



STIMSON

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REPORT

# Measuring Multidimensional Climate Risks in East Africa's Coastal Cities

**CASE STUDIES IN DAR ES SALAAM, TANZANIA,  
AND MOMBASA, KENYA**

The Climate and Ocean  
Risk Vulnerability Index

Environmental  
Security Program



## About this Report

Coastal cities are critical to the current and future prosperity of East Africa. Home to an estimated 15 million people, these cities are key economic gateways to their own nations, as well as to neighboring landlocked countries in Central Africa. Additionally, coastal cities are at the forefront of the region's growing blue economy, with shipping, tourism, and fisheries comprising a significant and growing share of East Africa's economic output. However, East Africa's coastal urban centers face the associated challenges of urbanization and climate change. Fast-paced growth and urbanization, while offering economic benefits and much needed revenue, stress city infrastructure, degrade the natural environment, and erode the health and security of coastal communities. On top of this, the impacts of climate change—including sea-level rise, increasingly erratic rainfall, extreme storms, drought, and growing heat events—compound existing social, economic, and environmental vulnerabilities. Put together, these stressors pose significant risks to coastal city residents and businesses, and undermine the natural environment upon which they depend. To be effective, resilience strategies must be informed by a complete and holistic risk picture. However, in East Africa such efforts are impeded by data gaps and a lack of investment in resilience planning.

This report views risk through a holistic lens, fills data gaps, and highlights specific priority actions to mitigate multidimensional climate risks in the East African cities of Dar es Salaam and Mombasa. It begins by exploring coastal urbanization trends in East Africa and the multidimensional threat posed by climate change. It then introduces the Climate and Ocean Risk Vulnerability Index (CORVI), a decision support tool developed by the Stimson Center to measure climate risks in coastal cities. The second half of the report presents CORVI risk profiles in Dar es Salaam and Mombasa. Each profile provides a detailed, data-driven assessment of how climate and ocean risks impact city residents, critical industries, and the environment across the land and seascape. These risks are analyzed with respect to resiliency planning already underway to develop priority recommendations that integrate risks into city planning and prioritize resilience investment. The report closes by connecting assessment findings from Dar es Salaam and Mombasa to broader opportunities to advance and expand integrated urban and coastal planning in East Africa.

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The Environmental Security program conducts research and analysis on pressing environmental challenges facing communities around the globe, including wildlife trafficking, illegal fishing, and the climate emergency. Working with international stakeholders across governments, civil society, businesses, and the security community, the program develops innovative solutions utilizing a research-to-action model.

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ORGANIZATIONS SURVEYED	
DAR ES SALAAM, TANZANIA	MOMBASA, KENYA
African Academy of Sciences	African Academy of Sciences
African Malaika	Bamburi Cement
Ardhi University	Catholic University of Eastern Africa (CUEA)
Blue Ventures	Climate Change Directorate, Ministry of Environment and Natural Resources, National Government of Kenya
Food and Agriculture Organization of the United Nations (FAO)	Coastal & Marine Resource Development (COMRED)
Marine Parks and Reserves Tanzania	Coastal Oceans Research and Development – Indian Ocean (CORDIO)
National Environment Management Council (NEMC)	County Government of Mombasa
The Nature Conservancy (TNC)	ERACOMA
Norwegian Meteorological Institute (NMI)	Hand in Hand Eastern Africa
The Open University of Tanzania	Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC)
President’s Office, Planning Commission, National Government of Tanzania	Kenya Association of Manufacturers (KAM)
Samaki Consultants	Kenya Bureau of Standards, National Government of Kenya
Tanzania Fisheries Research Institute (TAFIRI)	Kenya Electricity Transmission Company (KETRACO)
Tanzania Renewable Energy Association (TAREA)	Kenya Marine and Fisheries Research Institute (KMFRI)
UN Capital Development Fund (UNCDF)	Kenya Maritime Authority (KMA)
United States Agency for International Development (USAID), Tanzania	Kenya Red Cross Society (KRCS)
University of Dar es Salaam	National Environment Management Authority (NEMA)
Vice President’s Office, Division of Environment, Government of Tanzania	The Nature Conservancy (TNC)
Western Indian Ocean Marine Science Association (WIOMSA)	Norwegian Meteorological Institute (NMI)
Women Against Poverty (WAP)	Pwani University
	South Eastern Kenya University (SEKU)
	Technical University of Mombasa
	Tuktuk Transport
	UN Environment Programme (UNEP)
	United States Agency for International Development (USAID), Kenya
	University of Nairobi
	Western Indian Ocean Marine Science Association (WIOMSA)



## ORGANIZATIONS INTERVIEWED

### DAR ES SALAAM, TANZANIA

Association for Coastal Ecosystem Services (ACES)  
Blue Ventures  
Food and Agriculture Organisation of the United Nations (FAO)  
German Agency for International Development (GIZ)  
Institute for Climate Change Studies, University of Dar es Salaam  
International Union for Conservation of Nature (IUCN)  
Mikoko Ujamaa Community Org (MUCO)  
National Environment Management Council (NEMC)  
The Nature Conservancy (TNC), Tanzania Office  
Norwegian Embassy in Tanzania  
Regional Centre for Mapping of Resources for Development (RCMRD)  
Tanzania Renewable Energy Association (TAREA)  
UK Foreign, Commonwealth and Development Office in Tanzania (FCDO)  
UN Capital Development Fund (UNCDF)  
US Embassy, Dar es Salaam, Tanzania  
UN Environment Programme (UNEP)  
UN Habitat  
United States Agency for International Development (USAID), Tanzania  
Vice President's Office, Division of Environment, National Government of Tanzania Office  
Western Indian Ocean Marine Science Association (WIOMSA)  
Women Against Poverty (WAP)  
World Wildlife Fund (WWF)

### MOMBASA, KENYA

Association for Coastal Ecosystem Services (ACES)  
Blue Ventures  
Climate Change Directorate, Ministry of Environment and Natural Resources, Government of Kenya  
International Union for Conservation of Nature (IUCN)  
Coastal Oceans Research and Development – Indian Ocean (CORDIO)  
Department of Physical Planning, County Government of Mombasa  
Department of Environment, Waste Management, and Energy, County Government of Mombasa  
Department of Environmental Sciences, Machakos University  
Food and Agriculture Administration of the United Nations (FAO)  
International Conservation Caucus Foundation (ICCF)  
Kenya Association of Hotel and Caterers (KAHC)  
Kenya Electricity Transmission Company (KETRACO) Limited  
Kenya Maritime Authority (KMA)  
Kenya Ports Authority (KPA)  
Kenya Renewable Energy Association  
Miji Bora Project, COMRED  
National Environment Management Authority (NEMA)  
The Nature Conservancy (TNC), Kenya Office  
Port Management Association of Eastern and Southern Africa (PMAESA)  
Pwani University  
Regional Centre for Mapping of Resources for Development (RCMRD)  
UN Environment Programme (UNEP)  
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# Table of Contents

<b>Research Team and Acknowledgements</b>	<b>1</b>
<b>Summary</b>	<b>5</b>
<b>The Associated Challenges of Urbanization and Climate Change in East Africa</b>	<b>8</b>
Urbanization in Coastal East Africa	9
Accelerating Climate Risks	10
<b>Introducing the Climate and Ocean Risk Vulnerability Index</b>	<b>12</b>
Indicators	15
Data Collection and Structured Expert Judgement	16
<b>CORVI in East Africa</b>	<b>17</b>
<b>Dar es Salaam Risk Profile</b>	<b>21</b>
Summary Findings	21
Ecological Risk	24
Financial Risk	27
Political Risk	30
The Status of Urban Resilience Planning in Dar es Salaam	33
Recommendations to Build Resilience	34
<b>Mombasa Risk Profile</b>	<b>36</b>
Summary Findings	36
Ecological Risk	39
Financial Risk	42
Political Risk	46
The Status of Resilience Planning in Mombasa	49
Priority Recommendations to Build Resilience	50
<b>Meeting the Climate Challenge in Urbanizing Coastal Centers</b>	<b>52</b>
<b>Endnotes</b>	<b>54</b>



# Summary

Coastal cities across Africa and the world are growing at a tremendous rate, with profound implications for urban residents and the coastal environments in which they live. In East Africa, coastal nations cover a diverse geographic region, from Sudan in the North and Tanzania in the South, to the island nations of Madagascar, Comoros, Seychelles, and Mauritius.<sup>i</sup> In these nations, coastal urban centers are integral to social and economic security, sustaining significant blue economy industries and supporting large and growing populations. However, these coastal cities also face compounding ecological, financial, and political risks resulting from rapid urbanization and climate change.

Rapid urbanization in East Africa—while bringing positive benefits—poses challenges to the future sustainability of its coastal cities. In many cases, urban expansion has outpaced the development of housing, waste management, and transport infrastructure. Poor urban infrastructure management has exacerbated social and health inequities, leading to governance gaps and erosion of the natural environment which supports the city. On top of this, coastal cities in East Africa are exposed to accelerating climate risks. Several regional climate assessments have identified East Africa as among the most threatened coastal regions globally, with significant changes to temperatures, rainfall, extreme weather events, and sea levels expected by the end of the century.<sup>1</sup> Together, these challenges increase the risk of flooding, stress ecosystems upon which urban residents depend, degrade outdated infrastructure, and have the potential to upend economic stability.<sup>2</sup> Without action, these changes can undercut the health and

potential of the sustainable blue economy and undermine the economic, food, and environmental security of coastal cities.

The Stimson Center has developed the Climate and Ocean Risk Vulnerability Index (CORVI) to help municipal, regional, and national decision makers take action. CORVI compares a diverse range of climate- and ocean-related risks and vulnerabilities across the land and seascape to produce a coastal city risk profile. The city risk profile focuses on nearly 100 climate and ocean risk indicators across 10 categories, grouped under three risk areas: ecological, financial, and political. These indicators cover a range of issues, including the vulnerability of vital infrastructure, the health of marine ecosystems, and urbanization dynamics. Each indicator and category are scored using a 1-10 risk scale relative to other cities in the region, providing a simple reference point for decision makers looking to prioritize climate action and resilience investment.

CORVI combines empirical data and survey data from local experts to fill data gaps and develop a more complete understanding of how climate-related risks are impacting the coastal city.<sup>3</sup> CORVI risk scores—which form the basis of a coastal city risk profile—are augmented with existing academic and grey literature, government documents, and key informant interviews to develop a comprehensive narrative and understanding of the coastal city's climate risks and identify priority policy recommendations. In addition to providing decision makers in the specific city with a complete risk picture, the data from each city risk profile is added to a global database, allowing users to compare different city risk profiles and assess regional trends.

i This report uses the African Union definition of East Africa. The coastal and island nations in this region are Comoros, Djibouti, Eritrea, Kenya, Madagascar, Mauritius, Seychelles, Somalia, Sudan, and Tanzania.

## CORVI in East Africa

In collaboration with the Western Indian Ocean Marine Science Association (WIOMSA) and Coastal & Marine Resource Development (COMRED), the Stimson Center expanded the CORVI project to East Africa by conducting two CORVI city assessments in Dar es Salaam, Tanzania, and Mombasa, Kenya. Both cities are critical urban centers, not only to the economic development of Kenya and Tanzania, but also to the broader region and landlocked countries in Central Africa. However, significant and unplanned urbanization is degrading the terrestrial and marine environment, and climate change poses significant risks to Mombasa's and Dar es Salaam's residents, the blue economy, and the long-term sustainability of both cities.

### Dar es Salaam

A sprawling city, home to 6.4 million people, Dar es Salaam is an economic powerhouse in Tanzania, responsible for 17 percent of national GDP. It serves as a primary entry point for trade and tourism. With an annual urbanization rate of 5.6 percent, Dar es Salaam is expected to grow to 13.3 million residents by 2035. This dramatic growth poses challenges that are being intensified by climate change. While Dar es Salaam is relatively safe from tropical cyclones, heavy rainfall and flooding from both land and sea are a constant concern. The CORVI risk profile identified other issues, including:

- High reliance on climate-vulnerable industries such as shipping, tourism, agriculture, and fishing heightens economic vulnerability.
- Unplanned coastal development is harming the terrestrial and ocean environment, contributing to coastal erosion, freshwater shortages, and degraded fish stocks and ecosystems. These negative impacts, in turn, further threaten the long-term sustainability of agriculture and coastal tourism.
- Vulnerability to flooding increases risk to human capital and key infrastructure, and can hamper economic development. These risks are driven by extensive unplanned settlements—with 75 percent of the city population living in informal housing—and inadequate infrastructure, particularly roads, bridges, and the electrical grid.

The government of Tanzania has recognized the need to build resilience in Dar es Salaam. This is evident in the multiple national adaptation strategies and climate adaptation project partnerships that exist between local and international funders. However, to overcome existing financial and technical gaps, the government should focus on efforts to integrate climate adaptation planning and investment. It is crucial that planning and future activities connect the development of key sectors, the terrestrial and marine environment, and the needs of vulnerable communities. To build resilience and plan for systemic risks, the CORVI risk profile identifies three priority areas in need of action:

- **Establish a permanent coordination structure to explicitly integrate ocean risks and marine spatial planning into the city master plan.** To ensure a participatory process, this structure should include national and city-level governing entities, civil society, and the private sector and help disperse information about climate risks and promote the narrative that effective environmental and management of the land and seascape is critical to building resilience, rather than obstructing development.
- **Expand flood adaptation programs, with a focus on meeting the needs of vulnerable neighborhoods by expanding community-based savings schemes and strengthening waste management systems.** Specific actions include upgrading informal settlements to make them more resistant to flooding; expanding waste management services to vulnerable communities; increasing access to financial services, including community saving schemes, to improve household-level resilience; and further integrating nature-based solutions into flood defenses.
- **Enhance climate adaptability in port, tourism, and urban agricultural sectors** by protecting them from climate risks and ensuring that negative environmental impacts are minimized. To do this, an integrated strategic coastal environmental assessment is needed to incorporate various stakeholder and economic interests, including balancing hard infrastructure and economic development with natural infrastructure solutions.



By advancing cross-cutting policies and channeling resources and investment to these areas, Dar es Salaam can reduce its climate vulnerabilities and work to build a sustainable future.

## Mombasa

Centered on an island and with the largest international seaport in East Africa, Mombasa is critical to the economic security of Kenya and landlocked nations in East and Central Africa. Home to 1.2 million people, Mombasa has seen its population almost double over the past 20 years, posing challenges to urban planning and the natural environment. The blue economy in Mombasa is critical to the economic prosperity of the city and the wider East African region. However, climate and ocean risks threaten the tourism, shipping, and fisheries industries. Although Mombasa is relatively safe from cyclones, flooding from erratic rainfall and sea-level rise is a major problem. The CORVI risk profile identified other issues, including:

- Growing climate risks to key blue economy sectors, including fishing, tourism, and shipping, is increasing vulnerability, particularly for poorer city residents who depend on these sectors for economic security.
- Marine pollution from coastal hotels, industrial shipping, and dredging is degrading marine ecosystems and fish stocks, which underpin the blue economy.
- Low-lying coastal neighborhoods face growing flood risks from sea-level rise, storm surge, and increasingly erratic rainfall. This vulnerability is heightened by infrastructure and housing deficits, with informal housing proliferating across the city.

The CORVI profile shows that managing climate risks across Mombasa's unique and growing cityscape is key to the health and safety of city residents and the blue economy. By strengthening social and economic resilience and incorporating urban risks into marine planning, Mombasa can mitigate the threat posed by climate and ocean risks and build a resilient and sustainable future through the following priority actions:

- **Integrate urban resilience into coastal and marine spatial planning.** Expanding the role of the Mombasa County Executive in nationally led

integrated coastal zone management activities is critical for ensuring that future projects and actions meet the urban and ocean needs of Mombasa City. Similarly, to ensure that urban environmental risks are incorporated into ocean planning, it is essential that Mombasa City planners be included in marine spatial planning activities.

- **Increase investment to build resilience to climate risks across key sectors, including tourism, shipping, and fishing.** The marine environment underpins the blue economy. Specific actions include financing efforts to reduce pollution from ship ballast and raw material processing at Mombasa port, encouraging ecotourism as an entry point to further sustainable ocean management, and expanding the capacity of Beach Management Units to provide training to avoid unsustainable fishing practices. Finally, the integration of green/blue infrastructure should be increased to protect key sectors from climate change.
- **Improve urban planning by investing in climate-smart infrastructure and housing in vulnerable neighborhoods.** To upgrade informal housing, successful joint partnerships between the Mombasa County Governance and the private sector should be expanded. These efforts should also be augmented with efforts to improve waste management. Small-scale efforts, including requiring biodigesters in new homes, should also be accompanied by large-scale efforts to improve and expand sewage facilities.

With these measures, Mombasa can drive financial resources and build climate resilience to ensure a safe and sustainable future.

As the risks from climate change continue to grow, coastal cities in East Africa face an increasingly uncertain future. In the face of rapid urbanization and with limited financial resources, city, national, and regional decision makers need access to data and assessments that help them understand the complete risk picture to prioritize investment, make proactive decisions, and avoid costly mistakes and the dangers of maladaptation. In this environment, CORVI is a valuable tool for identifying and categorizing risk across sectors, aiding in the design of integrated urban-ocean solutions, and accessing climate investment to build resilience.

# The Associated Challenges of Urbanization and Climate Change in East Africa

Coastal cities are pivotal to the current and future prosperity of East Africa. Located at the interface between land and sea, they serve as vital economic zones that facilitate trade between countries' interior agricultural and industrial sectors and the rest of the world, house vital government institutions, and support a significant and growing proportion of the region's population.

The nine coastal states in East Africa are home to 209 million people.<sup>ii</sup> While historically rural, the region is currently undergoing rapid urbanization. Many East Africans have migrated from rural areas to the region's urban centers, which offer access to economic opportunities and improved transport infrastructure.<sup>4</sup> According to the OECD's Africa's Urbanization Dynamics 2020 report, East Africa has seen its urbanization rates increase from 23 percent in 2000 to 39 percent in 2015, with levels expected to continue rising in the coming years.<sup>5</sup> As part of this urbanization trend, East Africa's 19 primary coastal cities, which have an approximate population of 15 million, are experiencing rapid growth. They are diverse, including large cities like Dar es Salaam (Tanzania), secondary cities like Mombasa (Kenya), and smaller but important capitals in the region's Small Island Developing States.

Although these cities share common growth prospects, they are suffering from the negative consequences of urbanization and climate change.<sup>6</sup> Moreover, social and economic issues such as growing inequality and informal settlements, along with the degradation of the terrestrial and marine environment, are undermining coastal cities' ability to accommodate urban growth.

On top of this, coastal cities must contend with the growing impacts of climate change. As the most recent report by the Intergovernmental Panel on Climate Change (IPCC) concludes, climate change is increasing the likelihood and severity of heatwaves, drought, flooding, and storms, degrading the security of people.<sup>7</sup> The report also notes that cities are at the forefront of many of these impacts and that further urbanization will exacerbate heatwaves, heavy precipitation, and flooding.<sup>8</sup> As a result, coastal cities face an increasingly complex risk picture, and understanding these interlinked challenges is pivotal for effectively building resilience.

<sup>ii</sup> This report uses the African Union definition of East Africa. The coastal nations in this region are Comoros, Djibouti, Eritrea, Kenya, Madagascar, Mauritius, Seychelles, Somalia, Sudan, and Tanzania.





Figure 1: Coastal cities face many different interlocking risks connected to climate change

## Urbanization in Coastal East Africa

Located at the interface between land and sea, East Africa's coastal cities are critical to the region's economic development. They sustain growing populations and house vital ports that act as a gateway to their own nations as well as neighboring landlocked countries in East and Central Africa. Additionally, coastal cities are at the forefront of the region's growing blue economy, with shipping, tourism, and fisheries comprising a significant and growing share of East Africa's economic output. This growth is reflected in major policy documents, with the African Union describing the blue economy as a "major contributor to continental transformation and growth" in its Agenda 2063.<sup>9</sup>

In East Africa and throughout the sub-Saharan region, urbanization presents significant opportunities for regional growth. Studies have shown that in East Africa, urban centers record lower levels of poverty and higher GDP rates than rural areas. However, East Africa's coastal

cities—like many rapidly urbanizing areas—face significant challenges of overcrowding, social inequity, environmental stressors, and a lack of sound infrastructure. These factors may undermine positive developments and degrade the environmental, economic, and food security of city residents.<sup>10</sup> Unplanned urbanization has led to the expansion of informal "peri-urban" settlements in low-lying, flood-prone areas on the outskirts of urban centers.<sup>11</sup> In coastal cities, much of the cities' poor are relegated to informal settlements and lack access to basic needs, services, and infrastructure, including clean water, sanitation, solid waste management, electricity, housing, healthcare, and education.<sup>12</sup> As a result, East Africa's urbanization has led to a transfer of poverty from rural areas to urban centers as migration to cities continues.<sup>13</sup> For example, while overall poverty rates have fallen in Tanzania, this decline is primarily due to progress in rural areas, rather than urban centers. The urban share of the country's poor has increased by 0.6 million from 2007 to 2018, primarily due to rural-to-urban migration dynamics, urbanization challenges, and the slow pace of urban poverty reduction.<sup>14</sup>

The challenges posed by urbanization also have significant implications for the terrestrial and ocean environment.<sup>15</sup> City expansion, for example, can result in the overharvesting of surrounding forests and shared environmental resources.<sup>16</sup> It is estimated that approximately 80 percent of mangroves along the Indian Ocean coastline have been lost as a result of rising temperatures and sea levels, human exploitation, and the expansion of urban zones.<sup>17</sup> This problem is compounded by pollution resulting from limited sewage and solid waste management infrastructure.<sup>18</sup> These dynamics have been seen in Mogadishu, where a lack of reliable waste management infrastructure, combined with limited government capacity and inadequate enforcement, is leading to the mass accumulation of debris and waste along rivers and drains, polluting the ocean and the city's water supply.<sup>19</sup>

The environmental consequences of urbanization have significant economic implications. In East Africa, an estimated \$21 billion in economic output directly relies on marine ecosystems such as fisheries, mangroves, and coral reefs.<sup>20</sup> Nearshore fishing, a food source in many East African urban coastal areas, is harmed by aquatic system degradation and reduced fish stocks.<sup>21</sup> Likewise, the coastal tourism industry, a significant economic force in East African cities, relies upon clean beaches and unpolluted water.<sup>22</sup>

## Accelerating Climate Risks

In addition to urbanization trends, coastal cities across East Africa must contend with a multitude of climate change impacts. Several regional climate assessments have identified East Africa as among the most threatened coastal regions globally, with significant changes to temperatures, rainfall, extreme weather events, and sea levels expected by the end of the century.<sup>23</sup> From 1961 to 2008, East Africa saw an increase in the frequency of

extreme heat events, and over the next century, temperatures are expected to rise faster than global averages.<sup>24</sup> Moreover, according to IPCC estimates, rainfall patterns in East Africa will become increasingly unstable, with periods of heavy precipitation followed by periods of drought and water scarcity.<sup>25</sup> Finally, regional sea levels are predicted to rise by 0.55 meters by the end of the century.<sup>26</sup>

These changes are directly impacting East Africa's coastal region. An estimated 22 percent of the coastline is highly exposed to coastal hazards, with estimates expected to rise to 39 percent if mangroves, coral reefs, and seagrasses are lost.<sup>27</sup> This vulnerability is heightened for coastal cities with highly developed shorelines, such as Dar es Salaam and Mombasa, which are experiencing an increase in flood events.<sup>28</sup> Urban water scarcity is also projected to increase. Between urban population growth, increased drought, and saltwater intrusion, estimates suggest that 311.2 million (20.7 percent) of Africa's urban population could be at risk by 2050.<sup>29</sup>

Furthermore, the speed, intensity, and destructive capability of tropical cyclones are also expected to increase.<sup>30</sup> In 2019, Mozambique was struck by two storms: Cyclone Idai and Cyclone Kenneth. These storms are widely considered to be two of the five worst tropical cyclones ever to make landfall in Mozambique. According to UN estimates, the powerful storms killed over 650 people, left 1.3 million children in need of humanitarian assistance, and collectively destroyed nearly \$900 million in infrastructure, homes, and crops.<sup>31</sup>

In addition to the direct consequences of climate change, East Africa's coastal cities face contributing risks from the ocean and inland. Coastal cities are heavily reliant on the blue economy and associated infrastructure to sustain their economies, much of which are susceptible to climate-induced risks including coastal erosion, sea-level rise, ocean





Areas flooded and damaged following Cyclone Idai, northwest of Beira. Source: European Union (Flickr).

warming and acidification, and the increasing intensity of extreme storms.<sup>32</sup> Nearshore and offshore fishing—essential industries in many East African coastal cities—are adversely impacted by ocean warming and acidification-induced shifts in fish stock distribution and abundance.<sup>33</sup> Such changes adversely affect the income, livelihoods, and food security of marine resource-dependent communities. Climate change is also expected to cause increasingly severe and frequent drought and groundwater salinization in East Africa. According to the IPCC, drought and groundwater salinization will have serious economic consequences, undermining agricultural productivity, reducing crop output, causing food shortages, and reinforcing rural-to-urban migration trends.<sup>34</sup>

These interconnected issues have profound consequences for the social and political health of coastal cities. Climate-related risks undermine the economic, food, and environmental security of cities, potentially increasing tension and unrest, and hamper efforts to build resilience. As coastal cities continue to expand and the impacts of climate change grow more severe, decision makers need access to data and assessments that integrate complex climate impacts across the land and seascape. This information is critical to help them identify vulnerabilities and target climate adaptation measures to build resilience where it matters most.

# Introducing the Climate and Ocean Risk Vulnerability Index

Urban coastal areas are likely to experience the earliest onset and potentially most severe impacts from climate change. However, the risks associated with climate change for specific coastal cities are much more difficult to untangle. In order for coastal cities to efficiently allocate resources and enact effective adaptation strategies, they must understand their multidimensional climate risks. These efforts are impeded by incomplete data.<sup>35</sup> Data on climate risks is rarely available at the city level and, when it does exist, it is often poorly managed and stored in silos that make access and use difficult, even for city government officials.<sup>36</sup> This issue is compounded by technical, financial, and capacity gaps, trapping coastal cities in a vicious cycle where they cannot develop holistic strategies to prioritize investment and access the funds needed to implement resilience actions.

In multiple meetings with stakeholders, experts noted that data gaps impeded their ability to assess multidimensional climate risks and provide evidence-based policy recommendations to key decision makers.<sup>37</sup>

Without data at the appropriate geographic scale, decision makers are often left with the choice of either waiting for greater data availability or attempting to downscale national-level data. Neither of these is an ideal solution for effective climate change adaptation. This problem is particularly acute in small and intermediate cities. Besides absorbing the bulk of East Africa's future urban population growth, they often lack the resources to gather and maintain necessary data.<sup>38</sup>

Despite these challenges, decision makers need to act now in the face of uncertainty to build resilience to the climate crisis. To do this, they need tools that will enable them to consider multidimensional climate risks, develop cohesive strategies, and utilize this information to unlock additional climate finance and implement resilience actions.

In response, the Stimson Center developed the Climate and Ocean Risk Vulnerability Index (CORVI). CORVI is a decision support tool that compares a diverse range of climate-related risks across the land and seascape to produce a coastal city risk profile.<sup>39</sup> These risks are displayed across 10 categories, grouped under three risk areas: ecological, financial, and political (see figure 2). The 10 categories are in turn made up of close to 100 indicators, covering a range of issues including the vulnerability of vital infrastructure, the health of marine ecosystems, and urbanization dynamics in the chosen coastal city. Each indicator and category is scored using a 1-10 risk scale relative to other cities in the region, offering a simple reference point for decision makers looking to pinpoint and categorize climate risks. The CORVI risk scores that form the basis of a coastal city risk profile are augmented with existing academic and gray literature, government documents, and key informant interviews to develop a comprehensive narrative and understanding of the coastal city's climate risks and to identify priority policy recommendations.



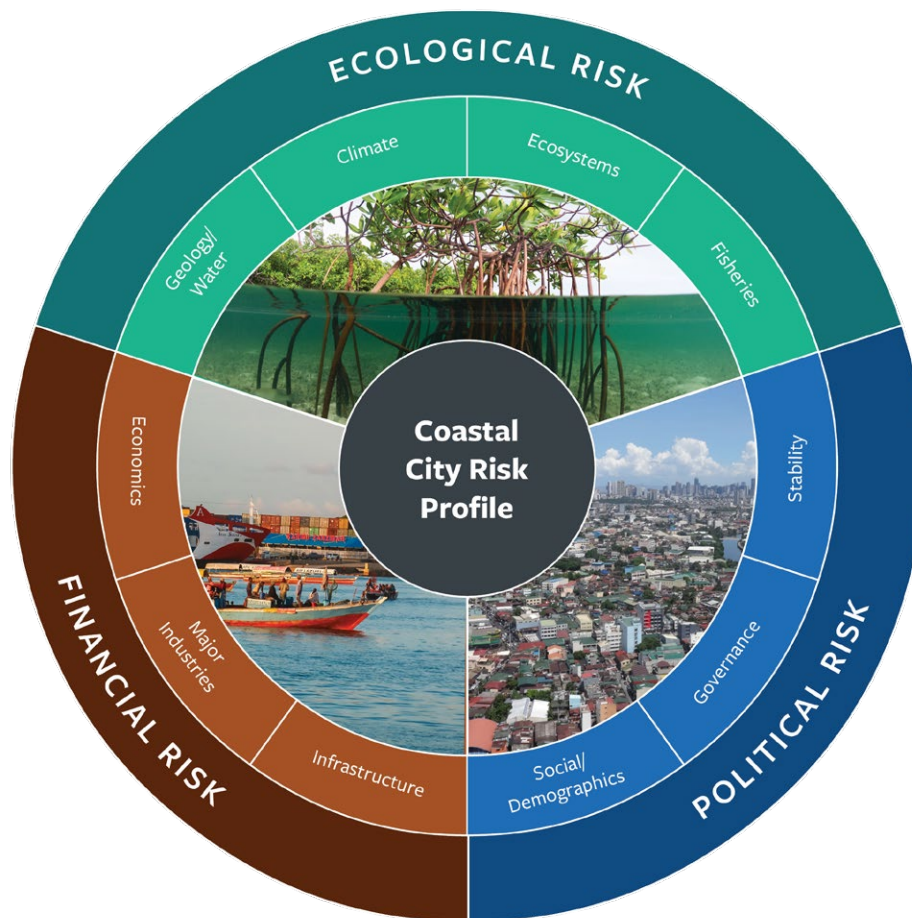


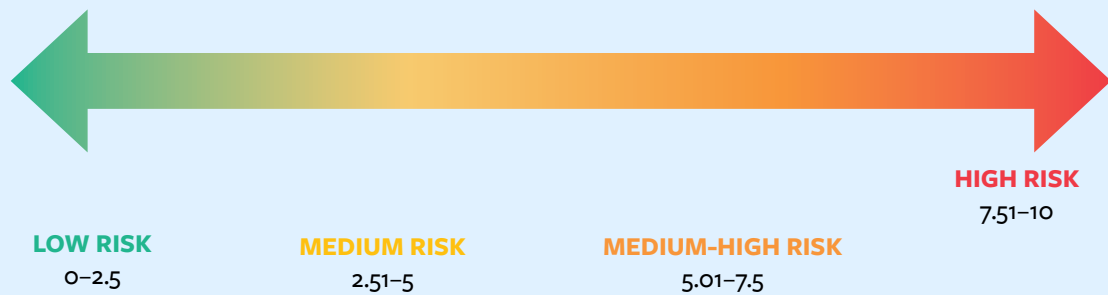
Figure 2: CORVI Risk Types and Categories

## How CORVI is Different

CORVI builds on the work of previous indices but is distinct in three ways.

1. **City-Based:** Unlike many other indices that tend to focus on the national level, CORVI is city-based, providing subnational-level detail on the nature and impact of climate and ocean risks. This focus is based on extensive interviews with potential issuers of the CORVI tool, who noted the difficulty of downscaling national-level risk and vulnerability data to inform policy action to build climate resilience in specific communities.
2. **Holistic:** CORVI looks across a broad set of ecological, financial, and political risk factors that are connected to climate change impacts and that influence vulnerability of coastal cities and their residents. As part of the category and indicator selection process, indicator inclusion was primarily based on its ability to capture and explain climate change risks in coastal cities, and not on whether data was available. This approach promotes a holistic understanding of climate change impacts on coastal cities.
3. **Data-Driven:** Through its utilization of SEJ, CORVI is suited to producing actionable insights in data-sparse environments. By combining empirical and survey data across a wide range of indicators, CORVI fills data gaps to provide a holistic assessment, while reducing data availability bias. This approach provides a contextual and data-driven evaluation of climate and ocean vulnerability.

## Categorizing Risk



### INTERPRETING RISK SCORES

**Low risk** scores mean that either the coastal city has successfully built resilience in the issue area or the indicator is not as relevant for understanding risk in that city.

**Medium risk** scores indicate that while resilience has been built to address the specific risk, future changes could destabilize resilience gains.

**Medium-High risk** scores mean that current measures are insufficient and more attention is required to build resilience against future climate security impacts.

**High risk** scores indicate that the issue area represents a key threat to the coastal city with the potential to undermine the security of its residents.

CORVI was successfully piloted in the coastal cities of Castries, Saint Lucia and Kingston, Jamaica. These first two CORVI city assessments demonstrated the value of CORVI's holistic approach in helping leaders and decision makers prioritize actions and smart investments for risk reduction in coastal cities. Despite the challenges posed by COVID-19, data and recommendations from both risk profiles are beginning to be incorporated into urban resilience planning.<sup>40</sup>

In collaboration with a wide range of on-the-ground research institutions, and the support of local and national governments, six additional CORVI coastal cities assessments are now completed or underway across the globe. In addition to providing decision makers in the specific city with a complete risk picture, each risk profile is added to a global database to improve decision makers' understanding of regional risk dynamics.

## ADVANCING THE SUSTAINABLE DEVELOPMENT GOALS

CORVI aims to contribute to the delivery of the SDGs—an essential framework to guide lasting, positive change. Twenty-seven CORVI indicators are directly related to SDGs, with a further 13 indicators indirectly supporting the implementation of an SDG indicator or target. By providing data and information to measure climate risks in coastal cities, CORVI supports the delivery of the following SDGs:



## Indicators

To ensure that the CORVI indicator scores provide a holistic risk rating, each comprises five factors: current, past, and expected trends, the rate of change of the risk, and the impact of this risk on the coastal city.

1. The **BASELINE** measures the current level of risk for each indicator relative to other coastal cities in the region. Baseline data for economic and social indicators are derived from the most recent year of complete data. Climate indicators use an extended time period of 15 years.<sup>41</sup>
2. **PAST TREND** assesses the trend of risk for the past 10 years, measured from the baseline year. The only exception to the 10-year trend measure is the climate indicators, which use a 15-year trend horizon to account for slow-onset changes.
3. **EXPECTED TREND** assesses the anticipated trend of risk in the next 10 years, measured from the baseline year. The only exception to the 10-year trend measure is the climate indicators, which use a 15-year trend horizon to account for slow-onset changes.
4. **MAGNITUDE** assesses the degree of expected future trend change relative to other cities in the region. Change that happens more quickly than expected are assumed to increase risk

### CORVI ASSESSMENTS COMPLETED

- Castries, St. Lucia
- Dar es Salaam, Tanzania
- Kingston, Jamaica
- Mombasa, Kenya
- Suva, Fiji

### CORVI ASSESSMENTS UNDERWAY

- Basseterre, St. Kitts and Nevis
- Chattogram, Bangladesh
- Dagupan, Philippines

when compared to changes that take place over a longer time scale. This assumes that longer periods of change contribute to less risk, as decision makers have more time to adapt and build resilience.

5. Finally, **IMPACT** assesses the importance of change for each indicator in describing future risk in the coastal city.

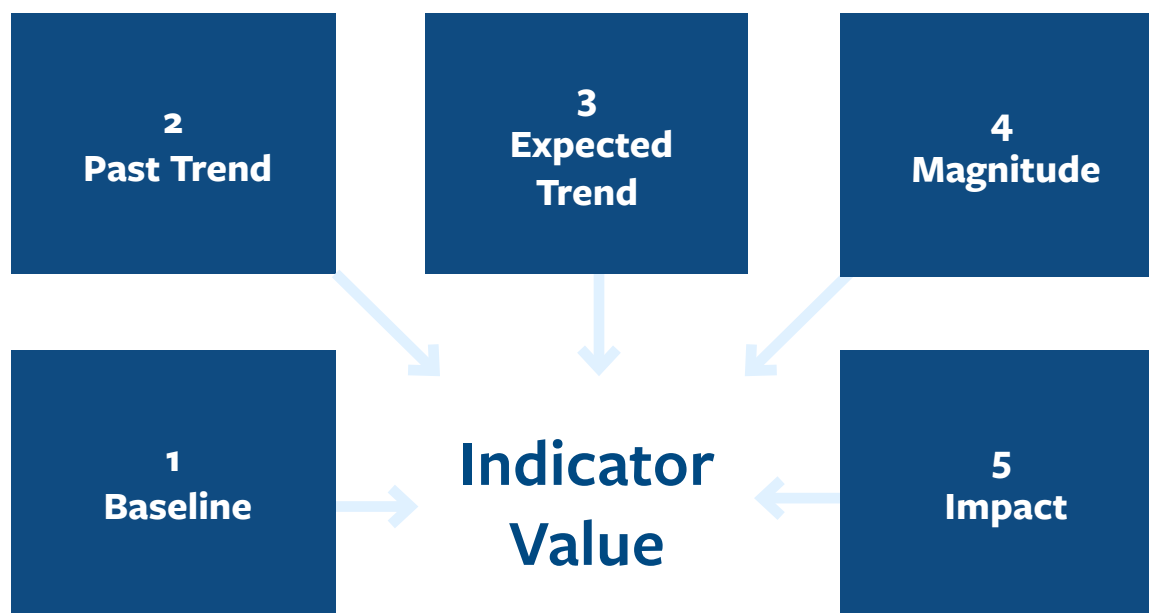


Figure 3: Indicator Factors

## Data Collection and Structured Expert Judgement

To overcome data gaps, CORVI employs structured expert surveys to collect data that is otherwise unavailable. This primary data is combined with secondary data using structured expert judgment (SEJ) to produce a comparative score for each indicator in the assessment.<sup>42</sup> SEJ is a well-established social science technique that seeks to quantify risk when preexisting secondary data is inadequate. Through interviews and surveys, as well as a series of weighting procedures to ensure that data is representative, SEJ allows researchers to quantify topics that might otherwise be challenging to study in such a systematic fashion.

To apply SEJ to CORVI, subject matter experts across academia, government, civil society, and the private sector are identified through research and extensive outreach to stakeholders in the target coastal cities. These experts then refer the project team to other experts and stakeholders with appropriate expertise using “snowball sampling.”<sup>43</sup> To guard against confirmation bias, survey answers are compared to a regional secondary empirical

dataset to weigh the expert responses by utilizing a coherence check.<sup>44</sup> The coherence check ensures that experts whose answers do not match secondary data are not weighed as highly as those who do.

This approach has several strengths. First, CORVI incorporates the views of subject matter experts and local stakeholders at each stage of its implementation. This allows the final product to better reflect the specific context it is seeking to measure and provide more focused information for end users. Second, pairing primary survey data with secondary data through SEJ allows CORVI to provide insight into risks relating to urban coastal environments that existing secondary datasets do not cover. While the use of SEJ allows CORVI to assess a diverse range of risks, however, it should not be regarded as a substitute for empirical data collection. Rather, SEJ is best viewed as an alternative research technique specialized to analyzing topics with significant data gaps.<sup>45</sup>



# CORVI in East Africa

In collaboration with the Western Indian Ocean Marine Science Association (WIOMSA) and Coastal & Marine Resource Development (COMRED), the Stimson Center expanded the CORVI project to East Africa by conducting two CORVI city assessments in Dar es Salaam, Tanzania, and Mombasa, Kenya. To adapt CORVI to East Africa, researchers employed the CORVI protocol to ensure that the resulting analysis is consistent and driven by the regional context.<sup>46</sup> Given the complexity of Africa's regional architecture and the number of different approaches to defining Africa's regions, the African Union's designation for East Africa was selected to ensure common understanding.

Although CORVI categories are consistent across regions, CORVI indicators were individually assessed to ensure that they would capture risks in East

Africa. For example, an indicator focusing on sargassum prevalence (a significant threat in the context of the Caribbean) was removed. However, given the importance of cyclical migration for understanding livelihood strategies in East Africa, this indicator was added.

Through a systematic review, comparable empirical data on 28 out of 96 CORVI indicators was collected at the national and city level, depending on the indicator in question. Expert survey data was collected in each city, with 49 collected from 35 individuals/organizations in Dar es Salaam, Tanzania, and 61 collected from 40 individuals/organizations in Mombasa, Kenya. The regional empirical dataset was combined with expert survey data from Dar es Salaam and Mombasa using SEJ to create CORVI risk scores. This information was supplemented by 31 key informant interviews in Dar es Salaam and 33 in Mombasa, and an assessment of academic and

gray literature on climate impacts to produce the final city risk profiles.

A complete list of indicators for CORVI East Africa is included below. For further details on indicators and data sources, please refer to the appendix. In addition, a list of organizations that provided surveys and participated in interviews is included in the acknowledgment section.

## CORVI East Africa Region



## Ecological Risk Categories and Indicators

Category	Indicator	
Geology/Water	Percent of Metro Area at Risk of Flooding	GW1
	Percent of Land that is Arable Land	GW2
	Degree of Soil Salinity in Arable Lands	GW3
	Projected Change in Sea-Level Rise	GW4
	Rate of Coastal Erosion	GW5
	Degree of Saltwater Intrusion in Coastal Aquifers	GW6
	Piped Water Supply Continuity	GW7
	Percent of Bodies of Water with High Quality	GW8
	Level of Geophysical Risk of Landslides	GW9
Climate	Total Number of Hurricanes/Tropical Cyclones	C1
	Total Number of Flood Events	C2
	Number of Extreme Heat Events	C3
	Number of Droughts	C4
	Number of People Affected by Extreme Weather Events	C5
	Number of Wet Days	C6
	Cases of Vector-Borne Disease Infections	C7
	Change in Sea Surface Temperature	C8
Ecosystems	Level of Mangrove Coverage	E1
	Level of Coral Reefs Coverage	E2
	Level of Sea Grass Bed Coverage	E3
	Health of Existing Mangroves	E4
	Health of Existing Coral Reefs	E5
	Health of Existing Sea Grass Beds	E6
	Percent of GDP Protected by Mangroves	E7
	Percent of GDP Protected by Coral Reefs	E8
	Percent of GDP Protected by Seagrass Beds	E9
	Rate of Occurrence of Harmful Algal Blooms	E10
	Incidence of High Invasive Species Abundance	E11
Fisheries	Nearshore Fish Stock Status	F1
	Offshore Fish Stock Status	F2
	Fish Consumption Per Capita	F3
	Level of Unreported Catch Estimate	F4
	Percent of Fisheries Certified by Marine Stewardship Council (MSC)	F5
	Capacity of Fisheries Enforcement Institutions	F6
	Number of Fisheries Access Agreements with Foreign Nations	F7
	Number of Incidents of Foreign Vessels Fishing in Exclusive Economic Zone (EEZ)	F8

Table: Stimson Center • Created with Datawrapper

## Financial Risk Categories and Indicators

Category	Indicator	
Economics	National GDP per Capita (Purchasing Power Parity)	ECON1
	National Unemployment Rate	ECON2
	National Youth Unemployment Rate	ECON3
	Debt Ratio (% of GDP)	ECON4
	Income Inequality	ECON5
	Urban Unemployment Rate	ECON6
	Level of Informal Economy	ECON7
	Market Losses from Extreme Weather Events	ECON8
	Percent of GDP Generated in Coastal Cities	ECON9
Major Industries	Percent of National Economy Based in Agriculture	MI1
	Percent of National Economy in Nearshore Fishing Industry	MI2
	Percent of National Economy Based in Offshore Fisheries	MI3
	Percent of National Economy Based in Tourism Industry	MI4
	Percent of National Economy Based in Port and Shipping Industries	MI5
	Diversity of Lodging Types	MI6
Infrastructure	Percent of Low-Income Housing in Relation to Flood Zones	I1
	Percent of People Living Below 5 Meters Above Sea Level	I2
	Level of Commercial Infrastructure Damage from Extreme Weather Events	I3
	Level of Housing Damage from Extreme Weather Events	I4
	Level of Shoreline Development	I5
	Level of Informal or Unplanned Settlement	I6
	Level of Grid Resilience	I7
	Renewable Energy Share in Total Energy Consumption	I8
	Level of Water Distribution Infrastructure Resilience	I9
	Proportion of Wastewater Safely Treated	I10
	Degree of Compliance For Solid Waste Management Procedures	I11
	Percent of Population with Adequate Access to Electricity	I12
	Level of Resilience for Roads	I13
	Level of Resilience for Airports	I14
	Level of Resilience for Ports and Shipping	I15

Table: Stimson Center • Created with Datawrapper

## Political Risk Categories and Indicators

Category	Indicator	
Social/Demographics	National Population	SD1
	National Population Density	SD2
	Percent of Population Below Poverty Line	SD3
	Percent of Population Engaged in Seasonal/Cyclical Migration	SD4
	Urban Population	SD5
	Percent of Urban Population Below 30 Years of Age	SD6
	Urbanization Rate	SD7
	Urban Population Density	SD8
	Dependency Ratio	SD9
	Percent of Population Achieving Proficiency in Literacy and Numeracy	SD10
	Percent of Adult Citizens Living Outside of the Country	SD11
Governance	Level of Perceived Transparency within Government	GOV1
	Capacity of Ethics Enforcement Bodies	GOV2
	Voter Turnout	GOV3
	Civil Society Participation	GOV4
	Access to Healthcare	GOV5
	National Climate Adaptation Plan	GOV6
	Rule of Law	GOV7
	Capacity of Current Disaster Response	GOV8
	Investment in Climate-Resilient Development Projects	GOV9
Stability	Percent of People Employed in Agriculture	S1
	Percent of People Employed in Tourism	S2
	Percent of People Employed in Port and Shipping Industries Nationwide	S3
	Percent of People Employed in the Commercial Fishing Industry Nationwide	S4
	Percent of People Employed in Artisanal and Subsistence Fishing	S5
	Number of Years that the Current Government Structure Has Been in Place	S6
	Level of Social Tension	S7
	Number of Incidences of Civil Unrest or Instability	S8

Table: Stimson Center • Created with Datawrapper



# Dar es Salaam Risk Profile

Dar es Salaam is a sprawling city, home to an estimated 6.4 million people. Once the capital of Tanzania, it is the world's second fastest-growing city, the most populated coastal city in East Africa, and the fifth-largest city on the African continent.<sup>47</sup> With an annual urbanization rate of 5.6 percent, Dar es Salaam is expected to grow to 13.3 million residents by 2035. This dramatic growth poses challenges that are being exacerbated by climate change. As a result of urban expansion, the geographic area of the risk profile includes the immediate city limits in the Msimbazi basin and all urban areas in the five municipalities that intersect with Dar es Salaam: Ilala, Temeke, Ubungo, Kinondoni, and Kigamboni. This urban area is administered by the Dar es Salaam City Council.

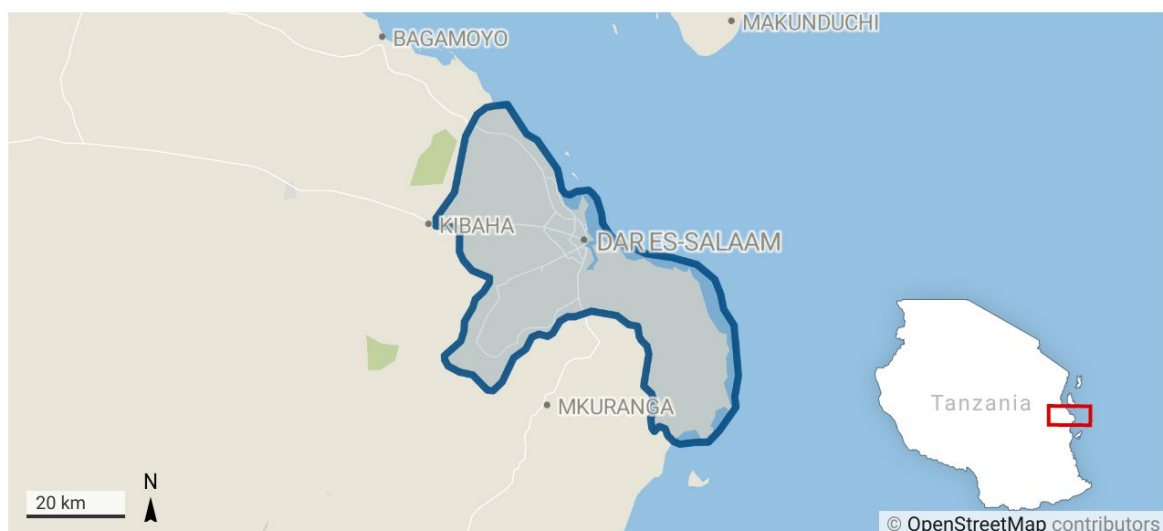
Empirical data and 49 expert surveys incorporated into the Dar es Salaam CORVI risk profile are displayed across 10 categories and 88 indicators.<sup>iii</sup> These scores are supplemented with information about resiliency planning already underway and 31 interviews from experts working on climate resilience in the Dar es Salaam metro area.

## Summary Findings

The CORVI analysis highlights significant economic and social factors under financial and political risk that are compounding climate change impacts and increasing vulnerability across the city. A high risk score for Major Industries (7.98) highlights significant reliance on key sectors, including ports and shipping, and tourism. Medium-high risk scores across Social/Demographics (7.31), Governance (6.66), and Infrastructure (6.50) categories reflect risks associated with unplanned urbanization and coastal development, vulnerability of city residents who reside in informal housing, and risks to waste infrastructure, and the economic impact of flooding. These impacts are closely associated with corresponding risks to the natural environment, which are captured in the Ecosystems category (5.93).

Rapid urbanization is a key issue, driving risk across multiple categories and indicators. Although Dar es Salaam and the surrounding metropolitan area is relatively safe from tropical cyclones, heavy rainfall and flooding from both land and sea is a

## Study Area: Dar es Salaam and the surrounding areas



Map: Stimson Center • Created with Datawrapper

<sup>iii</sup> Six indicators in the Stability category were excluded because of a lack of data. For a full list of organization interviews and data sources, please see the appendix.

constant concern. This problem is compounded by unplanned settlements, with 75 percent of the population living in informal housing.<sup>48</sup> Often located in low-lying, flood-prone areas, these neighborhoods are especially susceptible to climate risks. This issue is exacerbated by a lack of solid waste management, with waste regularly blocking drainage points and contributing to urban flooding, stagnant water in urban areas, and the spread of vector-borne diseases.

Dar es Salaam is an economic powerhouse, responsible for 17 percent of the national GDP of Tanzania and serving as the primary entry point for trade and tourism.<sup>49</sup> Under financial risk, key areas

of concern are economic reliance on key climate-vulnerable industries such as ports and shipping, tourism, and agriculture, as well as the risk posed by flooding to key infrastructure, including bridges, roads, and coastal development. Ecological Risk scored the lowest across the three categories, reflecting that Dar es Salaam is historically unlikely to be impacted by tropical cyclones and has relatively high fish stock health at the national level. However, continued coastal development is harming the terrestrial and ocean environment, contributing to coastal erosion, freshwater shortages, and degraded fish stocks and ecosystems. This development compounds climate impacts such as sea-level rise and flooding.

## Dar es Salaam Risk Profile

CORVI Category Scores: **Low Risk 1 - 2.5** **Medium Risk 2.51 - 5** **Medium-High Risk 5.01 - 7.5** **High Risk 7.51 - 10**

Ecological Risk		Financial Risk		Political Risk	
Ecosystems	5.93	Major Industries	7.98	Social/Demographics	7.31
Geology/Water	5.02	Infrastructure	6.50	Governance	6.65
Climate	3.76	Economics	4.22	Stability	3.69
Fisheries	3.10				

Table: Stimson Center • Created with Datawrapper

The government of Tanzania has recognized the need to build resilience in Dar es Salaam. This is evident in multiple national adaptation strategies and climate adaptation project partnerships that exist between local and international funders. However, disorganized urban planning that does not systemically integrate ocean and climate risks, exacerbated by gaps in financial and technical expertise, have stymied the formulation of integrated planning that connects the development of key sectors, the terrestrial and marine environment, and the needs of vulnerable communities. The CORVI risk profile identifies three priority areas in need of action in order to build resilience and plan for systemic risks:

- **Establish a permanent coordination structure to explicitly integrate ocean risks and marine spatial planning into the city master plan.** To ensure a participatory process, this structure should include national and city-level governing entities, civil society, and the private sector and help disperse information about climate risks and promote the narrative that effective environmental and management of the land and seascape is critical to building resilience, rather than obstructing development.
- **Expand flood adaptation programs, with a focus on meeting the needs of vulnerable neighborhoods by expanding community-based savings schemes and strengthening**

**waste management systems.** Specific actions include upgrading informal settlements to make them more resistant to flooding; expanding waste management services to vulnerable communities; increasing access to financial services, including community saving schemes, to improve household-level resilience; and further integrating nature-based solutions into flood defenses.

- **Enhance climate adaptability in port, tourism, and urban agricultural sectors** by protecting them from climate risks and

ensuring that negative environmental impacts are minimized. To do this, an integrated strategic coastal environmental assessment is needed to incorporate various stakeholder and economic interests, including balancing hard infrastructure and economic development with natural infrastructure solutions.

By advancing cross-cutting policies and channeling resources and investment to these areas, Dar es Salaam can reduce its climate vulnerabilities and work to build a sustainable future.



Dar es Salaam City. Source: Shutterstock.

## Ecological Risk

Dar es Salaam's coasts and coastal ecosystems—including beaches, mangroves, coral reefs, and coastal forests—add significant value to its urban blue economy. The Dar es Salaam coast draws thousands of tourists to the city each year and sustains nearshore fish stocks important to both food security and the fishing economy. Beyond their direct economic value, these ecosystems reduce coastal erosion and protect the coastline against extreme weather events. As the lowest scoring risk type in the CORVI risk profile, Ecological Risk highlights the importance of these ecosystem services, low risk from extreme storms, and relatively healthy national fish stocks. Nevertheless, Dar es Salaam also faces notable ecological risks that, unless properly addressed, could severely undermine the city's economy, biodiversity, and the security of city residents.

- In the **ECOSYSTEMS** category (expert weighted avg 5.93), both coral reef (7.18) and seagrass coverage (7.13) received medium-high risk scores, highlighting the decline of coastal ecosystems, which heightens coastal vulnerability to climate change. Harmful algal blooms (7.09) also received a medium-high risk score, indicating that pollution is a significant area of concern, posing an additional threat to coastal and human health.
- In the **GEOLOGY/WATER** category (expert weighted avg 5.02), the high and medium-high risk scores focus on the risks posed by vector-borne disease (8.29) and flood events (6.68).
- While the **CLIMATE** category scores as medium risk (expert weighted avg 3.76), high and medium-high risk scores emphasize Dar es Salaam's vulnerability to sea-level rise (8.20), coastal erosion (6.34), and saltwater intrusion in coastal aquifers (6.04), all of which highlight risks to coastal infrastructure, coastal populations, and access to clean drinking water.
- The medium risk score in the **FISHERIES** category (expert weighted avg 3.10) suggests that fisheries do not significantly impact risk for Dar es Salaam. However, medium-high risk scores for the percentage of fisheries certified by the Marine Steward Council (6.06), fish consumption (5.85), and the capacity of fisheries enforcement institutions (5.18) suggest

future vulnerabilities for the fishing industry if marine resources are not sustainably managed.

CORVI's Ecological Risk indicators show risks clustered around ecosystems and flood risk, with lower scores recorded in fisheries and climate. Nationally, Tanzania's coral reefs and seagrass beds, which cover about two-thirds (600 km) of Tanzania's continental shelf, serve important ecological and economic functions. For example, coral reefs and beaches are one of the country's main tourist attractions, sustain livelihoods in coastal communities, and provide an important source of foreign currency. Moreover, coral reefs help to prevent coastal erosion by mitigating the effects of strong waves on the coastline, thus shielding Tanzania's coastal biodiversity and infrastructure. However, Tanzania's coral reefs and seagrass beds are under threat from various human and non-human stressors, including coral bleaching events caused by increasing ocean surface temperatures, coastal development, and unsustainable fishing practices.<sup>50</sup> This is reflected in declining levels of coral (7.18) and seagrass bed (7.13) coverage.

Tanzania also houses one of the largest continuous mangrove forests in Africa, encompassing an estimated 115,000 hectares of coastline. This large expanse is reflected in a medium risk score for mangrove coverage (4.58). Mangroves are a vital coastal resource in Tanzania, providing shelter to juvenile fish species and coastal infrastructure, preserving the coastline's marine biodiversity, and providing an important source of food and income to local villagers.<sup>51</sup> In Dar es Salaam, small mangrove forests remain in the following areas: Dege, Nguvu, Kibugumo, the Mzinga Creek fork, Janwani Beach, and from Mbenwi northwards along the beach. However, mangrove deforestation continues as a result of coastal development, beach seine fishing techniques, tourism, and inadequate waste management.<sup>52</sup> This threat is noted in a higher risk score for mangrove health (5.53), indicating that the health of existing mangroves is declining.

The geography of Dar es Salaam, along with increasingly erratic rainfall and rising sea levels, increases the risk of flooding. While the number of annual rainfall events has decreased, individual rainfall events are growing more severe.<sup>53</sup> This has had corresponding impacts on people, businesses,



and the environment, as reflected in a medium-high flood risk score (6.68). Floods frequently impede city traffic, destroy homes, and curtail economic activity. The floods of April 2018, for example, destroyed roads and bridges, displaced 1,215 households, and generated household losses of approximately \$100 million.<sup>54</sup> Flood impacts are compounded by population growth, lack of adequate drainage, and the removal of green spaces, which inhibits stormwater absorption into aquifers.<sup>55</sup> Changing rainfall patterns are also impacting long-term water security. For example, the Ruvu River Basin, the principal water source for Dar es Salaam, is projected to experience a 10 percent decrease in runoff due to climate change.<sup>56</sup>

Flood risk also originates from the ocean storm surge. Percent of metro area at risk scored as low risk (1.00), suggesting that compared to other coastal cities in East Africa, Dar es Salaam's elevation profile makes it less susceptible to coastal flooding. Nonetheless, approximately 143,000 people, with \$168 million in assets, still live in a low elevation zone.<sup>57</sup> Moreover, significantly higher risk scores for sea-level rise (8.20) and coastal erosion (6.34) indicate growing threats that could undermine the city's future. Over the past 50 years, Dar es Salaam's

beaches have retreated several meters.<sup>58</sup> The Kunduchi beach areas, for example, has been heavily impacted by sea-level rise, recording 200 meters of coastal losses, with the subsequent loss of homes, businesses, and public buildings.<sup>59</sup>

Finally, although its contribution to national GDP has declined, fisheries remain an important sector in Tanzania. Nationally, it directly employs 170,000 small-scale fishers and supports four million people who rely on fisheries-related activities including fish processing and marketing, trade in fishing, boat building, and maintenance as a source of livelihood.<sup>60</sup> In Dar es Salaam, fishing is an important economic activity for all districts, with Kivukoni Fish Market serving as the primary center of fisheries-based trade.

Low CORVI indicator scores for the status of near (1.00) and offshore (1.00) fish stocks suggest that relative to other counties in East Africa, Tanzanian fish stocks remain sustainably managed. However, higher CORVI scores in the percent of fisheries certified as sustainable and a lack of fisheries enforcement capacity, along with relatively high levels of fish consumption, suggest that these indicators require continued monitoring.



Sea Wall in Dar es Salaam. Source: UN Environment Program.

## Dar es Salaam: Ecological Risk

Each category score comprises multiple indicators.

Low 1 - 2.5 Medium 2.51 - 5 Medium-High 5.01 - 7.5 High 7.51 - 10

Category		Indicator	
Ecosystems	5.93	Level of Coral Reefs Coverage	7.18
		Level of Sea Grass Bed Coverage	7.13
		Rate of Occurrence of Harmful Algal Blooms	7.09
		Incidence of High Invasive Species Abundance	6.72
		Health of Existing Coral Reefs	5.93
		Percent of GDP Protected by Sea Grass Beds	5.54
		Health of Existing Mangroves	5.53
		Percent of GDP Protected by Coral Reefs	5.45
		Health of Existing Sea Grass Beds	5.45
		Percent of GDP Protected by Mangroves	4.88
		Level of Mangrove Coverage	4.58
Geology/Water	5.02	Projected Change in Sea Level Rise	8.20
		Rate of Coastal Erosion	6.34
		Degree of Saltwater Intrusion in Coastal Aquifers	6.04
		Percent of Landscape that is Arable Land	5.20
		Degree of Soil Salinity in Arable Lands	5.10
		Percent of Bodies of Water with High Water Quality	4.91
		Piped Water Supply Continuity	4.37
		Level of Geophysical Risk of Landslides	3.11
		Percent of Metro Area at Risk of Flooding	1.00
Climate Change	3.76	Cases of Vector-Borne Disease Infections	8.29
		Number of Flood Events	6.68
		Number of Wet Days	4.51
		Number of Droughts	4.13
		Number of Extreme Heat Events	2.78
		Total Number of Hurricanes/Tropical Cyclones	1.28
		Change in Sea Surface Temperature	1.00
		Number of People Affected by Extreme Weather Events	1.00
Fisheries	3.10	Percent of Fisheries Certified by MSC	6.06
		Fish Consumption Per Capita	5.85
		Capacity of Fisheries Enforcement Institutions	5.18
		Number of Fisheries Access Agreements with Foreign Nations	4.67
		Level of Unreported Catch Estimate	2.75
		Nearshore Fish Stock Status	1.00
		Number of Incidents of Foreign Vessels Fishing in EEZ	1.00
		Offshore Fish Stock Status	1.00

Table: Stimson Center • Created with Datawrapper

## Financial Risk

Dar es Salaam is the economic hub of Tanzania. The city sustains significant tourism, shipping, manufacturing, and agricultural industries, and contributes more to Tanzania's national GDP than any other urban center. This economic strength also exposes significant vulnerabilities, including high reliance on climate-vulnerable industries and inadequate infrastructure that has not kept pace with rapid urbanization trends. That being said, low national debt increases the ability of the central government to borrow and invest in climate resilience.

- The highest-scoring category in the risk profile, **MAJOR INDUSTRIES** (expert weighted avg 7.98) indicators reveal significant dependence on the port and shipping industry (9.33), tourism (9.07), and the agricultural sector (8.45).
- The **INFRASTRUCTURE** category (expert weighted avg 6.50) shows high and medium-high risk scores in shoreline development (7.60), the proportion of wastewater safely treated (7.23), and the degree of compliance with solid waste management procedures (7.16), all of which compound flood risk in Dar es Salaam.
- While the **ECONOMICS** category scores as medium risk (expert weighted avg 4.22), medium-high risk scores for GDP generated in coastal cities (7.48), informal economy (7.32), and urban unemployment (7.27) indicate vulnerability to external economic shocks. Conversely, low levels of national debt (2.00) suggest capacity on the part of the Tanzania government to withstand and recover from climate risks.

Dar es Salaam is an economic powerhouse. It is nearly three times the size of the capital city of Dodoma and contributes 17 percent to Tanzania's GDP.<sup>61</sup> Tourism, shipping, financial services, and manufacturing are significant economic sectors, with much of the city's economic activity taking place in coastal zones. However, this economic activity is threatened by climate change and the unplanned consequences of urbanization. In addition, flooding frequently causes significant disruptions, with citywide damage from flooding accounting for three percent of GDP in 2018.<sup>62</sup>

The Port of Dar es Salaam is Tanzania's most important port, handling 95 percent of the nation's

international trade.<sup>63</sup> It is also an important hub for the tourism industry, transporting tourists between Dar es Salaam and the islands of Pemba and Zanzibar. Although the port is relatively safe from flooding, pollution remains a concern. Specifically, pollution from port activities and its corresponding impacts on coastal ecosystems contribute to declining mangrove, coral, and seagrass bed coverage. This compounds flood risks by reducing nature-based defenses and contributes to coastal erosion.<sup>64</sup>

Tourism is a cornerstone of Tanzania's economy, contributing 17.2 percent to national GDP, employing over 600,000 people, and generating \$2.4 billion per year.<sup>65</sup> Dar es Salaam is critical to the development of the sector, with the majority of tourists entering the country through the nearby Julius Nyerere International Airport. Dar es Salaam also houses a significant number of coastal hotels and facilities. This reliance is reflected in the high CORVI risk score (9.07). However, the sector is at risk from climate change. Retreating beaches, compounded by declining coastal ecosystems, are a significant threat to the long-term sustainability of the sector. The impacts of coastal erosion are particularly severe in the Kunduchi district, where beaches and hotels are disappearing as a result of coastal erosion.<sup>66</sup> Moreover, continued construction of coastal tourist facilities, reflected in a medium-high risk score for diversity of lodging types (7.15), suggests continued development in areas that will become more susceptible to climate change impacts.

Tanzania is heavily dependent upon agriculture, with 90 percent of the country depending on this sector for their economic or food security.<sup>67</sup> In Dar es Salaam and the surrounding metropolitan areas, urban agriculture forms at least 60 percent of the informal economy.<sup>68</sup> Primarily rain-fed, agricultural activity in Dar es Salaam relies on consistent and cyclical rainfall. Increasingly erratic rainfall, a reduction in moderate temperatures, and extended drought threaten livelihoods across the country. Climate risks to the agriculture sector intersect with Dar es Salaam in two primary ways. First, degrading rural livelihoods contribute to migration to Dar es Salaam, fueling urbanization trends. Second, climate change undermines urban agriculture in Dar es Salaam, an essential means of livelihood and sustenance for the city's poor.<sup>69</sup>



Dar es Salaam Port. Source: Ungureanu Catalina Oana (Shutterstock).

Comparatively lower, medium-high risk scores in near and offshore fisheries show that Dar es Salaam is less reliant on the sector than other East African coastal cities for its economic and food security. However, driven by the growth of the informal fishing economy and the consumption needs of a rapidly expanding population, an increasing number of nearshore fisherfolk are engaging in fishing activities.<sup>70</sup> This finding connects to the risk scores under ecological risk, which note higher levels of sustainability compared to other countries in East Africa, as well as current and future threats posed by a lack of enforcement and sustainability practices.

Risks to infrastructure are widespread, with at least medium-high risk scores for every indicator in the category. Compounded by unplanned urbanization and development near the shoreline is the city's lack of reliable waste management infrastructure. In 2011, only 10 percent of Dar es Salaam's population connected to the city's sewage system. Further, the city's solid waste collection and disposal services cannot properly manage 60 percent of its waste.<sup>71</sup> More recently, in 2017, the National Environment Report noted that 70 to 80 percent of Tanzania's mainland urban population live in informal settlements that lack appropriate infrastructure and waste management services.<sup>72</sup> Risks to infrastructure are reflected in a high risk score for level of coastal development (7.60) and medium-high scores for the proportion of wastewater safely treated (7.16) and degree of compliance for solid

waste management procedures (7.16). Due to this, many of the city's residents dispose of their solid waste in Dar es Salaam's streets, markets, rivers, and stormwater drainage channels. Consequently, many parts of the city and sewage system overflow during Dar es Salaam's rainy season, spreading polluted waters around the city and contributing to the spread of water-borne diseases.

Vulnerabilities to existing infrastructure also compound climate risks to key industries. Dar es Salaam's existing road infrastructure is inadequate, with only 25 percent of the roads in the city paved in 2011.<sup>73</sup> In addition to its insufficient and poorly maintained roads, Dar es Salaam suffers from severe traffic congestion, with a considerable increase in the number of cars on the roads over the past few years. Recently introduced rapid bus lines have relieved some transit pressure. However, bus parking areas are at risk of flooding.<sup>74</sup> These compounding risks are also reflected in a medium-high score for commercial infrastructure damage from extreme weather events (6.97). Finally, relatively low levels of grid resilience (6.70) and irregular access to electricity (6.72) continue to hamper businesses and city residents.<sup>75</sup> While renewable energy projects, such as Generator Zero, are installing solar panels on public facilities and businesses, inconsistent funding and regulations impede further rollout.<sup>76</sup> This is reflected in the medium-high score for renewable energy uptake (5.54).



## Dar es Salaam: Financial Risk

Each category score comprises multiple indicators.

**Low 1 - 2.5** **Medium 2.51 - 5** **Medium-High 5.01 - 7.5** **High 7.51 - 10**

Category		Indicator	
<b>Major Industries</b>	<b>7.98</b>	Percent of National Economy Based in Port and Shipping Industries	<b>9.33</b>
		Percent of National Economy Based in Tourism Industry	<b>9.07</b>
		Percent of National Economy Based in Agriculture	<b>8.45</b>
		Percent of National Economy Based in Near Shore Fishing Industry	<b>7.20</b>
		Diversity of Lodging Types	<b>7.15</b>
		Percent of National Economy Based in Offshore Fishing	<b>5.35</b>
<b>Infrastructure</b>	<b>6.50</b>	Level of Shoreline Development	<b>7.60</b>
		Proportion of Wastewater Safely Treated	<b>7.23</b>
		Degree of Compliance for Solid Waste Management Procedures	<b>7.16</b>
		Percent of Low-Income Housing in Relation to Flood Zones	<b>7.00</b>
		Level of Commercial Infrastructure Damage from Extreme Weather Events	<b>6.97</b>
		Percent of Population with Adequate Access to Electricity	<b>6.72</b>
		Level of Grid Resilience	<b>6.70</b>
		Level of Informal or Unplanned Settlement	<b>6.44</b>
		Percent of People Living Below 5 Meters Above Sea Level	<b>6.24</b>
		Level of Housing Damage from Extreme Weather Events	<b>6.21</b>
		Level of Resilience for Roads	<b>5.83</b>
		Level of Resilience for Ports and Shipping	<b>5.62</b>
		Level of Water Distribution Infrastructure Resilience	<b>5.59</b>
		Renewable Energy Share in Total Energy Consumption	<b>5.54</b>
		Level of Resilience for Airports	<b>5.15</b>
<b>Economics</b>	<b>4.22</b>	Percent of GDP Generated in Coastal Cities	<b>7.48</b>
		Level of Informal Economy	<b>7.32</b>
		Urban Unemployment Rate	<b>7.27</b>
		National GDP Per Capita (Purchasing Power Parity)	<b>6.27</b>
		Income Inequality	<b>5.53</b>
		Market Losses from Extreme Weather Events	<b>3.40</b>
		Debt Ratio (% of GDP)	<b>2.00</b>
		National Unemployment Rate	<b>1.00</b>
		National Youth Unemployment Rate	<b>1.00</b>

Table: Stimson Center • Created with Datawrapper

## Political Risk

Dar es Salaam is one of the most rapidly urbanizing cities in the world. Because of a lack of urban planning and housing deficits, 75 percent of Dar es Salaam's residents live in informal settlements, often located in low-lying areas and susceptible to climate risks.<sup>77</sup> These risks are exacerbated by outdated infrastructure and declining ecosystems, as highlighted in the ecological and financial risk sections. Other key issues highlighted include a lack of adaptation planning and investment.

- The second highest scoring category in the risk profile, **SOCIAL/DEMOGRAPHICS** (expert weighted avg 7.31) shows high risk scores for urbanization (9.48), urban population density (9.42), urban population (9.40), percentage of the urban population below 30 (9.03), and the dependency ratio (8.35), all of which reflect risks posed by rapid urbanization.
- In the **GOVERNANCE** category (expert weighted avg 6.66), the high and medium-high risk scores highlight a lack of investment in climate resiliency development projects (7.87), low confidence in ethics enforcement bodies (7.07), and lack of confidence in national climate adaptation planning (6.87).
- The lowest-scoring category in the risk profile, **STABILITY** (expert weighted avg 3.69) highlights a high degree of government stability (1.00) and low levels of social tension (1.00). However, a high-risk score for employment in agriculture (8.00) suggests that climate impacts could harm people employed in this sector and undermine the economic and social resilience of those who depend on the agricultural sector for their food security.<sup>iv</sup>

Urbanization is a key trend across the risk profile, contributing to climate and ocean risk in Dar es Salaam and reflected across high risk scores in the urbanization rate (9.48), urban population density (9.42), and urban population (9.40). While the most recent City Master Plan (2016-2025) highlights the opportunities that urbanization provides for economic growth and improved living standards, it also notes the need to expand infrastructure and public services to accommodate rising birthrates and rapid rural-to-urban migration.<sup>78</sup>

Approximately 22 percent of the city is classified as built-up areas, and around half of the buildings are unplanned. Thus, much of the city's expansion has occurred in informal peri-urban settlements (6.44).<sup>79</sup> Although much of the housing in planned areas of the municipality complies with city housing codes, many other dwellings are constructed in unplanned areas with poor-quality materials that do not meet code, increasing the risk of flooding. This is reflected in a medium-high risk score for damage to housing from extreme weather (6.21) in the financial risk section. Further, vulnerability is exacerbated by a high dependency ratio (8.35) that indicates a larger number of dependents per household, which lowers the city's capacity to withstand climate events. Although efforts have been made in informal areas of the city to link these areas to city infrastructure, these urban planning efforts have been hindered by a lack of coordination among city councils, utilities, and the central government.<sup>80</sup>

High and medium-high risk scores for investment in resilience projects (7.87) and the national adaptation planning (6.78) indicate a lack of confidence from experts surveyed that current measures are sufficient to meet the challenge posed by climate change. Further, medium-high scores in civil society participation (6.02) and perceived level of transparency (5.45) suggest lack of confidence that the government has the human and financial capacity to meet climate challenges. This was reflected in expert interviews, which noted a lack of public consultations on ecosystem protection measures in and around the city.<sup>81</sup>

Efforts to build resilience are further hampered by a lack of local planning, technical capacity, and financial gaps. For example, the Environment Management Act's 60-meter rule prohibits building near the coastline in Dar es Salaam. However, a lack of compliance and enforcement has led to significant construction in areas at risk of flooding in Dar es Salaam.<sup>82</sup> This is reflected in estimates that it costs US\$500 million per year to address current climate risks, with a further US\$150 million needed to enhance resilience against future climate change in Tanzania.<sup>83</sup> Ensuring that local planning and regulations are adequately financed is important to effectively building resilience.

iv Five indicators in the Stability category were excluded because of a lack of data.





Informal housing in Dar es Salaam. Source: Rob Atherton (Shutterstock).

Finally, a lack of data prevented CORVI from generating all risk scores in the stability category. Nevertheless, high levels of employment in the agricultural sector (8.00) and its corresponding vulnerability to climate change could present secondary risks to Dar es Salaam, as highlighted in the financial risk section. Conversely, social tension scored as low risk (1.00).<sup>v</sup> While Tanzania's democratic institutions have been in place since 1971, in recent years Tanzania faced significant

challenges, including an increasingly powerful executive branch, limited civil society participation, and limited government capacity leading to low-quality public services. These difficulties are reflected in medium-high risk scores in the rule of law (6.67) and trust in ethics bodies (7.07) indicators. Despite these difficulties, the country has recently committed to its people and the international community to improve its democratic governance.<sup>84</sup>

<sup>v</sup> Because of a lack of surveys, the level of social tension indicator was measured by the occurrence of protests and strikes as catalogued in the Social Conflict Analysis Database. For more information on indicators and empirical data sources, please refer to the appendix.

## Dar es Salaam: Political Risk

Each category score comprises multiple indicators.

**Low 1 - 2.5** **Medium 2.51 - 5** **Medium-High 5.01 - 7.5** **High 7.51 - 10**

Category		Indicator	
<b>Social/Demographics</b>	7.31	National Population	9.54
		Urbanization Rate	9.48
		Urban Population Density	9.42
		Urban Population	9.40
		Percent of Urban Population Below 30 Years of Age	9.03
		Dependency Ratio	8.35
		Percent of Population Below Poverty Line	7.02
		Percent of Population Engaged in Seasonal/Cyclical Migration	6.48
		Percent of Adult Citizens Living Outside of the Country	5.89
		Percent of Population Achieving Proficiency in Literacy and Numeracy	4.25
		National Population Density	1.00
<b>Governance</b>	6.65	Investment in Climate Resiliency Development Projects	7.87
		Capacity of Ethics Enforcement Bodies	7.07
		National Climate Adaptation Plan	6.87
		Rule of Law	6.87
		Access to Healthcare (HAQ)	6.77
		Voter Turnout	6.46
		Capacity of Current Disaster Response	6.15
		Civil Society Participation	6.02
		Level of Perceived Transparency within Government	5.45
<b>Stability</b>	3.69	Percent of People Employed in Agriculture	8.00
		Level of Social Tension	1.00
		Number of Years that the Current Government Structure Has Been in Place	1.00

Table: Stimson Center • Created with Datawrapper



## The Status of Urban Resilience Planning in Dar es Salaam

The government of Tanzania has made significant steps to integrate climate change adaptation and mitigation strategies into its national policy and development framework. The National Climate Change Strategy, adopted in 2012, culminating in the submission of its Nationally Determined Contribution to the United Nations Framework Convention on Climate Change in 2015.<sup>85</sup> This work has been accompanied by climate resilience programs for agriculture, health, and water sectors.<sup>86</sup>

Although the Ministry of Environment manages climate policy and urban resilience planning, implementation is spread across several agencies in Tanzania. The 1997 National Environmental Policy and the 2004 Environment Management Act require that the Vice President's Office—Division of Environment (DoE) manage and oversee all environment- and climate change-related efforts. DoE is tasked with integrating climate change into national policies, and the National Environment Management Council manages enforcement of these policies as required by the Environmental Management Act. DoE also houses the Disaster Management Unit, which is primarily responsible for disaster risk reduction efforts.

In Dar es Salaam, multiple projects are underway to build resilience, several of which have received international support. In 2014, the World Bank undertook the Building Climate Resilience in Tanzania Water Sector project, which improved Tanzania's urban flood risk mapping and helped cities engage in more effective disaster risk management.<sup>87</sup> In addition, the Tanzania Urban Resilience Program, established by the government of Tanzania in 2016 with support from the World Bank and the UK Department for International Development, enhanced urban resilience to climate and disaster risk.<sup>88</sup> Finally, the EU, through the Adapting to Climate Change in Coastal Dar es Salaam project, is working to help Dar es Salaam's municipalities better design climate adaptation policies and better integrate them into urban planning.<sup>89</sup>

However, due to the centralization of climate resilience planning, capacity gaps at the subnational level impede local climate adaptation planning and action.<sup>90</sup> Most of Tanzania's national climate resilience initiatives and policies rely on a top-down process that could benefit from greater coordination between the federal and local levels of government.<sup>91</sup> Furthermore, the city of Dar es Salaam has a fragmented governance structure, with multiple and overlapping local jurisdictions between the Dar es Salaam City Council and the five municipal councils—Illala, Temeke, Ubungo, Kinondoni, and Kigamboni. This fragmentation can inhibit effective coordination and implementation of a holistic resilience strategy.<sup>92</sup> As a result of these limitations, existing climate adaptation efforts in Dar es Salaam have tended to focus on local projects within the city limits, which are not clearly integrated across other key sectors.<sup>93</sup>

The most recent City Master Plan (2016-2025) notes the importance of building resilience to climate change impacts and balancing natural and human resources to enhance the socioeconomic development of the city.<sup>94</sup> However, there is currently no integrated coastal management program for Dar es Salaam, which is hindering the development of a holistic urban resilience strategy.<sup>95</sup> Other notable gaps identified include limited financial and technical capacity to assess compounding climate impacts, the need for additional research to understand the climate vulnerabilities of the urban poor in Dar es Salaam, and the risks posed by development in fragile ecosystems such as wetlands, river valleys, and marine ecosystems. The most recent National Adaptation Report also highlighted that data gaps contribute to a lack of subnational climate change policies, plans, and strategy.<sup>96</sup> Similarly, interviews noted that while some departments, ministries, and local bodies have created environmental desks to develop climate change policy, persistent technical gaps and a lack of financial resources impede the development of climate-resilient policies, frameworks, and budgets.<sup>97</sup>

## Recommendations to Build Resilience

Despite institutional and capacity barriers, Dar es Salaam has made notable progress in building urban climate resilience. Yet climate and ocean risks, compounded by urbanization and land-use changes, continue to increase. The most recent update to the National Adaptation Plan noted the need for updated vulnerability and adaptation assessments that are downscaled to local needs and impacts.<sup>98</sup> The evidence gathered through this assessment is a first step in doing this, yet more work is needed to develop integrated strategies and implement projects that build resilience to the multidimensional climate risks facing Dar es Salaam.

The highest risks identified in the CORVI assessment are categorized under Major Industries (7.98), Social/Demographics (7.31), and Infrastructure (6.50). The analysis identified urbanization and high levels of shoreline development, excessive reliance on major industries including shipping and tourism, and risks to key infrastructure including the electrical grid and roads. Moreover, compounding impacts on vulnerable people and ecosystems, such as land-based pollution from key sectors and inadequate wastewater and solid waste management, are highlighted through high numbers of informal settlements and declining coral and mangrove coverage and health. These risks can begin to be addressed through the following priority actions.

### **Develop a holistic climate resilience implementation strategy across the land-seascape**

Indicators, interviews, and analysis of resilience actions already underway in Dar es Salaam all highlight the need for better coordination in planning and implementation. In addition, high levels of ocean risks, including saltwater intrusion, coastal erosion, the reliance on blue economy sectors, and risks to coastal ecosystems, point to the need to better integrate the seascape into urban planning.<sup>99</sup> Given the compounding impacts of these issues for flood and pollution risks in Dar es Salaam, implementation of the city's master plan needs to explicitly integrate ocean issues and risks.

To ensure integration between national and the various city-level governing entities, such a process should involve primary national agencies, including the Vice President's Office, Division of

Environment, the Ministry of Finance, and the National Environment Management Council, local government actors including relevant municipalities and the City Council, civil society, and the private sector. This process will also help to disperse information about climate risks and promote the narrative that effective environmental and land-use planning is critical to building resilience, rather than obstructing development.<sup>100</sup>

Finally, to ensure effective implementation, permanent coordination structures should be established. This is critical to addressing the compounding risks identified, ensuring a participatory stakeholders-driven process, and avoiding the dangers of maladaptation.

### **Improve and expand flood adaptation and resilience planning**

Flooding poses a substantial threat to Dar es Salaam, particularly in outlying peri-urban areas. Underlying economic and social conditions exacerbate climate risks. Vulnerable infrastructure, inadequate waste management, population density, and unsustainable land-use practices were all noted as key factors.<sup>101</sup> The city's poor, many of whom live in these outlying areas, not only face greater flood risks, but are also less able to cope with flood damages. In addition, CORVI findings highlighted a growing infrastructure gap, which impacts flood resilience in two ways: first, inadequate drainage and waste infrastructure exacerbate root causes of flooding; and second, the impact of flooding on road, water supply, and electrical networks impedes recovery.<sup>102</sup> Waste blocking drainage and inadequate management of natural drainage were both identified as critical issues exacerbating flooding, particularly in low-lying areas near the coastline and rivers.

Work is already underway to build resilience, but more is needed to address these specific problems, such as moving informal housing out of harm's way and upgrading existing housing to withstand climate change impacts. It is also essential to expand infrastructure to informal housing neighborhoods. Upgrading waste, sanitation, and drainage systems is critical to reducing the risks posed by flooding. Moreover, improving the resilience of roads, the water supply, and electrical networks has significant benefits to poor and marginalized communities.<sup>103</sup>

Detailed evaluation is also needed on the impacts of infrastructure improvements to ecosystems, including nature-based solutions, prior to project approval, to ensure that infrastructure growth is in parallel with nature-based solutions. Measuring the economic value of natural infrastructure and integrating it into urban planning is key to ensuring that future development preserves and expands such areas.<sup>104</sup> To save costs and further preserve the natural environment, efforts should also be made to extend waste management coverage to peri-urban areas, as well as to integrate alternative waste solutions, including organic waste and recycling, into city waste management.<sup>105</sup>

Finally, priority actions should be taken to increase stability at the household level by expanding community-based finance schemes. For households, ensuring that financial resources are available to address flood impacts before they occur is critical. Community saving schemes and banking programs are two measures that help local communities pool financial resources and invest in flood protection measures, have been successful in helping vulnerable communities adapt and build resilience to flood risks.<sup>106</sup> Such schemes should be expanded, while ensuring that local program ownership is maintained.

### **Enhance the climate adaptability of key industries**

The shipping, tourism, and agricultural sectors are especially vulnerable to climate change and comprise a large portion of Dar es Salaam's, and Tanzania's, economic output. It is critical to protect these industries from climate risks and ensure that negative environmental impacts are minimized.

Dar es Salaam's port is primarily managed by the Tanzania Shipping Agencies Corporation (TASAC), which regulates marine transport in Tanzania. In 2017, an amendment to the Tanzania Shipping Agencies Act 2010 sought to expand TASAC's regulatory control to reduce pollution from ships. In addition, Maritime Technologies Cooperation Centers Africa, a regional organization seeking

to reduce emission from the maritime sector, has partnered with the port to cut greenhouse gas emissions and air pollution from its ships and facilities.<sup>107</sup> Such efforts are worth noting and should be expanded to include further efforts to reduce local environmental impacts, with a focus on curtailing pollution runoff into the marine environment.

Coastal tourism is clearly impacted by climate change and pollution from unplanned urbanization and unsustainable land-use changes. In response, local government and private companies have begun to undertake projects to build resilience. For example, projects to build seawalls and groins, particularly along Kunduchi beach, have had some success. However, these projects are costly to implement and maintain, and often have corresponding negative impacts by contributing to erosion further along the coastline. As a result, an integrated strategic coastal environmental assessment is needed to incorporate various stakeholder and economic interests, including balancing hard infrastructure with natural infrastructure solutions. It is important to harmonize efforts between local governments, the National Environment Management Agency, and the private sector to blend financial resources and ensure that adaptations that benefit one area do not increase risk in another.

Finally, the CORVI assessment highlighted the importance of urban farming for livelihood and substance functions.<sup>108</sup> However, pollution and climate risks threaten the agricultural sector in Dar es Salaam. Moreover, unplanned expansion of urban agriculture into wetlands can also impede nature-based defenses if not adequately managed. Given its importance to the economic and food security of poor residents—and particularly women—urban farming should be more explicitly integrated into urban planning, allowing farmers to secure tenure and increase the economic value derived from this activity.<sup>109</sup> More broadly, city planners can also incorporate these land features into city flood management.

# Mombasa Risk Profile

Centered on an island and home to the largest international seaport in East Africa, Mombasa is critical to the economic security of Kenya and landlocked nations in East and Central Africa. Home to 1.2 million people, it is Kenya's second-largest city.<sup>110</sup> However, over the past 20 years, the population of Mombasa has almost doubled, posing challenges to urban planning and the natural environment that are being exacerbated by climate change.<sup>111</sup> To fully capture how climate change is interacting with urbanization and environmental challenges in Mombasa, the geographic area of the risk profile includes Mombasa Island, the mainland areas of the city, and the immediate urban coastline areas in the neighboring counties of Kilifi and Kwale.

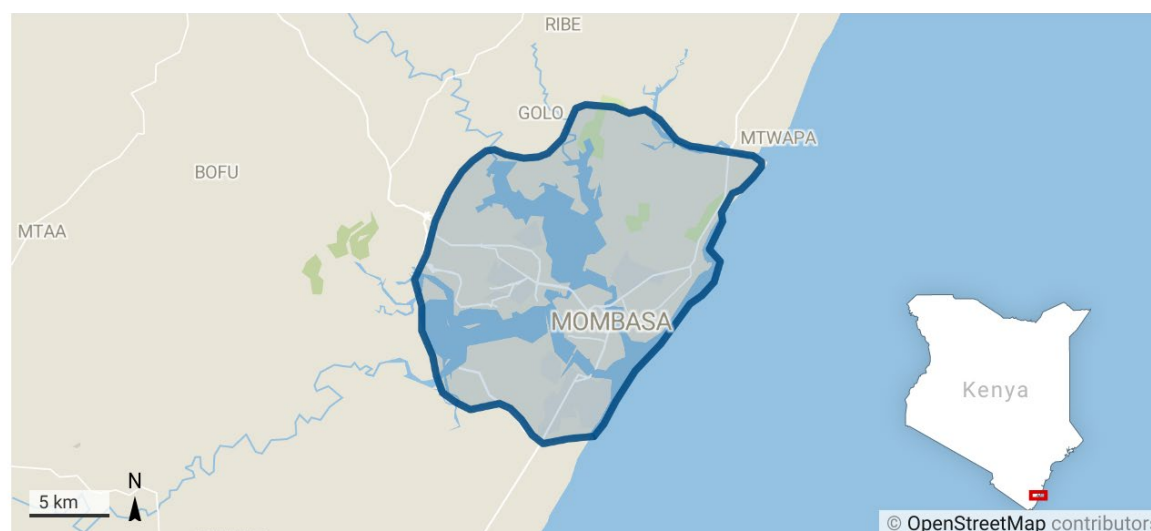
Empirical data and 61 experts' surveys incorporated into the Mombasa CORVI risk profile are displayed across 10 categories and 94 indicators. These scores are supplemented with information about resilience planning already underway and 33 interviews from experts in Mombasa.<sup>vi</sup>

## Summary Findings

The CORVI analysis shows significant vulnerability under financial risk, followed by political and ecological threats, respectively. These risks are tied to key themes. The two highest category scores—Major Industries (7.12) and Stability (6.73)—reflect high reliance and employment in key blue economy industries, closely followed by the risks posed by unplanned urbanization under Social/Demographics (5.95) and the ocean-related risks to the coastline and freshwater resources under Water/Geology (5.93). Other issues identified include flooding and risks to ecosystems, which underpin the tourism and fishery sectors.

The blue economy in Mombasa is critical to the economic prosperity of the city and the wider East African region. However, climate and ocean risks threaten the tourism, shipping, and fisheries industries. While Mombasa is relatively safe from cyclones, flooding from erratic rainfall and sea-level rise is a major problem.

## Study Area: Mombasa and the surrounding areas



Map: Stimson Center • Created with Datawrapper

vi For a full list of organization interviews and data sources, please see the appendix.



Flood risk is exacerbated by Mombasa's unique geography, with much of the city's infrastructure, major industries, and poorer neighborhoods located in low-lying areas. Coastal erosion also poses significant risks to the tourism sector, with high costs both to the shoreline hotels and the industry workers who live in flood-prone areas. Fast-paced urbanization has also exacerbated infrastructure and housing deficits, which, if left unaddressed, could impede the ability of the city to build climate resilience.

Moreover, despite recent successes in limiting waste, pollution from key sectors and urban households continues to harm the marine environment. The degradation of Mombasa's natural environment has contributed to a decline in the health of nearshore fisheries and the destabilization of the ocean ecosystem, which underpins the blue economy. These challenges are compounded by inadequate sewage and solid waste infrastructure in the city.

## Mombasa Risk Profile

CORVI Category Scores: **Low Risk 1 - 2.5** **Medium Risk 2.51 - 5** **Medium-High Risk 5.01 - 7.5** **High Risk 7.51 - 10**

Ecological Risk		Financial Risk		Political Risk	
Geology/Water	5.93	Major Industries	7.12	Stability	6.73
Ecosystems	4.68	Economics	5.75	Social/Demographics	5.95
Fisheries	4.64	Infrastructure	4.90	Governance	5.16
Climate	4.57				

Table: Stimson Center • Created with Datawrapper

Kenya is a leader among African nations in prioritizing action to mitigate and adapt to climate change impacts and build a sustainable blue economy. However, experts highlighted risks related to disjointed coordination between the national and county government, a lack of coordination between departments at the country level, and inadequate integration of urban and marine planning throughout the research process. Given its statutory and regulatory powers, the Mombasa County Executive is well placed to overcome these silos and provide the necessary leadership on climate action. By strengthening social and economic resilience and incorporating urban risks into marine planning, Mombasa can mitigate the threat posed by climate and ocean risks and build a resilient and sustainable future.

A lack of integrated planning and financial constraints impede these efforts. Based on an analysis of the CORVI risk scores and expert interviews, three priority areas for action are identified.

- Integrate urban resilience into coastal and marine spatial planning.** Expanding the role of the Mombasa County Executive in nationally led integrated coastal zone management activities is critical for ensuring that future projects and actions meet the urban and ocean needs of Mombasa City. Similarly, to ensure that urban environmental risks are incorporated into ocean planning, it is essential that Mombasa City planners be included in marine spatial planning activities.
- Increase investment to build resilience to climate risks across key sectors, including tourism, shipping, and fishing.** The marine environment underpins the blue economy. Specific actions include financing efforts to reduce pollution from ship ballast and raw material processing at Mombasa, encouraging ecotourism as an entry point to further sustainable ocean management, and expanding the capacity of Beach Management Units to provide training to avoid unsustainable fishing practices. Finally, the integration of green/blue

infrastructure should be increased to protect key sectors from climate change.

- **Improve urban planning by investing in climate-smart infrastructure and housing in vulnerable neighborhoods.** To upgrade informal housing, successful joint partnerships between the Mombasa County Governance and the private sector should be expanded. These

efforts should also be augmented with efforts to improve waste management. Small-scale efforts, including requiring biodigesters in new homes, should also be accompanied by large-scale efforts to improve and expand sewage facilities.

With these measures, Mombasa can drive financial resources and build climate resilience to ensure a safe and sustainable future.



Mombasa City. Source: Adobe Stock.

## Ecological Risk

As a result of Mombasa's unique urban geography, ecological risks are concentrated in the Geology/Water category. Other categories scored medium risk, with high levels of mangrove, coral, and seagrass bed coverage contributing to several low risk indicator scores in the Ecosystems category. In contrast, high risk indicator scores highlight the importance of coastal ecosystems to the city's tourism and fishing industries, as well as the dangers posed by coastal flooding.

- In the **GEOLOGY/WATER** category (expert weighted avg 5.93), high and medium-high risk scores for coastal erosion (8.70), water quality (6.76), and sea-level rise (6.00) demonstrate the threat posed by ocean risks to the urban center.
- In the **ECOSYSTEMS** category (expert weighted avg 4.68), high and medium-high risk scores highlight the declining health of Mombasa's mangroves (8.20), as well as their importance for protecting economic activity (6.49). While seagrass bed (2.00), coral reef (1.00), and mangrove (1.00) coverage scored as low risk, medium-high scores for the health of existing coral reefs (6.47) and seagrass beds (6.16) underline the dangers posed by climate change and pollution to the ocean and coastal environment.
- The **FISHERIES** category (expert weighted avg 4.64) shows medium-high risk scores for the number of access agreements with foreign nations (6.67) and the status of nearshore fish stocks (5.60), and the number of fisheries certified as sustainable (5.92).
- Although the **CLIMATE** category (expert weighted avg 4.57) scored the lowest under ecological risk, medium-high indicator scores for flood events (7.25), droughts (5.90), vector-borne diseases (5.75), and heavy rainfall (5.32) showcase significant hazards that, if left unaddressed, could degrade the resilience of city residents.

The ecological risk analysis shows that Mombasa's vulnerability is spread across all four categories. Most significant are the compounding effects of sea-level rise (6.00), coastal erosion (8.70), and the health of existing mangroves (8.20). Thirty-

two percent of Mombasa City is located within the low-lying coastal zone. As coastal erosion continues, Mombasa's highly developed coastal infrastructure will also sustain significant damage and financial losses.

Estimates suggest that a 0.3-meter rise in sea level could submerge 17 percent of Mombasa City. This would result in devastating and costly consequences for the city's inhabitants (particularly those living in informal settlements), as well as harming the tourism industry and key infrastructure.<sup>112</sup> Studies predict the economic cost of sea-level rise to be between \$31 million and \$313 million per year by 2050.<sup>113</sup> Saltwater intrusion in estuaries and freshwater aquifers (5.94) is another negative consequence of sea-level rise. This is also reflected in the medium-high risk score for water quality (6.76). In response to freshwater challenges, borehole usage has proliferated in Mombasa as a means to extract water. This temporary solution has led to environmental challenges, including declining water tables and saltwater intrusion.<sup>114</sup> Efforts are underway to procure additional water sources in adjacent counties.<sup>115</sup>

Despite the climate category's comparatively low risk score, climate indicators also reflect the growing threat posed by climate hazards to Mombasa. This includes medium-high risk scores for the number of floods (7.25), droughts (5.90), and heavy rainfall days (5.75). Climate change and rapid urbanization to accommodate Mombasa's expanding population are also straining ecosystems that underpin the blue economy and protect urban areas on the outskirts of the city.<sup>116</sup> Mangrove coverage scored as low risk (1.00) in the CORVI assessment. However, this reflects national mangrove coverage; mangrove losses have been higher in coastal urban areas like Mombasa than in coastal rural areas like Gazi Bay.<sup>117</sup> Mangroves in and around Mombasa declined by approximately 80 percent from 2007 to 2017, particularly in Tudor Creek, according to government estimates.<sup>118</sup> Additionally, Mombasa's reefs are particularly vulnerable to climate change impacts, pollution, and dredging. These risks are reflected in high and medium-high risk scores for the health of existing mangroves (8.2), coral reefs (6.47), and seagrass beds (6.16).<sup>119</sup>



While not a specific indicator, dredging was noted by several experts as important to understanding climate risk and resilience in Mombasa.<sup>120</sup> As a result of the expansion of Mombasa Port, two major dredging operations have been conducted over the past five years. While bringing economic benefits, dredging has also had negative repercussions to the marine environment and other sectors. For example, the dredging waste disposal process has negatively impacted local coral reefs and fish populations.<sup>121</sup> In addition to its significant environmental impact, dredging operations have undermined the tourism sector, which relies on a healthy, pristine ocean as a key natural resource.<sup>122</sup> Understanding the consequences of dredging to other climate risks is important to the long-term health and resilience of the city.

Finally, fisheries serve as an important food source in Kenya's coastal regions, supporting the livelihood of many residents within Mombasa. This is reflected in the medium-high fish consumption indicator (5.08). However, declining marine ecosystems have had secondary impacts on the health of nearshore fish stocks (5.60).<sup>123</sup> These impacts are compounded by a growing demand for seafood, as well as unemployment and poverty that can cause people to turn to the sea as a supplemental source of food and income. This growing demand is increasing pressure on coastal Beach Management Units (BMUs), community organizations that bring together fishers, traders, and boat owners, with the Director of Fisheries to monitor and regulate nearshore fish stocks in Kenya.<sup>124</sup> However, in some cases new fisherfolk have had difficulty joining BMUs, leading to fisheries' noncompliance and engagement in illegal fishing practices.<sup>125</sup>

Concerns over the high number of fisheries access agreements with foreign nations (6.67) also reflect growing concern about the future sustainability of Kenya's fish stocks. However, low and medium risk scores for unreported catch (2.00) and the capacity of enforcement institutions (4.64) suggest that experts are nonetheless confident in the ability of the government to monitor foreign fishing and protect national fish stocks.



Nyali Beach in Mombasa. Source: Wikimedia Commons



## Mombasa Ecological Risk

Each category score comprises multiple indicators.

**Low 1 - 2.5** **Medium 2.51 - 5** **Medium-High 5.01 - 7.5** **High 7.51 - 10**

Category	Indicator	
<b>Geology/Water</b>		5.93
	Rate of Coastal Erosion	8.70
	Percent of Bodies of Water with High Water Quality	6.76
	Projected Change in Sea-Level Rise	6.00
	Degree of Saltwater Intrusion in Coastal Aquifers	5.94
	Piped Water Supply Continuity	5.76
	Degree of Soil Salinity in Arable Lands	5.29
	Percent of Metro Area at Risk of Flooding	4.76
	Percent of Landscape that is Arable Land	4.47
	Level of Geophysical Risk of Landslides	3.69
<b>Ecosystems</b>		4.68
	Health of Existing Mangroves	8.20
	Percent of GDP Protected by Mangroves	6.49
	Health of Existing Coral Reefs	6.47
	Percent of GDP Protected by Sea Grass Beds	6.35
	Health of Existing Sea Grass Beds	6.16
	Rate of Occurrence of Harmful Algal Blooms	6.13
	Percent of GDP Protected by Coral Reefs	6.08
	Incidence of High Invasive Species Abundance	5.34
	Level of Sea Grass Bed Coverage	2.00
	Level of Coral Reefs Coverage	1.00
	Level of Mangrove Coverage	1.00
<b>Fisheries</b>		4.64
	Number of Fisheries Access Agreements with Foreign Nations	6.67
	Percent of Fisheries Certified by MSC	5.92
	Nearshore Fish Stock Status	5.60
	Fish Consumption Per Capita	5.08
	Capacity of Fisheries Enforcement Institutions	4.64
	Offshore Fish Stock Status	4.57
	Number of Incidents of Foreign Vessels Fishing in EEZ	4.50
	Level of Unreported Catch Estimate	2.00
<b>Climate Change</b>		4.57
	Number of Flood Events	7.25
	Number of Droughts	5.90
	Cases of Vector-Borne Disease Infections	5.75
	Number of Wet Days	5.32
	Number of People Affected by Extreme Weather Events	4.77
	Number of Extreme Heat Events	4.40
	Total Number of Hurricanes/Tropical Storms	1.65
	Change in Sea Surface Temperature	1.00

Table: Stimson Center • Created with Datawrapper

## Financial Risk

Like many other coastal cities, Mombasa is heavily dependent upon key blue economy sectors such as shipping, fishing, and tourism for its economic security. Climate risks to these industries, along with corresponding impacts to the economic vulnerability of city residents, mean that Mombasa may incur significant losses if such vulnerabilities are not addressed.

- As the highest-scoring category in the risk profile, **MAJOR INDUSTRIES** (expert weighted avg 7.12) highlight the significant expansion of tourism lodging types (8.31), as well as the importance of agriculture (8.28), port and shipping industries (7.57), and tourism (7.08) to the economic security of Mombasa.
- The **ECONOMICS** category (expert weighted avg 5.75) shows the importance of Mombasa to the economic output of Kenya (8.75). However, it also highlights the vulnerability of city residents to potential shocks, with high risk scores in the informal economy (9.10), income inequality (8.90), and the urban unemployment rate (8.35).
- The **INFRASTRUCTURE** category (expert weighted avg 4.90) scored lower than Major Industries and Economics, with medium risk scores for port (3.47), airport (3.55), and road

(3.92) resiliency. However, high and medium-high risk scores across the level of shoreline development (7.95), informal settlements (7.37), and commercial infrastructure damage from extreme weather events (6.70) underline compounding risks to both city residents and critical industries.

Mombasa's economy is highly dependent on tourism and shipping. The city's two major harbors, Kilindini Harbour and Old Port, serve as the largest seaport in Eastern Africa and handle trade for Kenya and its landlocked East and Central African neighbors such as Uganda, Rwanda, Burundi, Congo, Ethiopia, and South Sudan. Kenya's import-export industry accounts for 33 percent of its national GDP, with Mombasa's ports comprising the largest portion of the country's shipping industry.<sup>126</sup> The importance of Mombasa's port and shipping industry is reflected in its high risk score (7.57), as any disruption would severely impact the city's economic security. However, a lower risk score (3.47) for port resilience indicates that the port is relatively safe from climate and ocean risks. This was confirmed in interviews, which noted several projects to climate-proof the port. Efforts have included building a three-kilowatt solar power



Mombasa Port. Source: Make it Kenya Photo / Stuart Price (Flickr).



plant and installing eco-terracing in areas of the port vulnerable to soil erosion.<sup>127</sup> However, waste and pollution from ships and the offloading of raw materials used in cement production remain a crucial challenge.<sup>128</sup> A lack of ballast water receptors has also led to the discharge of foreign water into the port, increasing the likelihood of introducing invasive species (as reflected in the invasive species indicator: 5.34).

Tourism is a crucial sector for Mombasa, with 65 percent of Kenya's tourists visiting the country's coastal region. From key historical and heritage sites—such as the Vasco Da Gama Pillar, the ruin of Gedi, and the Fort Jesus—to natural spaces—including coastal beaches, rainforests, and marine parks—Mombasa serves as an important tourist destination. The tourism industry has also expanded in recent years, both in Mombasa City and throughout the neighboring counties of Kwale and Kilifi. The growing importance of the sector is reflected in a high risk score for diversity of lodging types (a measure of tourism development) (8.31) and percent of the national economy based in the tourism sector (7.08).

Various climate risks, including rising temperatures, heavy rainfall, flooding, and coastal erosion, pose a significant threat to Mombasa's tourist facilities and beaches. In response, efforts to build resilience

are underway, but vary significantly. For example, hotels in Swahili Beach have resorted to importing sand to rebuild beaches. However, these efforts are costly, ad hoc, and rarely integrated into long-term resilience planning.<sup>129</sup> In addition, although the tourism sector primarily operates in the dry season, tourists have previously had to be rescued from flooding during the rainy season.<sup>130</sup>

Risks to ecosystems and fisheries, outlined in the ecological section, also negatively impact the tourist sector, as the natural ocean environment is a key tourist attraction. Climate risks to other economic sectors also impact the tourism sector. For example, food price spikes resulting from climate impacts to the agricultural sector (8.28) have led to upward pressure on wages as the cost of living increases.<sup>131</sup>

Risks to these major industries have corresponding impacts on the urban population, and particularly the urban poor, who face outsized financial risks as a result of climate change.<sup>132</sup> Relatively low poverty levels at the national level (1.0), combined with high urban poverty scores (8.35), suggest that much of Kenya's poverty is concentrated in cities. In Mombasa, income inequality is considered a significant issue, with an 8.90 risk score, reflecting recent studies showing that 20 percent of Mombasa's residents hold 78 percent of the city's wealth.<sup>133</sup>



Small sewage canal in Mombasa. Source: Shutterstock.

Proportion of wastewater safely treated (5.25) and solid waste management (5.15) both scored as medium-high risk. This shows that experts surveyed indicated that improvements are needed to Mombasa's waste management infrastructure, while also noting that Mombasa is performing better than many other coastal cities in East Africa. However, expert interviews also highlighted that inadequate waste infrastructure intersects and exacerbates climate risk in Mombasa.<sup>134</sup> Mombasa generates approximately 879 tons of waste each day, but only 46 percent of that waste is collected.<sup>135</sup> Inadequate solid waste management has led to the frequent dumping of garbage along roads, which blocks drainage systems and increases the risk of flooding. Leakages are particularly common in Mombasa's Tudor district, where cholera outbreaks have resulted from drainage seepage polluting residents' water sources. In other cases, stagnant water at these dumping sites attracts mosquitoes and leads to increased malaria incidences, which disproportionately affect children, pregnant women, and the elderly. In addition, pollution into rivers and the ocean impacts the natural environment and contributes to declining ecosystem health, as noted in the ecological analysis section.

The significant and growing income disparity has important implications for the resilience of the urban population of Mombasa. Poorer residents live in the city's periphery, which often lacks access to basic services and is particularly susceptible to climate impacts such as flooding. These risks are reflected in numerous indicators across the Economic and Infrastructure categories. For example, high levels of urban unemployment (8.35), informal economy (9.10), unplanned settlement construction (7.37), and percent of low income housing in flood zones (5.30) all exacerbate the vulnerability of Mombasa's poorest to cope with and build resilience to climate risks.

The CORVI analysis also highlights infrastructure risks. Due to its geography and significant coastal development (7.95), Mombasa is exposed to current and future climate risks. For example, medium-high risk scores for commercial infrastructure damage from extreme weather events (6.70) reflect studies showing that as much as \$4.8 billion worth of Mombasa's coastal assets could be exposed to flooding and inundation by 2050.<sup>136</sup> Conversely, low risk scores for electrical grid (3.92), road (3.92), and airport (3.55) resilience suggest that climate risks are less prevalent with these forms of infrastructure. This was confirmed in interviews noting that the construction of new electrical transmission lines to Mombasa increases overall capacity. In addition, after flooding impacted transmission lines between Ruba and Lamu north of Mombasa, new transmission lines on the coast are being constructed on higher ground. However, a lack of data and technical expertise has limited efforts to integrate future climate impacts into electrical grid resilience planning.<sup>137</sup>

Finally, high levels of renewable energy in Kenya (3.50) have reduced the country's reliance on vulnerable energy sources, such as oil imports. In Mombasa itself, solar power is growing in popularity, with increasing numbers of installations on public facilities and buildings. Interviews also highlighted the potential for renewable power to mitigate climate risks by decentralizing the power grid through the upscaling of rooftop solar. This will provide the added benefit of reducing reliance on key substations.<sup>138</sup>



## Mombasa Financial Risk

Each category score comprises multiple indicators.

Low 1 - 2.5 Medium 2.51 - 5 Medium-High 5.01 - 7.5 High 7.51 - 10

Category	Indicator	
Major Industries	7.12	Diversity of Lodging Types
		Percent of National Economy Based in Agriculture
		Percent of National Economy Based in Port and Shipping Industries
		Percent of National Economy Based in Tourism Industry
		Percent of National Economy Based in Offshore Fishing
		Percent of National Economy Based in Near Shore Fishing Industry
Economics	5.75	Level of Informal Economy
		Income Inequality
		Percent of GDP Generated in Coastal Cities
		Urban Unemployment Rate
		Market Losses from Extreme Weather Events
		National GDP Per Capita (Purchasing Power Parity)
		Debt Ratio (% of GDP)
		National Youth Unemployment Rate
		National Unemployment Rate
Infrastructure	4.90	Level of Shoreline Development
		Level of Informal or Unplanned Settlement
		Level of Commercial Infrastructure Damage from Extreme Weather Events
		Percent of People Living Below 5 Meters Above Sea Level
		Level of Housing Damage from Extreme Weather Events
		Percent of Low-Income Housing in Relation to Flood Zones
		Proportion of Wastewater Safely Treated
		Degree of Compliance for Solid Waste Management Procedures
		Level of Water Distribution Infrastructure Resilience
		Level of Grid Resilience
		Level of Resilience for Roads
		Percent of Population with Adequate Access to Electricity
		Level of Resilience for Airports
		Renewable Energy Share in Total Energy Consumption
		Level of Resilience For Ports and Shipping

Table: Stimson Center • Created with Datawrapper

## Political Risk

Given its rapid expansion, Mombasa has sought to build resilience to climate risks. However, a lack of institutional and technical capacity has been a significant barrier to effective development and the implementation of a climate resilience strategy. CORVI analysis also highlights underlying social and economic factors, including social tension, high employment in vulnerable economic sectors, and significant urbanization, which, if left unaddressed, could impede efforts to build resilience to climate change.

- The **STABILITY** category (expert weighted avg 6.73) shows high risk scores in social tension (8.30) and employment in ports and shipping (7.55), and medium risk scores across other vital sectors.
- In the **SOCIAL/DEMOGRAPHICS** category (expert weighted avg 5.95), urbanization is a key risk theme, with high and medium-high risk scores focusing on the national population (8.69), the urbanization rate (7.75), and urban population density (7.25).
- In the **GOVERNANCE** category (expert weighted avg 5.16), the high and medium-high risk scores show risk related to investment in climate resiliency development projects (6.99), government transparency (6.13), and access to healthcare (5.62).

Compared to other coastal cities in East Africa, Mombasa's labor force is highly dependent on the blue economy for its economic security. While these sectors—including ports and shipping, tourism, and artisanal and commercial fishing—are diverse, they are all vulnerable to climate risks. As outlined in the financial section, flooding, coastal erosion, and rising temperatures all pose direct risks to these sectors, as well as to the environmental, economic, and social systems that support and rely on them. These risks are reflected in a high risk score for percent of people employed in the port and shipping industries

(7.55) and medium risk scores for employment in tourism (7.00), artisanal and subsistence fishing (6.27), and commercial fishing (6.13).

High scores for social tension (8.30) and civil unrest (7.55) reflect the fact that, relative to other coastal cities in East Africa, Mombasa experiences more cases of instability. Combined with a perceived pack of government transparency (6.13), this may contribute to electoral grievances, ethnic divisions, and political instability in Kenya.<sup>139</sup> Kenya has experienced other challenges, including corruption and misuse of public resources.<sup>140</sup> As a result, public trust in government is low. According to a 2016 Pew Research poll, 91 percent of respondents felt that government corruption is a problem in Kenya, and 58 percent believed that the government is run for the benefit of a few groups of people.<sup>141</sup> Such risks could also have secondary impacts on the economic security of Mombasa. The tourism sector has previously suffered from other external shocks, including unrest in the 1990s and terrorism in 2015, which reduced demand. Although the industry has proven to be resilient to these shocks, the increasing severity and likelihood of climate impacts, including flooding and damage to coral reefs, could reduce the number of tourists and increase costs to the industry.<sup>142</sup>

Urbanization is also impacting climate and ocean risks in Mombasa. Kenya is undergoing rapid urbanization, as many Kenyans are moving from rural to urban centers searching for jobs and more economic opportunities. With an annual growth rate of 3.8 percent per year, Mombasa's population has nearly doubled over the past 20 years.<sup>143</sup> Approximately 65 percent of the population reside in informal settlements, which are likely to increase as a result of rural migration and the development of Special Economic Zones in the city.<sup>144</sup> Many of the larger informal settlements are located next to the city's major industries, including Kilindini Port.



Street in downtown Mombasa. Source: Shutterstock.

Vulnerabilities surrounding Mombasa's rapid urbanization are evident in the social/demographics category. High risk scores for urbanization rate (7.75), urban population density (7.25), and percent of the population below the age of 30 (7.07), and a medium-high risk score for the dependency ratio (6.45), all highlight a fast-growing young population. However, this growth has, in many cases, outpaced infrastructure development. A shortage of affordable housing continues to be a significant issue in Mombasa, with an annual housing deficit of 380,000 units in 2012.<sup>145</sup> As Mombasa's population continues to grow, a more significant number of low- and middle-income migrants are moving into informal settlements, located in the city outskirts. This vulnerability is connected to risk scores in the Economics and Infrastructure categories in the

financial section and highlights the vulnerability of poorer residents to climate risks such as flooding.

Despite these challenges, lower risk scores for its national adaptation plan (3.99), civil society participation (3.63), and rule of law (4.37) indicate confidence in the Mombasa County Executive and the National Government of Kenya to invest in climate adaptation. Kenya has engaged in notable national climate planning activities and worked with various international partners, including the World Bank and the International Climate Fund, to begin to address its climate vulnerabilities. However, numerous interviews noted that current efforts have been inadequate,<sup>146</sup> as reflected in the medium-high risk score for investment in climate resiliency projects (6.99).

## Mombasa Political Risk

Each category score comprises multiple indicators.

Low 1 - 2.5 Medium 2.51 - 5 Medium-High 5.01 - 7.5 High 7.51 - 10

Category		Indicator	
Stability	6.73	Level of Social Tension	8.30
		Percent of People Employed in the Port and Shipping Industries	7.55
		Percent of People Employed in Tourism	7.00
		Number of Incidences of Civil Unrest or Instability	6.85
		Percent of People Employed in Artisanal and Subsistence Fishing	6.27
		Percent of People Employed in the Commercial Fishing Industry Nationwide	6.13
		Percent of People Employed in Agriculture	5.28
		Number of Years that the Current Government Structure Has Been in Place	4.80
Social/Demographics	5.95	National Population	8.69
		Urbanization Rate	7.75
		Urban Population Density	7.25
		Percent of Urban Population Below 30 Years of Age	7.07
		Urban Population	6.73
		Dependency Ratio	6.45
		Percent of Population Below Poverty Line	6.40
		Percent of Population Engaged in Seasonal/Cyclical Migration	5.00
		Percent of Adult Citizens Living Outside of the Country	4.03
		Percent of Population Achieving Proficiency in Literacy and Numeracy	2.43
		National Population Density	2.00
Governance	5.16	Investment in Climate Resiliency Development Projects	6.99
		Level of Perceived Transparency within Government	6.13
		Access to Healthcare	5.62
		Capacity of Current Disaster Response	4.83
		Rule of Law	4.37
		Voter Turnout	4.14
		Capacity of Ethics Enforcement Bodies	4.01
		National Climate Adaptation Plan	3.99
		Civil Society Participation	3.63

Table: Stimson Center • Created with Datawrapper



## The Status of Resilience Planning in Mombasa

Resilience planning in Mombasa is dependent on both national and county-level action. The national government of Kenya is an established leader in climate change action. Since its Initial National Communication on Climate Mitigation and Adaptation Policy in 2002, Kenya has developed several measures to mainstream climate adaptation into national and subnational policy. This work culminated in the 2013-2017 National Climate Change Action Plan, which emphasized climate adaptation and the need to mainstream the integration of climate change into development planning. In 2016, the government implemented the Climate Change Act, which established the Climate Change Directorate at the Ministry of Environment and Natural Resources (MENR) and the Climate Change Council to design and implement climate action. The Act also established a 2015-2030 National Climate Change Adaptation Plan.<sup>147</sup>

Despite these broad efforts, the MENR's power, relative to other ministries, remains relatively limited. As a result, its capacity to convene, coordinate, and lead climate change efforts is often undermined.<sup>148</sup> In addition, experts noted that data collection and action plans relating to climate change are conducted through a sector-led approach at the national level.<sup>149</sup> While this process is inclusive, a sector-by-sector approach could limit understanding of interlocking and systemic climate risks.

Compared to other coastal cities in East Africa, the Mombasa County Government has significant power to design and enact resilience planning and projects. This is due to the decentralization process in Kenya. Passed under the new constitution in 2010 and part of Kenya's Vision 2030 agenda, many planning processes have been delegated to the county level. Counties have significant powers under devolution, responsible for the majority of city planning and delivery beyond national strategic projects.

Mombasa County has made harnessing the blue economy a central pillar of its economic plan and has established a new Blue Economy Unit to coordinate activities across different departments. This reflects national prioritization of the blue economy, with the State Department of the Blue Economy within the Ministry of Agriculture, Fisheries, Livestock, and Co-operatives. Mombasa County is also currently developing a climate change policy and action plan to inform and harmonize future climate resilience projects, with support from domestic and international funders.<sup>150</sup> However, data gaps and issue silos inhibit this

process.<sup>151</sup> County governments are still largely dependent on financial transfers from Kenya's central government. This has led to integration and implementation challenges, both between the national and county governments and between county-level departments.

Over the past decade, the city of Mombasa partnered on a range of projects—funded by both the national government and international donors—to develop and implement climate resilience planning. For example, Kenya is currently working with the World Bank to implement the Coastal Region Water Security and Climate Resilience Project, a \$200 million project focused on improving water access, supply, and sanitation in Mombasa County and Kwale County.<sup>152</sup> Kenya has also partnered with the World Bank on “The Water Security and Climate Resilience for Kenya Project,” which seeks to provide better access to irrigated water, improve flood control in the Nzoia watershed, enhance flood early warning systems, and strengthen the institutional capacity of the Mombasa Water and Sanitation Company.<sup>153</sup> Additionally, the United Kingdom's International Climate Fund is funding an infrastructure-improvement program in Mombasa to enhance the sustainability of Mombasa's port, and Mombasa County has developed a Long-Term National Low Carbon Resilient Development Pathway.<sup>154</sup> Despite these efforts, however, interviews noted the need for more detailed data on multidimensional climate impacts to better target investments from international donors.<sup>155</sup>

Given Mombasa's fast-paced urbanization and reliance on the blue economy, integrating climate and ocean risks into urban and marine planning is critical. In the past, country master plans have focused only on terrestrial planning, and incorporating marine aspects into this process continues to be a key challenge. Historically, planning in Kenya has been undertaken for terrestrial spaces, with the national spatial plan in 2016/17 criticized for not adequately integrating marine issues and failing to incorporate marine spatial planning frameworks.<sup>156</sup> In response, the national government of Kenya has enacted a maritime spatial planning exercise and the “Go Blue” Program, funded by the European Union in partnership with UN-Habitat and the UN Environment Program. Go Blue is working with Kenya's coastal counties to bridge gaps and improve land to sea planning.<sup>157</sup>

## Priority Recommendations to Build Resilience

Despite significant progress, Mombasa City must contend with growing climate risks. Economic reliance on key blue economy sectors, fast-paced urbanization, the vulnerability of poorer residents, and risks to marine ecosystems were all prominent issues in the CORVI risk profile. Experts also highlighted risks related to disjointed coordination between the national and county government, a lack of coordination between departments at the country level, and inadequate integration of urban and marine planning throughout the research process.

Given its statutory and regulatory powers, the Mombasa County Executive is well placed to overcome these siloes and provide the necessary leadership on climate action. With support from the national government ministries and international partners, the Mombasa County Executive is well placed to overcome and address these silos and provide necessary leadership on climate change, develop and build integrated plans, and galvanize action necessary to build a more resilient and sustainable city. By strengthening social and economic resilience and incorporating urban risks into marine planning, Mombasa can mitigate the threat posed by climate and ocean risks and build a resilient and sustainable future.

### **Integrate urban climate resilience issues into coastal and marine spatial planning**

The need for the county and national government of Kenya to develop spatial planning methods that transcend these governance and land-seascape boundaries was noted in numerous interviews. Connections between the marine environment and the resilience of Mombasa are prominent throughout the risk profile, including the impact of terrestrial stressors on the marine environment, the extent to which ocean risks—such as coastal erosion—pose risks for Mombasa, and the economic, social, and cultural benefits Mombasa derives from the ocean.

The government of Kenya is embarking on a marine spatial plan over the next two years. Experts noted that a dialogue with city planners from coastal counties (including Mombasa) has started, and that getting land planners to engage in this process is key.<sup>158</sup> However, integrated coastal zone management exercises have been primarily undertaken by national-level ministries and agencies.

Expanding the role of the Mombasa County Government in this process is crucial for ensuring that the plan meets the urban and marine needs of Mombasa City.

### **Expand efforts to reduce climate risks and build sustainable blue economy sectors**

Major Industries is the highest-scoring risk category in the assessment, reflecting the significance, and vulnerability, of these sectors. Given the impact of the blue economy on the marine environment and the risks posed by climate and ocean risks, decision makers need to embrace a multidimensional approach that accounts for the full range of Mombasa's climate risks.

CORVI analysis highlights the threat posed by flooding to port facilities and the consequences associated with marine pollution, as well as dredging, for the marine environment. Actions by Mombasa Port to install eco-terracing and renewable energy facilities have helped alleviate these risks, but more work needs to be done. Increasing investment to reduce pollution risks from ship ballast and raw material processing, and greater integration of green/blue infrastructure, can help to ensure that further port development takes place in harmony with, and not at the expense of, Mombasa's natural resources.

Given the proximity of Mombasa's tourism industry to the ocean, it is necessary to minimize risks, both to facilities and people who rely on it as a significant source of income. In addition, reducing pollution from coastal hotels is critical to reducing damage to the immediate marine environment that the tourism industry depends on. Encouraging ecotourism activities in coral reefs and supporting recreational fishing opportunities along the coastline is an entry point for furthering sustainable management. More effective social safety net programs are also needed to strengthen socioeconomic resilience among the industry's most vulnerable workers.<sup>159</sup>

Finally, improving the sustainability of nearshore fish stocks by improving fisheries management and enforcement and helping local fisherfolk diversify their employment is needed. Expanding the capacity of Beach Management Units, which help regulate local fisheries and promote poverty reduction among the fishers' communities, is one

potential avenue for reform. Finally, local leaders could expand job training and provide financial support to local anglers, encouraging them to avoid unsustainable fishing practices and allowing them to purchase less damaging fishing gear, both of which may reduce risk to the marine environment. These targeted interventions can help to ensure that Mombasa continues to develop its blue economy with the natural environment.

### **Improve urban planning and invest in climate-smart infrastructure in vulnerable neighborhoods**

In tandem with integrating urban and marine planning, it is essential to further address risks to informal outlying settlements, which suffer from inadequate waste management, sanitation, drainage and sewer systems, and settlements planning, and high incidence of flooding. In response, the Mombasa County Government has started joint venture partnerships with private investors to improve several coastal neighborhoods, including

Tudor, Mzizma, and Buxton. Augmenting such plans with upgraded infrastructure is critical to further mitigate adverse risks to the terrestrial and marine environment.

The compounding risks posed by sewage and solid waste to flood risk are high priorities, and can be addressed through large- and small-scale approaches. Projects such as biodigesters, which are currently being implemented on Mombasa Island as part of planning regulation reforms for new builds, are an important step to reduce pressure on the overall waste system.<sup>160</sup> Larger infrastructure projects should also be augmented by small-scale approaches. The city's only sewage plant, Kipevu, is currently operating far below capacity. Existing infrastructure is inadequate, and large-scale interventions are needed to increase capacity. Such expansion must be undertaken after social and environmental impact assessments, to ensure that new infrastructure meets the needs of vulnerable city residents and does not harm the marine environment.

# Meeting the Climate Challenge in Urbanizing Coastal Centers

Coastal cities are key to the current and future development prospects of East Africa. In 2019, the African Union released its first blue economy strategy, signaling both the untapped potential of this sector to improve development prospects across the continent, and the consequences of unplanned economic development for the same marine resources that sustain this economy.<sup>161</sup> On top of this, climate change is degrading the terrestrial and ocean environment, the human security of city residents, and the economic future of coastal cities.

The UNDP 2020 Human Development Report states that nations and communities must integrate resilience thinking into every aspect of policy and planning to meet the climate challenge. To do this, we must adapt to climate impacts now and ensure that future development builds resilience with—rather than at the expense of—the natural world.<sup>162</sup>

To meet this challenge, decision makers across the region need access to data and information that considers social and economic risk factors in coastal cities, the impacts of climate change, and corresponding risks to the terrestrial and ocean environment. CORVI does this by generating a holistic and data-driven assessment of multidimensional climate risks and highlighting priority actions needed to build resilience in coastal cities and surrounding areas. Governments, international financial institutions, and the private sector can use this information to allocate resources wisely, make climate-smart adaptation and resilience decisions, advocate for additional climate resilience investment, and better integrate urban and marine spatial planning.

The CORVI assessments in Dar es Salaam and Mombasa illustrate both the need to assess climate risks facing coastal cities through a holistic lens and the importance of integrating urban and ocean planning. In Dar es Salaam, rapid and informal urbanization is a key component of understanding cities' vulnerability to climate change. Flood risk, exacerbated by sea-level rise and increasingly erratic rainfall, is compounded by unplanned coastal zone development. Pollution from inadequate sewage and waste infrastructure damages ecosystem

services, which play a critical role in reducing flood risk and coastal erosion. In addition, financial vulnerability is exacerbated by high reliance on climate-exposed sectors for economic security and inadequate infrastructure. Actions needed to mitigate these risks are hampered by a lack of coordination between government actors and the need to further downscale climate adaptation planning and investment to the city level.

In Mombasa, managing climate risks across its unique and growing cityscape is key. Growing climate and pollution impacts to the marine environment threaten critical blue economy sectors such as tourism and shipping. Moreover, low-lying areas that house major industries, including tourism and shipping, infrastructure, and poorer neighborhoods face growing flood risks. This vulnerability is heightened by infrastructure and housing deficits. Understanding the intersection between climate risks, the blue economy, increasing pollution, and the vulnerability of coastline communities underlines the importance of further integrating urban and ocean planning.

By identifying key risk areas, CORVI enables government policy makers, international financial institutions, and the private sector to better understand how multidimensional climate risks impact the environmental, economic, and political security of coastal cities. The first two East Africa city risk profiles in Dar es Salaam and Mombasa demonstrate how the CORVI tool can aid decision makers by providing evidence to prioritize investment for risk reduction effectively and build a sustainable future.

Beyond specific action in these two coastal cities, CORVI also contributes to coastal resilience efforts by aiding regional marine spatial planning (MSP). Multiple countries are developing and enacting MSP initiatives to combat the threat posed by climate change to coastal areas and to build a sustainable blue economy across East Africa and the greater Western Indian Ocean region. For example, South Africa, Seychelles, and Mauritius have developed and enacted national MSP and blue economy policies.<sup>163</sup> Meanwhile, Kenya is currently developing an integrated MSP roadmap,<sup>164</sup>



In addition to supporting decision makers in each coastal city, both risk profiles will be added to the CORVI data portal. In this portal, users will be able to visualize and interact with the CORVI risk data from completed assessments. As more CORVI assessments are added, users will also be able to compare different city risk profiles and assess regional trends.

and Tanzania is linking up multiple subnational MSP efforts already underway. At the regional level, the Nairobi Convention is spearheading efforts to align national MSP and blue economy priorities and specifically calls for the inclusion of coastal cities and urbanization dynamics in coastal zone management.<sup>165</sup> In these efforts, CORVI is a valuable tool to integrate urban and ocean planning to ensure that future urbanization meets city and national development objectives, while safeguarding the region's ocean resources in an era of unprecedented climate change.

As the risks from climate change continue to grow, coastal cities in East Africa face an increasingly uncertain future. In the face of rapid urbanization and with limited financial resources, city, national, and regional decision makers need access to data and assessments that help them understand the complete risk picture to prioritize investment, make proactive decisions, and avoid costly mistakes and the dangers of maladaptation. In this environment, CORVI is a valuable tool to identify and categorize risk across sectors, aid in designing integrated urban-ocean solutions, and access climate investment to build resilience.

### CORVI Coastal City Assessments



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