for other uses. Finally, capping urban water usage at 200 lpcd for key Egyptian cities could further reduce the water stress by 1.8 bcm.

Leveraging wastewater circularity and focusing on robust performance monitoring systems would reduce water security and water resource pollution risks. Egyptian cities need to focus on strengthening the regulatory enforcement and performance monitoring systems of existing wastewater treatment (WWT) plants, which in turn would strengthen water quality monitoring, the operational and treatment efficiencies of treatment plants, and GHG mitigation. Mainstreaming water use rationalization with wastewater recycling for industrial usage – with focus on tertiary treatment plants, and for agricultural use – with focus on improving the quality of treated wastewater, would deliver additional economic benefits from water resource circularity while also reducing freshwater stresses for key economic and urban centers. Further, leveraging the resource recovery potential of sludge to produce biogas and recycle essential nutrients for agricultural use could help reduce GHG emissions as well as the dependence on the chemical fertilizers that currently contribute to resource contamination. These steps would require a dedicated national policy shift toward wastewater resource circularity. That said, developing and implementing the investments at the sub-national level and across cities will be necessary, and that will require strengthened coordination among sub-national governments and relevant line ministries as well as ensuring access at the sub-national level to the necessary technical and financial resources.

5.2.4. Green buildings, housing, and energy efficiency

Green buildings and housing are one of the fundamental transitioning levers for "net-zero cities" because they provide economies of scale for transformative, low carbon-focused urbanization. Emerging evidence indicates that green buildings, or buildings that use energy and water more efficiently, have a higher value and lower risk than conventional structures against low-carbon transitions. Pivoting toward green buildings as an integral part of urbanization will also enable the mainstreaming of upstream interventions for deep decarbonization. That pivot can include several elements, detailed below:

- Retrofitting and enhancing the energy efficiency of existing buildings in a phased and programmatic manner is critical for a long-term transition to new-zero cities. Incremental additional investments to catalyze the pillars of green building and energy efficiency can provide significant mitigation returns, lower payback periods, and long-term financial returns from household energy savings and decreased demand.
- Integrating the pillar of green building into meeting affordable housing needs can lead to multi-fold socio-economic and climate resilience benefits.
- Integrating distributed renewable energy, such as rooftop solar, with green buildings can also complement and scale up the transformative levers mentioned above for energy decarbonization.
- Leveraging existing certifications, such as the EDGE certification, to reduce energy and water consumption (and GHG emissions) can help smooth the path toward low-carbon urbanization.[71] Complementing such design-focused certifications with building performance rating systems and

[71] EDGE, a green building certification system for emerging markets created by IFC. EDGE is a measurable way for builders to optimize their designs, leading to a more investment-worthy and marketable product. The EDGE software shows within minutes how committing to a few practical energy and water-saving options improves building performance at little or no cost. The numbers are brought to the forefront to reveal the most economically viable path to building green. EDGE focuses the certification process on technical aspects that yield meaningful results. This makes it easier for developers to build a portfolio of innovation that attracts new customers and boosts brand equity.

certificates such as the EU's Energy Performance Certificates (which help measure and monitor buildings' energy performance and provide tips on how to cost-effectively improve buildings' energy ratings)[72] can multiply the impact of a focus on green buildings.

The national government needs to establish clear green building codes, complemented with the necessary monitoring and regulatory frameworks for implementation. In addition, the government must develop the necessary fiscal incentives to promote green building for new constructions and retrofits by homeowners and private developers.

5.2.5. Sustainable solid waste management and resource circularity

Sustainable waste management practices focused on resource recovery maximization and circularity are a "low-hanging" opportunity to accelerate Egyptian cities' transition to net zero. To sustainably address the challenge of mismanaged waste and plastic waste and mitigate GHG emissions, Egypt requires sustained, coordinated efforts that target regulatory, institutional, financial, and market bottlenecks. The government has already made headway through the enactment of the new waste management law (202/2020), but sustained effort (in terms of resources, capacities and enabling policies) is still needed to enable the law's implementation. In particular, the GoE should strengthen the operationalization of the Waste Management Regulatory Authority (WMRA) and enable cities and governorates to enter and move up the waste hierarchy. The key building blocks of a long-term transformative pathway include:

- First, the central government should provide support for governorates and local governments to establish environmentally and financially sustainable solid waste management systems. The top priority for the sector is to end current, widespread dumping and littering, and to end plastic leakage into the environment. Financially viable systems need to be put in place, across all Egyptian cities, to provide the infrastructure and operational resources needed to adequately collect and dispose of all waste, including plastic waste.
- Second, monitoring and enforcement must be guaranteed to ensure the sound management of waste and to discourage dumping/burning. Establishing the clear accountability of local governments, with necessary incentives and penalties, is paramount for strengthening overall regulatory enforcement of the waste sector.
- Third, policies that promote recycling and resource recovery need to be consistently introduced at the national and governorate levels, to promote a national shift toward a more circular approach to resource use and consumption in the waste and plastics sector. This would require adopting a comprehensive national policy framework to maximize resource efficiency and move toward circular practices in plastic consumption and waste management through a combination of economic, fiscal, and regulatory instruments. A shift of this nature requires leadership and support at the highest level of government and will need interventions at the upstream and downstream ends of the sector across cities.
- Fourth, complementary educational and communication campaigns will be needed to ensure sufficient institutional capacity and encourage the overall behavioral changes that will be required for the country to pivot toward a more resource-efficient and sustainable model.

5.3. Enabling systems and resources

Enabling systems (policies, institutions, and financing) are fundamental to strengthening the role of cities in mitigating and adapting to climate change impacts. A lack of enabling policies, weak institutional systems for climate-smart planning (covering land-use planning, specific sectoral planning, urban investments planning, etc.), and inadequate financing could lead cities down a development path where the lock-in effects are not easily reversed and the costs of addressing climate risks and reducing emissions are extremely high and fiscally unaffordable. In this context, governorates need to focus on

[72] IFC (2021) Green buildings: A finance and policy blueprint for emerging markets

streamlining and strengthening the enabling systems for climate-informed urbanization and economic growth, as follows:

- **Climate-smart spatial and capital investment planning:** Integrate climate-smart practices in city planning systems (covering spatial and land-use planning, infrastructure planning, and investment/financial planning) to mainstream climate-change cautiousness at the local level. Such climate-smart practices play a key role in reducing cities' emissions intensity and mitigating the lock-in effect of emissions in cities' physical form and built environment. They also ensure that elements such as urban densities, land-use mix, connectivity, public transport, municipal services and infrastructure, climate vulnerabilities, and emerging hotspots are considered in an integrated manner.
- **Funding and financing:** Climate change risk mitigation requires a significant level of climate financing, but that financing needs to be supported by levers to ensure financial sustainability and cost recovery across urban sectors. In this regard, there is an urgent need to i) streamline fiscal transfers to governorates to prioritize the use of public funds for catalyzing climate-smart investments, ii) balance the investments across mitigation and adaption aspects, and iii) mobilize resources for financing climate-resilient and green infrastructure investments through the build-up of capacity and systems at the local level to leverage private sector financing, land value capture (LVC) instruments, and innovative instruments for climate/green financing.
- **Institutional systems for climate-smart service delivery systems:** Building capacities and systems in governorates and at the local level for developing, operating, and maintaining infrastructure assets is fundamental to enable the required transition across cross-cutting areas: sustainable service delivery, circular/resource efficient approaches, incentive mechanisms, environmental monitoring and enforcement, asset management systems, digital solutions for energy/resource efficiency, resilience/disaster proofing, etc.

Capable and empowered local institutions within Egypt's multi-tier public administration system will be fundamental for climate action. Empowering the local institutions and strengthening their institutional capacity and systems is vital for Egypt to advance its action against climate change at the local level—both for building resilience to climate hazards and chronic stresses, as well as for decarbonizing its economy. This is a major strategic policy shift that needs to be pursued by the Egyptian government through coordinated, planned policy and regulatory interventions. It is essential that the local administration system is functional and capable of, first, assessing climate risks and their impacts in a spatially focused and integrated manner, and second, identifying, prioritizing, planning, and implementing the necessary actions to ensure that communities and citizens are protected from the disastrous effects of climate risks—as well as the accompanying economic losses. The remainder of this section details eight additional enabling steps, specific to the Egyptian context, that Egypt can take to further enable the ability of its cities to mitigate and adapt to climate change.

Leverage the new "Unified Planning Law" to pivot existing planning systems toward an integrated approach that prioritizes climate-smart spatial development by integrating climate sensitivity in city planning and management (covering spatial, land-use, infrastructure, economic development, and investment/financial dimensions). Integrated local and sub-national climate-smart planning systems are critical for ensuring that climate sensitivity is present in spatial planning and development, the development of green public spaces and blue infrastructure, a pivot toward green buildings, improvements to connectivity and mobility, and efforts to enhance cities' competitiveness. The new planning law enhances the role of local governments (consistent with the articles of Egypt's constitution related to the local administration system and decentralization) in preparing the development of plans and encourages local governments to mobilize more financial resources to meet investment needs. That said, local governments will require significant resources (financial and technical) and enabling sub-national and local regulations in order to enact a true shift from "plans" to "resilient infrastructure and service delivery". Further, these plans need to ensure, through necessary supporting policies, that the planning process at the sub-national level is integrated, climate-risk informed, emission-sensitive, and well-resourced so that the priorities are identified and implemented in a focused manner and cities can drive sustainable, resilient, and inclusive development.

Mainstream climate resilience and low-carbon growth in urban development strategy. Egypt's seven Key Performance Indicators for Urban Development to 2030, launched in 2016, include increasing per capita green landscape in cities from .85 m^2 to 3 m^2, increasing the number of passengers using public transportation by 50% from 1.9 billion passengers, and reducing agricultural land infringement by 100%. Achieving these targets would help relieve urban heat stress, reduce desertification, and lower pollution in cities, all of which would create more livable cities that are also resilient to climate, economic, and food supply shocks. At the same time, an expected outcome is a 3% addition of land to inhabited areas, which can be optimized with focus on compact cities. While Egypt's KPI list in a good start, it should be updated to include several additional indicators for climate resilient and low-carbon urban development. These could include: GHG reduction targets; direct measures/targets of lowered pollution such as reduced concentrations of particulate matter during peak commute times; congestion levels; a measure of city growth according to densification versus expansion; volume and population accessibility estimates of drinking water; resource circularity; reduced percentage of dwellings in a flood risk zone; and more. Mainstreaming climate sensitivity in urban development in this way can promise a more sustainable urban development that is resilient to the effects of climate change.

Leverage the Ministry of Planning and Economic Development's existing national program to localize the Sustainable Development Goals (SDGs) so as to move local-level planning, fiscal, and service delivery systems in the direction of climate-resilient local development. On this front, there is a precedent as well additional action on the horizon. The World Bank-supported Upper Egypt Local Development Program focused on using performance-based approaches for integrated local development and service delivery performance in a spatially focused manner. As a follow-on from that project, a performance grant (PG) is being introduced to incentivize the improvement of governorates' institutional performance and localize the achievement of sustainable development goals (SDGs) related to livability, sustainability, access to services, and productivity. Governorates will receive additional financing conditional upon demonstrated performance in key areas—selected because they are currently acting as binding constraints to improvements in resilient infrastructure and service delivery. In this way, the PG will increase financing for infrastructure and services to governorates in a manner commensurate with their performance.[73] Integrating climate sensitivities in an updated list of performance indicators (as discussed in the previous paragraph) will be critical to incentivize governorates to plan their investments in a climate-resilient and green manner. In addition, some of the government's ongoing flagship programs, such as "*Haya Karim,"*" that focus on improving livability standards at the local and regional level also need to pivot toward climate-resilient and green development approaches for long-term sustainability. Further, these grant programs need to be supplemented by comprehensive capacity development and institutional strengthening support to assist governorates and districts in implementing the necessary reforms and developing systems to improve their institutional performance.

Build up sub-national and local resource (fiscal and technical) capacities. Pivoting toward climate-resilient and low-carbon development requires substantial fiscal resources—intergovernmental fiscal transfers, own revenues, and access to market/commercial finance—to finance city investment needs. Egypt's level of intergovernmental fiscal transfers to local institutions (governorates and districts) is among the highest in the world; these funds can serve as a powerful instrument to shift local-level

[73] The following key policy shifts are expected from the PG i) Responsive delivery of public investments with an emphasis on efficiency and accountability; ii) Improved decision-making by governorates on how to prioritize investments, allocate and manage funds (combined with performance requirements and controls); and iii) Greater emphasis on measuring and tracking governorates' performance and evaluating services.

investment planning and financing practices toward climate resilience and green solutions. Such a role for intergovernmental fiscal transfers would require:

- A strengthened intergovernmental fiscal transfer system so that governorates and districts have access to predictable, transparent, rules-based, and reliable funding for priority investments.
- The introduction, in a phased manner, of performance conditions attached to fiscal transfers to incentivize actions by local-level governments to build climate resilience and adopt green, low-carbon service delivery solutions.
- The empowerment and fiscal strengthening of governorates through the devolution of revenue powers and the ability to expand their local funding base.
- A shift from the current model of fragmented investment planning at the local level into multi-year investment planning with necessary programmatic policy push by the governorates while leveraging on the fiscal transfers from national government.
- The introduction of policy reforms that enable governorates to access, in a sustainable and responsible manner, market sources of finance to meet their rapidly increasing investment needs. This will also enable governorates to leverage on the limited public finances and blending the same with commercial sources to scale up the overall financial resources to meet the investments needs for resilient and low-carbon development pathways.

While financial resources and decision-making power are critical for enhanced local administration, the government needs to work in parallel on strengthening the capacity of local staff, motivating and creating the right incentives for them, and revisiting administrative/bureaucratic processes to address systemic inefficiencies and achieve better public services.

Leverage Public Private Partnerships (PPPs) and build sub-national capacities to design, structure, and monitor complex PPPs. The scale of the required investments underscores the need to leverage private financing for adaptation and mitigation actions. Some combination of private sector expertise, sophisticated technologies, and/or the establishment of private and public-private financing schemes will be needed to reduce inefficiencies in water management, enhance wastewater treatment, scale up NBS, mainstream urban mobility, and increase recycling and resource recovery from solid waste management (SWM). For SWM, for example, the Ministry of Environment and the Ministry of Local Development should explore ways to leverage the Waste Management Regulatory Authority's budgetary appropriation and develop tools to enable active private participation in SWM, particularly in treatment and disposal facilities for all types of waste. Finally, the significant potential to generate energy from biogas through wastewater treatment (WWT), as well the lower cost of power from biogas as compared to grid-supplied power, makes WWT a strong and viable case for private sector participation. Mainstreaming PPPs across urban sectors would require transparent and fair risk-sharing mechanisms, secured revenue streams to attract private sector financing, and concerted efforts in project development and clear risk-sharing frameworks to mitigate the risk perception associated with urban investments. Enhancing the financial sustainability of urban services (water, waste, wastewater, urban transport) in a focused and programmatic matter is critical for attracting the private sector and leveraging external sources of financing.

Leveraging external (commercial, concessional and climate financing) sources of financing through innovative instruments is critical for financing the transition to resilient and low-carbon local development. Innovative financing mechanisms can play a key role in catalyzing the transition to resilient and low-carbon urbanization, and will be needed to address the gap between the scale of the financing needs and the availability of public finances. The government may consider establishing a "Green and Resilient Local Development Fund" as a financial intermediary at the national level to leverage external sources of finance for climate mitigation and adaptation at the local level. In addition to scaling up sustainable and climate financing, such a facility can play a key role in bridging the local capacity gaps in project preparation and structuring. Various innovative instruments such as credit enhancement instruments, concessional financing, and securitization of carbon credits can be integrated within the Green and Resilient Local Development Fund to enhance the market attractiveness of local/municipal projects across key sectors such as waste, recycling, wastewater, water, nature-based solutions, EVs for public transport, green buildings, etc.

Mainstreaming digital systems for urban management and local governance can provide cross-cutting benefits in the areas of enhancing efficiency, reducing risks, and enhancing the resilience of cities. Digital information systems that pull together information on land, land use, buildings, and available services can play a key role in climate-sensitive planning, while also providing a solid base for long-term improvements in city management and city finances. Some of the cross-cutting digital interventions that could enable service delivery efficiency and catalyze a shift toward resilient and low-carbon cities include:

- Digital building platforms, which are fundamental to enhancing property tax collection, monetizing land assets, implementing land value capture instruments and TIFs (tax incremental finances) for adaptation, and scaling up nature-based solutions across cities.
- Smart digital solutions (such as SCADA - Supervisory Control and Data Acquisition, for water and wastewater systems, water quality monitoring systems, asset management systems for preventive maintenance, etc.) for wastewater and water management systems can improve the efficiency of existing service delivery systems and assets while also enhancing resource governance at the local level.
- Integrated and sound digital technology-enabled monitoring systems for the waste sector can enable strict enforcement of existing rules and regulations at various levels.
- Energy efficiency and localized energy management systems can play a key role in enabling demand-side management measures for public and private consumption while also enhancing the resilience of energy grids.
- Digital solutions are fundamental to enabling "Mobility as a Service," as well as leveraging shared mobility and non-motorized transport (NMT) modes to enhance the inclusivity of public transport systems and implementing critical policy interventions like congestion pricing and low-carbon zones.

Integrating such service-focused digital solutions with disaster preparedness, forecasting, and Monitoring, Reporting and Verification (MRV) systems for GHG mitigation can lead to wider socio-economic benefits (from improved climate resilience), while also capitalizing on the often-missed opportunity of leveraging climate finance for GHG mitigation.

Fostering behavioral changes in citizens can reduce inefficiencies in the use of water resources, promote waste management, and enable a shift toward sustainable transportation and energy efficient choices across cities. Improving urban water resources management is key to dampening water demand in cities. By implementing water saving programs in its cities, the GoE can help reduce inefficiencies in the use of water by households, firms, and industry. Investment programs that facilitate water storage, treatment, recycling, and reuse can help ensure that cities continue to have access to the water they need. Information, Education & Communication (IEC) campaigns, along with thoughtfully designed incentives and penalties, play a key role in inculcating necessary behavioral changes for waste minimization, waste segregation, more climate-friendly consumption choices, curtailed littering, and the use of public transportation and/or non-motorized transportation. In addition to pricing interventions (e.g., congestion charging), behavioral change measures include eco-driving training courses, driver awareness campaigns (informational signs and billboards promoting safe and eco-driving), and the enforcement of speeding through speed cameras and ITS equipment. A shift toward energy-efficient choices also begins by encouraging different behaviors and consumer preferences. Finally, for enhancing the preparedness to extreme heat, cities should educate the public about the health risks of heat exposure, train health workers to treat the effects of extreme heat, provide cooling centers, and consider shifting working hours, among other measures. These measures should focus on particularly vulnerable neighborhoods (e.g., those lacking vegetation), demographic groups (e.g., the elderly, people with disabilities), and occupations (e.g., construction, manufacturing).

5.4. Financing needs and economic trade-offs

To enable a systemic shift toward resilient and low-carbon cities, the multi-sectoral policy and investment levers shown in Figure 25 were modelled in an integrated manner to assess the normative economic trade-offs as well as investment needs for Egypt's 14 major cities. The Resilient & low-carbon cities transformation scenario offers a unique perspective by integrating a cross-sectoral analysis, core climate change risks, and GHG emissions of the main 14 cities. Based on these elements, it assesses the impact of adaptation, efficiency, and mitigation measures in spatial policies, infrastructure, and service delivery options

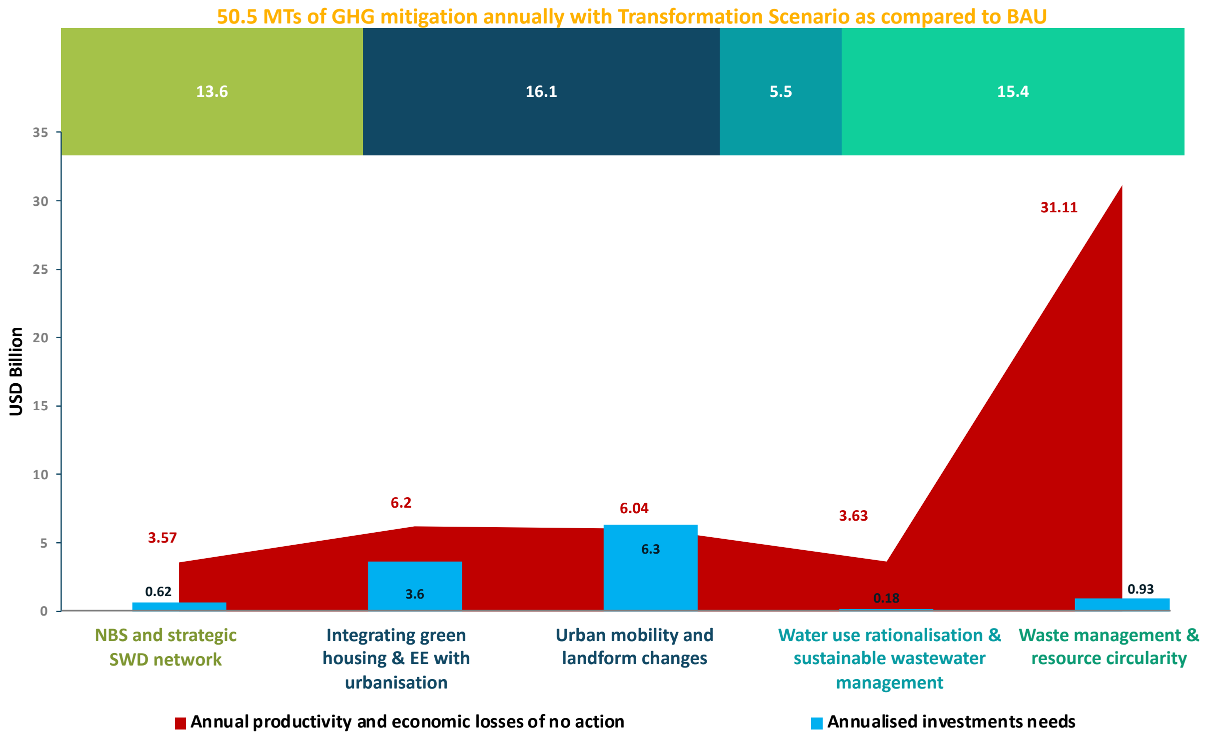
Figure 25: Modelled policy levers for potential transition from Business as Usual

The sheer scale of urbanization on the horizon for Egypt, paired with the cross-cutting climate change risks and resilience gaps, presents an opportunity to pivot toward green, resilient, sustainable, and inclusive systems for urban infrastructure and service delivery**. The analysis reveals that the economic costs associated with "no action" are far greater than the annual financing needs required for this transformation.**

The total investment needs between 2022 and 2030 are estimated at US$105 billion (at 2022 real prices), of which i) US$5.6 billion is for NBS and a strategic Storm Water Drainage (SWD) network, ii) US$32.4 billion is for integrating green housing and energy efficiency with urbanization, iii) US$1.65 billion for urban water rationalization and sustainable wastewater management, iv) US$57 billion is for urban mobility and landform changes, and v) US$8.4 billion is for waste management and resource circularity. An additional US$4.35 billion (at 2022 prices) is cumulatively needed to meet the operations and maintenance (O&M) needs of the infrastructure over the period 2022-2030.

The annual financing needs (annualized capex based on service life of assets), as shown in Figure 26 below, of the transformation scenario are estimated at US$11.7 billion, with annual economic benefits—considering economic costs avoided—reaching 4.3 times the financing needs.

. Figure 26: Investment needs and economic trade-offs



Source: Authors' elaboration of the results of financing needs and economic modelling

Action across waste management and resource circularity provides the most significant benefits in terms of avoided economic and productivity costs, followed by those across NBS for enhancing resilience to floods, SLR and heat stresses. The key economic trade-offs for investing in resilient cities include i) avoided cost of productivity losses and relocations during hazards, due to improved flood resilience; ii) reduced resource stress and decreased energy consumption, due to green buildings and energy efficiency across urban systems; iii) avoided loss of the economic/productive value of recycled water plus positive effects of water circularity; iv) reduced vehicle kms traveled, due to the integration of the urban form and mobility; v) avoided loss of the energy recovery potential from waste and wastewater, due to leveraging resource recovery; vi) avoided environmental pollution and mismanaged natural resources (air, land, and water—including reduced marine litter) plus associated health benefits; and vii) job creation.

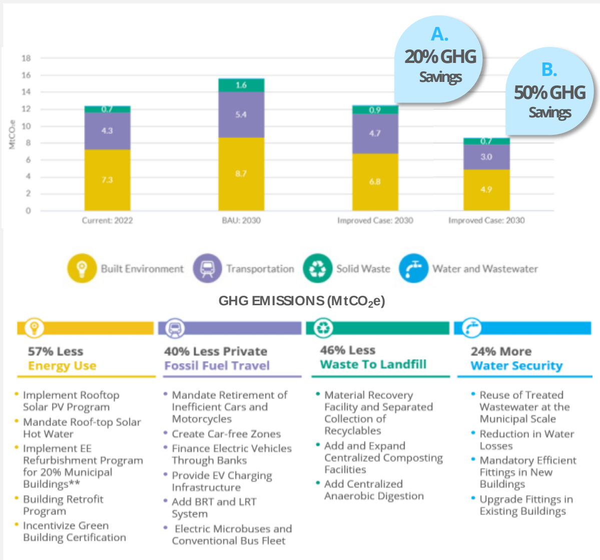
This analysis offers a transformative scenario that could enhance the resilience of cities while also contributing to GHG mitigation—an approximately 18% reduction (~50.5 MtCO2e) **of annual GHG emissions by 2030, compared to a continuation of current urbanization trends.** Integrating this kind of low-carbon focus with urbanization will enable Egyptian cities to limit their contributions to the country's GHG emissions and transition their urbanization patterns to low-carbon trajectories. The sectoral contribution to GHG emissions mitigation is as follows: 13.6 MtCO2e from NBS and strategic actions in the SWD network; 16.1 MtCO2e from actions integrating green housing and energy efficiency with urbanization (including better urban mobility and management of the urban form); 5.5 MtCO2e from urban water rationalization and sustainable wastewater management; and 15.4 MtCO2e from waste management and resource circularity investments.

While the economic benefits outlined above are much higher than the investment needs, Egyptian cities need a calibrated, city-focused approach to prioritize investments across localized adaptations to climate change risks. At the same time, they must integrate the low-carbon pathways as part of their urbanization to unlock the respective economic productivity from climate-smart and sustainable urbanization. The case study for Alexandria presented below highlights how the various pillars of the transition pathways need to be integrated at the city level to develop a city-focused, low-carbon, and resilient urban growth strategy.

Box 2: Low-carbon and resilient pathway for Alexandria

A detailed, city-focused assessment[74] conducted by the WB-IFC team as part of the "Alexandria, Egypt: Exploring climate ambition, costs, and co-benefits" study modeled the implementation of various cross-sectoral interventions across the city that could lead to GHG mitigation as well as enhanced climate change adaptation. While adaptation is of utmost priority, the mitigation interventions—and hence the subsequent investments needs—are highly correlated with national and city governments' levels of ambition for each city's transition to low-carbon pathways. Aligning urbanization with low-carbon and resilient pathways can enable the GoE to achieve its national GHG emission targets, while improving adaptation for citizens at the local level. These potential benefits underscore the need for an integrated, climate-smart, spatial approach to infrastructure and service delivery in cities. As highlighted in the transition framework above, improved institutional systems and capacities at the local level and for city finances (including leveraging green and climate financing) are fundamental to enable the local implementation of such interventions.

Figure 27: Low carbon pathways for Alexandria



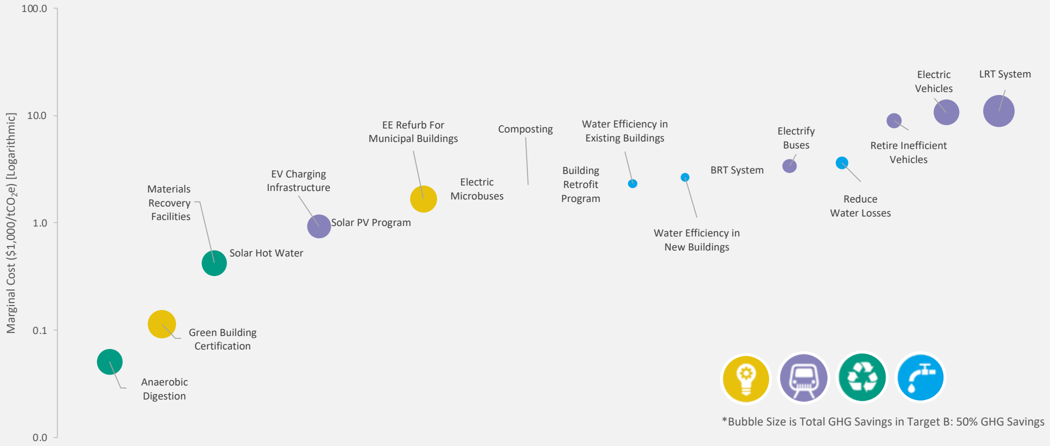
Source: Initial findings of the study presented at COP27

Depending on the level of ambition for Alexandria's transition to a resilient and low-carbon city, interventions across the built environment, transportation, solid waste, and water and wastewater can lead to a 20% GHG savings (compared to BAU GHG emissions of ~15.7 MtCO2e in 2030) or even a 50%

[74] The assessment conducted jointly by WB and IFC team is focused for Alexandria and was presented at CoP. The report is still at draft stage.

GHG savings.[75] To achieve that 50% savings, 20 multi-sectoral investment interventions prioritized by the GoE would require US$14.23 billion by 2030 (against the BAU for 2030). Figure 28 highlights the marginal costs of such interventions for mitigating GHG emissions—a majority of which would also contribute to improving local adaptation (for instance reduced flooding from solid waste management, reduced air pollution and subsequent local heat stresses, reduced urban heat islands, improved water resource preservation and circularity that lowers the water security risks of the city). Integrating green covers as part of the city's built infrastructure and integrating NBS as part of service delivery choices will further provide GHG mitigation and adaptation co-benefits; these would require a shift to climate-smart, integrated urban and land-use planning.

Figure 28: Marginal GHG abatement cost for various cross-sectoral interventions



Source: Initial findings of the study presented at COP27

Improving climate change adaptation to coastal erosion requires a focus on planning systems as well as critical adaptive investments, as follows: i) preparation of a Local Shoreline Protection Action Plan related to the national ICZM and ii) implementing coastal protection against erosion in vulnerable and priority shoreline areas. For flood resilience, Alexandria needs an elaborate, water-sensitive urban approach that covers i) investments in NBS solutions that enhance the retention and adaptive capacity of the city ii) investments to increase the capacity of and linkages between existing water bodies and natural drains, iii) investments in the rainwater drainage network to manage run-off, and iv) alignment of streets and local infrastructure to increase retention, improve efficiency of rainwater run-off to drainage, and enable infiltration to groundwater. The integration of resilient, climate-smart, and circular design and investment interventions—and leveraging of digital technologies (such as SCADA systems)—across water and wastewater systems (treatment and network) will enhance the city's resilience against water security and flooding risks while also contributing to GHG mitigation from improved system efficiency. Prioritized investment by the city government across flood and coastal resilience requires ~US$101 million.

To strengthen institutional systems and capacities, Alexandria needs to focus on i) integrating climate risk and emission-reduction approaches across its investment, spatial, and economic planning systems, ii) enhancing asset management and investing in data infrastructure (such as an Infrastructure Network Center, hydro-met, early warning systems, and a GIS-based asset inventory and monitoring) to ensure long-term sustainability and resilience to climate change and natural hazards, and iii) enhancing capacity to leverage green finance and mobilize the private sector by focusing on adopting climate-smart capital investment planning, improving own-source revenues, and realigning the role of governorates to mobilize private financing for green investments, leverage climate financing, and undertake public private partnerships.

[75] Findings of IFC's APEX tool

6. Roadmap

The scale of the economic benefits that cities can realize through a balanced adaptation- and mitigation-focused approach depends on the ambition and resilience of the Government of Egypt to respond to climate change. In the short term, the key actions (summarized in the table below) need to focus on continuing and accelerating the government's efforts to scale up and deepen the climate agenda in cities. Accordingly, a mix of short-term actions (policies, investments, and pilot initiatives) to enable better information and risk management, improve efficiencies in resource use, and enhance resilient infrastructure and services are necessary. The performance against the short-term actions, enabling the shifts toward resilient and low-carbon cities, will buttress the long-term trajectories. Highly urbanized coastal cities along the Mediterranean Sea and densely populated cities in the Nile Delta should be urgently prioritized for the implementation of cross-cutting actions that enhance adaption and mitigation in such cities.

A strategic, reform-oriented approach to green and resilient local and territorial development can play a key role in strengthening systems and access to resources at the sub-national/local level in order to achieve the desired transition toward resilient and low-carbon cities. Such a strategic national program would consolidate all the ongoing interventions along the climate agenda in an integrated manner and strengthen and expand current efforts on climate resilience and sustainability. This consolidation can also lead to a "multiplier effect" in terms of the economic, environmental, and social benefits for the country that would accrue through improved systems, capacities, access to resources, and opportunities for climate resilient, green, and inclusive economic development. The approach will enable the GoE to develop a new model for the institutional, planning, and fiscal reforms that are necessary to pivot toward this model of development—one that integrates climate change, inclusion, and the development agenda for the country's overall economic growth. ***This ambitious approach will also enable Egypt to demonstrate an innovative model for reforms and establish itself as a regional and global leader on the climate agenda by i) showcasing Egypt's pioneering, innovative, and reform-oriented model for climate action globally (as it did at COP27) as well as through regional platforms such as the African Initiative and Arab League, and ii) attracting financial resources through market and concessional routes for long-term investments, including from the private sector.***

6.1. Priority short-term actions (1-3 years)

Sr. No.	Actions	Stakeholders	Impl. Challenges
ENHANCE CLIMATE RISK SENSITIVITIES AND RESPONSE SYSTEMS WITH MANAGED URBAN EXPANSION FOR CITIES			
I.	Develop a national policy and city-level strategies/densification plans for compact, including transit-oriented-development (ToD) urban development, to manage urban expansion. While the national policy is critical for setting the policy direction for promoting compact urban development (prioritizing infill development over urban expansions), the city-level strategies and subsequent densification plans, including FSI, and zoning instruments such as ToD, are critical to implement such policies based on local socio-economic conditions.	MoHUUC, GoPP, MoLD, Governorates	High
II.	Strengthen climate risk sensitivity (flooding, heat, SLR as priorities) in local planning systems and development plans. – Mainstream climate resilience in urban development strategy – Identify priority cities across Coastal regions, the Delta region, and Upper Egypt – Augment the existing planning documents (strategic plans, development plans) with city-level, granular climate risk information for the priority cities	MoP, MoLD, GoPP, Governorates	High

	– Provide necessary fiscal incentives to governorates and districts, to drive the shift toward climate-resilient planning systems for long-term strategic/development plans in priority cities, including key coastal cities.		
III.	Develop robust city-level early warning systems for floods (pluvial, coastal, and fluvial), heat waves and other climate change/natural disaster events. – Conduct assessments and gain knowledge of flood risks (people, infrastructure asset vulnerabilities) in specific risk-prone areas across priority cities, including coastal cities – Design and implement local hazard monitoring system and hydro-met systems across priority cities – Design and implement flood hazard risk dissemination and communication services across priority cities. In addition, install digitally enabled public billboards/hoardings to provide real-time information to citizens on key climatic indicators, including extreme events such as cyclones, heavy rainfall, heat waves, and other hazard risks. – Develop a robust hazard-specific response plan for priority cities, including coastal cities	Governorates and Districts	Medium
FOCUS ON RESILIENT AND RESOURCE-EFFICIENT URBAN SYSTEMS			
I.	Establish resilient storm water management system with integrated NBS. – Assess the resilience of existing wastewater networks to handle the combined loads of wastewater and storm water across key cities – Develop flood resilience plans with a focus on NBS along with optimal network dependence for priority cities – Implement a pilot investment for flood hotspot areas in the city	MoHUUC, MWRI, MoLD, Governorates	Low
II.	Improve water sector efficiency and rationalize water use. – Revise the per capita water supply norms to lower levels – Incentivize use of treated wastewater and recycling by industrial and commercial consumers – Enact a large-scale communication/behavior change campaign to communicate the value of water (engage schools and youth groups) – Introduce reform to set water tariffs that reflect the value of water in Egypt as well as the true cost of water production and supply across cities	MoHUUC, Governorates	High
III.	Implement wastewater resource circularity. – Develop a national wastewater reuse and resource circularity policy – Develop sub-national policies with defined targets, incentives, institutional roles and responsibilities, implementation roadmap, etc. – Develop a wastewater recycling and reuse plan for each of the governorates, with identified investment needs and financing plans across cities	MoHUUC, Governorates	Medium
IV.	Enhance the operational efficiency and performance monitoring of existing wastewater treatment plants. – Conduct an operational performance review of existing wastewater treatment plants across cities – Develop rehabilitation and technology upgradation plans – Establish performance monitoring systems and strengthen regulatory compliance monitoring systems	MoHUUC, Ministry of Environment, Governorates	Medium
LEVERAGE THE MITIGATION POTENTIAL OF ADAPTATION ACTIONS WHILE ALSO LIMITING THE ENVIRONMENTAL EXTERNALITIES WITH URBANIZATION			
I.	Facilitate multimodal urban transport across existing and new cities as part of Sustainable Urban Mobility. – Complete the ongoing sustainable transport projects i.e., Metro Extension, Monorail, Ring Road Bus Rapid Transit (BRT) – Develop and implement a BRT expansion plan in Greater Cairo, including electric fleet. Incorporate a reform and needed – Mainstream last mile connectivity and NMTs as an integral form of urban mobility – Assess the performance of road transport pricing programs (e.g., pilot street parking pricing in Greater Cairo) and develop policy/regulatory reforms and an investment package to encourage modal shift from cars to public transport	MoT, New Urban Communities Authority, MoLD, Governorates	High

	– Develop/adopt/improve a cross-ministerial, multimodal transport vision for key cities that focuses on deliverable results and builds on ongoing transport infrastructure investment projects such as Bus Rapid Transit		
II.	Support the transition to Low/No Emission Vehicles with clear roles and responsibilities for local governments. – Enforce legal age limits to retire old motor vehicles – Promote conversion of diesel buses and gasoline private cars to CNG vehicles – Shift public transportation to EVs/CNG vehicles – Develop local policies (planning for low carbon zones for future, public charging stations) for mainstreaming EVs as part of urban mobility.	MoT, Land Transport Regulatory Authority, Traffic Police, Ministry of energy, MoLD, Governorates	High
III.	Implement "green" building and energy efficiency across municipal services. – Develop a Green/Net-zero building strategy for government-supported affordable housing – Adopt business models and conduct a pilot using IOT-based models to enable energy efficiencies in household/commercial appliances – Conduct a feasibility study and launch a pilot implementation of EE-focused refurbishments and retrofits for a municipal building to showcase the potential and model the approach that can be adopted to reduce the GHG footprint of existing buildings	Ministry of Energy, MoHUUC, Governorates and Districts	Medium
IV.	Undertake a comprehensive programmatic approach for enforcement of the national SWM Law. – Strengthen the enabling regulatory and institutional landscape (including operationalization of the Waste Management Regulatory Authority (WMRA)) for robust regulation, management, and enforcement of laws during the provision of SWM services – Develop regional SWM plans, with identified investments and financing needs. – Streamline a cost-recovery mechanism from user charges so that the collected revenues contribute to the shift toward the financial sustainability of SWM operations – Conduct a pilot project to assess the feasibility of a regional integrated SWM project on a PPP basis – Raise awareness and support from the public at large to expect and demand adequate services	MoLD, Ministry of Environment	Medium
V.	Develop bio-energy resource recovery (bio-CNG, bio-methane etc.) for bio-waste policy to incentivize bio-energy applications for bio-waste streams, to include: – Assessment of current situation/stock taking – Identification of incentives for private sector participation – Assessment of low carbon opportunities (GHG emission reduction) associated with the policy	Ministry of Environment, MoLD, Ministry of Energy	Medium
VI.	Develop necessary policies for unlocking the economic value of plastics circularity. – Develop plastic-focused EPR policy for prioritized plastic waste streams (covering stakeholders, roles and responsibilities, taxonomy, implementation modalities) to enhance plastic recycling and circularity – Create a recycled plastics market by setting minimum recycling or renewable input legal requirements, including regulations for plastics free of hazardous chemicals and hygiene and safety concerns, to promote reuse specifically for food and drink packaging	Ministry of Environment, MoLD, MoTI	High
VII.	Leverage the energy recovery potential of wastewater treatment. – Equip wastewater treatment systems with biogas capture systems to reduce GHG emissions, use the same biogas to power the plant, and provide treated water to be reused in agriculture and industries	MoHUUC, Private Sector	Medium
ENABLING ACTIONS			

I.	Adopt a reform-oriented approach for Green and Resilient Territorial Transformation. – Establish a fiscal transfer system with PBC-linked incentives to promote public finances for green and climate-smart investments – Incentivize the development of climate-smart spatial and capital investment plans and digital systems – Improve institutional capacities and systems for developing, implementing and maintaining green and climate-smart investments	MoPED	Medium
II.	Consider establishing a “Green and Resilient Local Development Fund” as a financial intermediary at the national level for leveraging external sources of finance for funding climate mitigation and adaptation at the local level. – Develop a business plan and strategy – Develop a financing and funding plan with appropriate credit enhancement instruments and concessional lending instruments	MoPED, MoF	Medium
III.	Reduce institutional fragmentation and enhance institutional coordination to integrate climate sensitivities across urban systems by: – Clearly defining ministerial responsibilities – Improving coordination among ministries – Synchronizing planning – Designating a lead institution to champion the industrial resource-efficiency agenda – Establishing a central repository of data, updated on an annual basis, on energy and water use, water treatment and re-use by industrial sub-sectors – Establishing a mechanism for public-private dialogue on transition to a greener economy	MoPED, MoLD, MoHUUC	Medium
IV.	Increase sector-level (local and national) government capacity to implement climate-sensitive policies across cities. – Continue initiatives that train and increase the number of staff, building on initiative such as the GIZ “Training Program for Electricity Sector and Climate Change Joint Activities”	MoPED, MoLD, MoHUUC	Low
V.	Integrate climate sensitivity into city and local government planning. – Continue the localization of SDGs and embed climate-smart performance parameters as part of the same – Align and use synergies of the socio-economic development plan and climate change objectives – Use performance-based approaches to incentivize implementation	MoP, MoLD, GoPP, Governorates	Medium
VI.	Strengthen the role of local governments by increasing: – Their capacity to assess climate change risks and their impacts – Their capacity to identify, plan and implement local climate change actions – Finance available for implementing local climate change initiatives		Medium

6.2. Medium- to long-term actions (3+ years)

Over the medium to long term, while the actions are dependent on the success of the short-term actions as well as the government’s ambitions, the focus should be shifted to capitalizing on successes from the short term and scaling up implementation, with a larger role for governorates and local governments as well as a focus on leveraging private sector financing.

Sr No.	Actions	Stakeholders	Impl. Challenges
ENHANCE CLIMATE RISK SENSITIVITIES AND RESPONSE SYSTEMS WITH MANAGED URBAN EXPANSION FOR CITIES			
I.	Mainstream climate risk sensitivity (flooding, heat, SLR as priorities) in local planning systems and development plans.	MoP, MoLD, GoPP	High

	– Scale and expand the implementation of climate risk-informed local planning systems and development plans to other cities in the Coastal region, Delta region and Upper Egypt		
II.	Land management for pivoting toward climate risk-informed and efficient urban expansion. – Modernize land and property registration – Develop a robust Geospatial Information System and boundaries – Enhance management and allocation of state land – Enhance allocation of land to the private sector – Improve the effectiveness of expropriation procedures – Enhance linkages between strategic planning and capital investment planning – Establish a land readjustment law and clear policy instruments for managing urban expansion – Restructure the legal framework governing land-based financing – Review options to establish a single land agency	Ministry of Justice, NUCA	High
III.	Develop robust city-level early warning systems for floods (pluvial, coastal, and fluvial), heat waves and other climate change/natural disaster events. – Improve robustness, integrate AI into forecasting, and scale up implementation to other cities	Governorates and Districts	
FOCUS ON RESILIENT AND RESOURCE-EFFICIENT URBAN SYSTEMS			
I.	Mainstream Nature-based Solutions (NBS) penetration, covering green and blue infrastructure, as part of the urban form across key cities. – Develop a city-level NBS penetration strategy – Amend local development plans and bylaws to mainstream NBS as an integral part of the urban form – Establish NBS/green cover targets for specific cities – Develop pilot NBS demonstration projects with NBS financing models – Establish a dedicated budgetary allocation/incentivizing mechanism for scaling NBS adoption. Then, scale up the use of NBS as mainstream way of improving urban bio-diversity and enhancing resilience against heat, flooding, and air pollution/GHG emission.	Governorates and Districts	Medium
II.	Scale up reuse of treated wastewater (TWW) to supplement industrial and agricultural water. – Launch a system-scale planning effort based on an assessment of wastewater treatment capacity, wastewater treatment improvement needs, as well as cropping patterns and proximity to wastewater treatment capacity – Scale up and retro-fit existing wastewater treatment systems to ensure sufficient quality to meet phytosanitary needs for TWW-appropriate cropping systems – Implement relevant infrastructure to support treated wastewater reuse, including conveyance systems	MoHUUC, Governorates	Medium
III.	Implement investments to promote wastewater resource circularity. – Develop and implement the TTP (tertiary treatment plant) investments for wastewater circularity on a PPP basis for key cities and scale up the planning, PPP project preparation, and implementation	MoHUUC, Governorates	Medium
IV.	Enhance the operational efficiency of existing wastewater treatment plants. – Undertake rehabilitation and technological augmentations (including EE technologies and pumping systems) for wastewater systems across cities	MoHUUC, Governorates	Medium
LEVERAGE THE MITIGATION POTENTIAL OF ADAPTATION ACTIONS WHILE ALSO LIMITING THE ENVIRONMENTAL EXTERNALITIES OF URBANIZATION			
I.	Facilitate multimodal urban transport. – Execute policy/regulatory reforms and investment program to enable pricing interventions to encourage the shift from cars to sustainable transport, including i) street parking pricing and ii) urban highway congestion pricing to link toll levels to operational and maintenance costs as well as carbon and environmental footprint	MoF, MoI, Governorates, MoT	High

II.	Transition to higher levels of the "waste hierarchy" and plastics circularity. – Implement policies and local bylaws to ban dumping and littering – Improve city infrastructure and service delivery systems, leveraging PPP models, across i) segregated waste collection and transportation; ii) recycling and resource recovery with streamlined throughputs and established market linkages; iii) bio-waste and non-recyclable plastic waste treatment; and (iv) safe disposal of residual waste – Shift to formally established recycling operations with improved technology adoption to maximize resource efficiency and align local plastic production and consumption patterns – Remediate prioritized waste hotspots and open dumpsites in a programmatic manner to prevent further natural resource degradation – Improve financial sustainability in the waste management services through generator level fee as well as via innovative mechanisms such as gate fees, eco-modulated fees for specific streams of plastic waste, etc. – Capitalize on digital technologies to catalyze the transition to more circular production and consumption practices and monitor compliance with existing rules and regulations	MoLD, Ministry of Environment	High
III.	Implement green building and EE across municipal services. – Implement affordable housing projects in line with Green/Net-zero building principles to replace low-income housing and hazard-prone establishments – Develop a national policy for "peer to peer renewable energy (RE) trading" that enables local production (households/buildings), local consumption of RE by local businesses, and conduct a feasibility of the same on PPP basis – Scale up the implementation of EE-focused refurbishments and retrofits for municipal/government in a programmatic manner – Pilot an integrated command and control center for automation of streetlights (with EE lighting) across key cities – Implement Digital/EMIS (energy management information system) for monitoring, reporting, and verification on the municipal sector's energy use to enable EE improvements across the sector	Ministry of Energy, MoLD, Governorates and Districts	High
IV.	Implement EPR models, cost recovery and monitoring systems for priority plastic waste streams. – Support upstream circular interventions (such as design for circularity, minimum recycling content in manufacturing, plastic waste minimization, etc.) for enabling the shift to circular economy	Ministry of Environment, MoLD, MoTI	High
V.	Support implementation of bio-waste to bio-energy projects at the local level on a PPP basis. – Conduct feasibility assessments for bio-waste to bio-energy projects – Pilot the fiscal incentives, if any, laid down as part of the policy (proposed in short term) – Develop a robust performance-linked PPP concession agreement in line with international standards – Conduct market sounding activities and undertake PPP transactions – Scale up the implementation on a PPP basis based on the learnings from initial projects	Ministry of Environment, MoLD, Ministry of Energy	Medium
ENABLING ACTIONS			
I.	Develop and test existing and new blended finance instruments to leverage public/concessional finance to mobilize private capital for green and resilient investments across cities (e.g. with guarantees, green credit lines, co-lending, etc.)	MoF, Governorates	Medium
II.	Adopt a reform-oriented approach for Green, Resilient and Inclusive Territorial Transformation and scale up green fiscal transfers	MoPED	Medium