

Climate Change and Transportation in Africa Assessing Vulnerability and Adaptation Strategies in Coastal Cities: A Comparative Study of Alexandria, Dakar, Lagos, Mombasa and Durban

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Abstract

This study examines the vulnerability of transport infrastructure to climate change and the adaptation strategies adopted in five major African coastal cities: Alexandria (Egypt), Dakar (Senegal), Lagos (Nigeria), Mombasa (Kenya), and Durban (South Africa). Using a mixed-methods approach, the study combines a systematic review of climate and transport literature, government and development-partner reports, and a quantitative vulnerability-scoring framework. It assesses exposure to flooding, sea-level rise, storm surges, coastal erosion, and related hazards, while evaluating structural, nature-based, and policy adaptation measures. A weighted incident-scoring system and city-specific vulnerability rate (VR) were used to develop an aggregate transport-vulnerability index. Findings indicate that flooding (45.2%) and intense rainfall (22.0%) account for over two-thirds of transport vulnerability across the five cities. Lagos (33.9%), Mombasa (21.7%), and Durban (16.4%) are the most vulnerable, while Dakar (16.1%) and Alexandria (11.9%) are comparatively less exposed. ANOVA confirms a statistically significant difference in vulnerability among the cities ($F = 5.342$, $p = .002$), leading to rejection of the null hypothesis. Adaptation profiles vary: Alexandria emphasises hard coastal engineering; Dakar combines coastal protection with resilient transit design; Lagos integrates land reclamation, drainage upgrades, and policy reform; Mombasa prioritises port resilience and route redundancy; and Durban combines ecosystem-based adaptation with community flood early-warning systems. The study recommends increased climate finance, regional cooperation, maintenance funding, faster policy implementation, community-based early-warning systems, inclusive adaptation planning, and greater use of GIS and remote sensing for climate-risk monitoring.

Introduction

Africa is one of the continents most vulnerable to the impacts of climate change, despite contributing the least to global greenhouse gas emissions. From rising temperatures and shifting precipitation patterns to extreme weather events such as droughts and floods, the continent faces multifaceted challenges that threaten food security, water availability, health systems, biodiversity and socio-economic development. Coastal cities in Africa are expanding rapidly, concentrating people, economic activity and transport infrastructure in low-lying zones that are highly exposed to climate hazards. Rising temperatures, changing rainfall patterns and more intense storm events are already increasing flood frequency and damaging transport assets such as roads, bridges, ports and rail corridors disrupting mobility and supply chains, and raising the cost of urban transport services. Sea-level rise and coastal erosion further threaten port facilities, coastal road corridors and informal transport nodes that are critical to urban livelihoods and trade. These climate-driven impacts are projected to intensify in the coming decades, placing urgent demands on transport planners and city authorities to assess vulnerability and scale up adaptation measures that maintain connectivity and protect vulnerable populations (IPCC, 2022).

Transportation systems including roads, bridges, ports, rail corridors and urban mass transit are both physically exposed and operationally vulnerable to asset damage and service disruption in coastal settings. The Climate Policy Initiative (2024), for example, estimates that road-maintenance costs in Africa could rise by up to 2.7 times as a result of climate stressors. In parallel, rapid urbanisation, population growth and rising transport demand are amplifying exposure and sensitivity in many African coastal cities. Yet adaptation efforts in the transport sector remain limited: existing assessments of urban climate policy suggest that the great majority of Africa's large coastal cities still lack transport-specific adaptation policies aligned to future climate scenarios (UN-Habitat, 2021; African Development Bank, 2023). This research assesses vulnerability and adaptation strategies across five major African coastal cities, with the objective of (i) comparing vulnerability across cities and transport modes, (ii) assessing adaptation interventions and institutional capacity, and (iii) deriving recommendations for strengthening climate-resilient transport in these contexts.

Despite growing recognition of climate risk, many African coastal cities continue to rely on transport infrastructure and operational systems that were not designed for current or future climate extremes. Recent case studies of flood impacts in Lagos, for instance, highlight recurring damage to roads, disruption to commuter and goods movement, and large economic losses attributable to flooding and storm events (Interconnected Disaster Risks, 2022). At the same time, adaptation efforts such as drainage upgrades, coastal defences, road elevation, contingency routing remain uneven across cities because of differences in institutional capacity, financing, planning integration and local awareness. Without a systematic, comparative assessment of (a) how specific transport modes and corridors in coastal cities are vulnerable, and (b) which adaptation strategies are most effective under local governance and socio-economic constraints, policy responses risk being reactive, poorly prioritised, or inaccessible to those most affected. This research addresses that gap by assessing vulnerability and adaptation strategies across five major African coastal cities. The following questions guide the research.

1. How vulnerable are transport modes and infrastructure in the selected African coastal cities to current and projected climate hazards (flooding, storm surge, coastal erosion, heat extremes)?
2. Which transport modes (road, rail, ports/ferries, aviation, informal/last-mile services) and which specific corridors or nodes are most at risk in each city?
3. What adaptation measures such as structural, operational, policy and community-based have been implemented in each city, and how effective are they in reducing disruption and economic loss?

4. How do institutional capacity, funding availability and stakeholder engagement influence adaptation effectiveness across the cities?
5. What best-practice, scalable responses could be recommended for coastal-transport resilience that are sensitive to local socio-economic contexts?

Hypothesis Formulation

H0 (null): There is no statistically significant difference in the transport-vulnerability index among the five coastal cities.

H1 (alternative): There is a statistically significant difference in the transport-vulnerability index among the five coastal cities, with cities of lower adaptive capacity tending to show higher vulnerability scores.

Methodology

The study adopts a mixed-methods design, integrating quantitative and qualitative approaches to provide a holistic assessment of climate-change impacts, vulnerabilities and adaptation strategies within Africa's major coastal transport systems. A mixed-methods approach is appropriate because climate-transport interactions are complex, context-dependent, and shaped by both measurable factors (e.g., frequency of flooding) and perceptual factors (e.g., institutional awareness and readiness) (Creswell & Plano Clark, 2018; IPCC, 2022).

The study focuses on five major coastal African cities that are important economic and transport hubs but are also highly exposed to climate hazards: Alexandria (Egypt), Dakar (Senegal), Lagos (Nigeria), Mombasa (Kenya) and Durban (South Africa). Cities were randomly selected on the basis of (a) coastal location and exposure to sea-level rise and flooding, (b) importance to national and regional transport networks, (c) rapid and often unplanned urbanisation, (d) inadequate drainage infrastructure, and (e) the presence of ongoing or planned adaptation initiatives (UN-Habitat, 2021; African Development Bank, 2023).

A comprehensive review of academic literature, government reports and climate-policy documents was conducted, drawing on IPCC assessment reports, African Union and national policy documents, national adaptation plans, development-partner project reports (World Bank, African Development Bank, French Development Agency), and news and technical media coverage of individual flood and storm events. Because precise, transport-specific damage figures are rarely isolated in public reporting, they are typically bundled into general flood-damage estimates, the compilation instead focuses on documented incidents, their dates, and their described impacts on transport systems (road closures, bridge damage, port and airport disruption, and economic losses from traffic paralysis), which are often the most significant and best-documented consequences.

Each documented climate-hazard incident with a direct or indirect effect on transport infrastructure was assigned a weighted score (500 points, depending on severity and directness of impact), summed for each climate-change variable and for each city. A separate scoring pass captured the transport-specific consequence of each incident (e.g., road closure, port disruption, rail suspension), with events that caused direct or indirect transport-infrastructure damage scored at 1,000 points each. To arrive at the total transport-vulnerability index for each city, the summed transport-impact score was multiplied by a city-specific vulnerability rate (VR), drawn from the literature on physical, institutional and socio-economic exposure: Alexandria (VR = 9), Dakar (VR = 7), Lagos (VR = 9), Mombasa (VR = 8) and Durban (VR = 7). A one-way analysis of variance (ANOVA) was conducted in SPSS to test whether the mean transport-vulnerability scores differ significantly across the five cities, at a 0.05 level of significance.

Results and Discussion

Climate Hazard Exposure by City

Coastal cities face not only direct threats from rising sea levels and storm surges, but also less visible threats such as rising groundwater, which can turn urban areas into de facto wetlands, eroding road foundations, backing up sewers and overwhelming septic systems. Alexandria, with over six million residents, is among the most climate-vulnerable urban centres in the region, contending with coastal erosion, flooding and rising sea levels. Sea-level rise contributes to flooding, saltwater intrusion, land subsidence and erosion, threatening housing, infrastructure, agriculture, tourism, water resources, biodiversity and health. The city is subsiding by roughly three millimetres a year weakened by upstream Nile dams that block silt renewal and by offshore gas extraction, while the sea rises at a comparable rate due to warming and ice-cap melt. The IPCC projects that a one-metre sea-level rise by 2050 could inundate roughly a third of the Nile Delta's most fertile land and threaten historic cities such as Alexandria. Rapid population growth (nearly two million additional residents in the last decade) has outpaced infrastructure investment: the city's drainage system, designed to absorb about one million cubic metres of rainwater, has in recent storms received up to eighteen million cubic metres in a single day.

For Dakar which sits on a peninsula, making it highly exposed to coastal erosion, sea-level rise and urban flooding. Extreme water levels (1.78 m) are increasing by roughly 8.4 mm per year, and the annual duration above this threshold rose sharply between 1994 and 2015 from a maximum of

148 hours in the late 1990s to 248 hours in 2008. Senegal's coastline is also receding by 0.5-1 metre annually. Many of Dakar districts flood for weeks each rainy season, damaging roads and homes, promoting disease vectors and contaminating drinking water.

Lagos which is bordered by the Atlantic Ocean and by lagoons and creeks, is highly vulnerable to coastal flooding and erosion. Rising lagoon levels during heavy rainfall cause tidal lock, blocking drainage and worsening flooding, while parts of the city are subsiding at rates of up to 87 mm per year. Poorly maintained waterways and drainage systems compound the hazard. The 2019 floods affected hundreds of thousands of residents and caused fatalities and extensive economic damage; the national hydrological agency classifies large parts of Lagos as high flood-risk zones. Transport-corridor losses and disruption contribute to economic losses estimated in the billions of naira annually, and coastal reclamation projects such as Eko Atlantic City have been associated with accelerated erosion and loss of land, including roads, in adjacent vulnerable communities.

Mombasa's drainage infrastructure some of which dating to the 1920s, is poorly equipped for current rainfall volumes, and is further compromised by waste-clogged drains. An estimated 190,000 people and roughly US\$470 million in assets are exposed to a 1-in-100-year extreme water level, concentrated mainly on Mombasa Island, where large populations live below 10 metres of elevation. A 30-centimetre sea-level rise could submerge parts of Mombasa and around 17 percent of coastal areas, putting an estimated 267,000 people at risk of coastal flooding by 2030 in the absent further intervention.

Durban's flood frequency has likely doubled over the past century, with the April 2022 event recording the highest 24-hour rainfall total on record. Sea-level rise along South Africa's coast (roughly 2.4–2.7 mm per year at Durban, and higher still at Cape Town) compounds the risk from storm surge and spring tides, which can overtop seawalls and cause extensive inland flooding. Rapid, uneven urban growth, ageing infrastructure and hilly terrain crossed by flash-flood-prone rivers add to the city's exposure.

Climate Factors Driving Transport Vulnerability

Table 1 and Fig. 1 summarise the intensity of each climate-change factor across the five cities. Flooding is the dominant driver of vulnerability overall (35.4% of total climate-factor weight), and is most severe in Durban (28.6%), Lagos (26.9%) and Mombasa (16.8%). Intense rainfall is closely linked to flooding and accounts for a further 17.8%, and is most pronounced in Lagos (30.0%), Mombasa (23.3%) and Durban (20.0%). Sea-level rise (13.4%) is a common factor across all five cities but is most acute in Lagos and Mombasa (31.1% each), followed by Dakar (17.8%) and Alexandria (15.6%). Storm surge (8.6%) is most severe in Durban, Dakar and Alexandria, while high wind/tide/cyclonic activity (8.0%) is most severe in Dakar, Mombasa, Alexandria and Lagos. Extreme weather (5.0%) is concentrated overwhelmingly in Durban (82.3% of this factor). Secondary but locally important consequences include coastal erosion (5.6%, most severe in Dakar, Alexandria and Mombasa), landslide/subsidence (4.2%, most severe in Lagos, Alexandria and Durban), and smaller shares attributable to groundwater salinisation, coral-reef degradation, sand-dune destabilisation and beach retreat.

Table 1. Coastal cities and climate change factors (score / % of city total)

Source: Authors' rating and computation, 2026.

Transport-Sector Vulnerability Index

Table 2 translates these climate factors into transport-sector consequences, weighted by each city's vulnerability rate (VR). Flooding again dominates, accounting for 45.2% of total transport-vulnerability, followed by intense rainfall (22.0%); together these two factors account for 67.2% of transport vulnerability across the five cities. Sea-level rise contributes 9.0% (most damaging in Mombasa, Alexandria and Lagos), storm surge 6.7% (most damaging in Durban, Dakar and Lagos), and high wind/tide 6.5% (most damaging in Lagos, Mombasa and Alexandria). Landslide/subsidence (5.6%) and coastal erosion (2.9%) are secondary but locally significant, concentrated in Dakar, Alexandria and Mombasa. Extreme weather contributes a smaller 2.1% share, concentrated mainly in Durban and Mombasa.

Ranked by the VR-weighted transport-vulnerability index, Lagos (33.9%), Mombasa (21.7%) and Durban (16.4%) are the most vulnerable of the five cities, followed by Dakar (16.1%) and Alexandria (11.9%), which is the least vulnerable in the sample.

Table 2. Transport-sector vulnerability index by coastal city

Source: Authors' rating and computation, 2026.

City Vulnerability Narratives

Lagos's vulnerability is illustrated by a long sequence of disruptive events: 2011 flooding that increased travel times up to tenfold and left transport vehicles unavailable; 2012 gridlock with damage to roads, water facilities, communications and power infrastructure; the choking of the Epe Expressway, which affected 25–37% of the Lekki Peninsula; submerged vehicles and homes in 2021 and 2022; and, in August-September 2025, flooding that submerged communities in Ikorodu and disrupted the Ago Palace Way, Apple Junction and Ago Bridge corridors. Particularly

exposed assets include the Lagos-Ibadan railway corridor, the low-lying Murtala Muhammed International Airport, and informal transport services such as water ferries, okada (motorcycle taxis) and danfo (minibuses).

Mombasa's vulnerability reflects damage recorded as early as October 2006 such include saltwater intrusion and losses to coastal agriculture (mango, cashew and coconut) through to 2025 events in which roads and homes were submerged and only a single lane of the Mombasa-Malindi highway remained passable. Particularly exposed assets include the Port of Mombasa (East Africa's largest port), the Standard Gauge Railway terminus, Moi International Airport, and the Likoni Ferry crossing.

Durban's vulnerability is evident in repeated washouts and bridge failures along the N2 coastal highway, closures of the N3 linking Durban to Johannesburg, and the suspension of port operations by Transnet after heavy rain damaged access roads. The April 2022 floods alone caused an estimated R5.7 billion in damage to provincial roads, destroyed dozens of bridges, and severed access to fuel depots via Bayhead Road. Subsequent events in 2025 caused further landslide damage, road closures and power outages across multiple suburbs.

Dakar's vulnerability includes stagnant floodwater reaching 1.5 metres in August 2015, storm-surge damage to housing in Hann Bay in 2017–2018, the displacement of more than 3,000 people around Dakar and Thiès in September 2020, and periods in which emergency services could not reach flood-isolated localities.

Alexandria records the lowest vulnerability score of the five cities, though it is not immune: 2015 flooding closed Prophet Daniel Street for a week and forced the closure of the Alexandria and Dekheila harbours; the Corniche coastal road, the city-centre road network, the Cairo-Alexandria rail line in delta sections, and the historic tram network in low-lying coastal areas all remain exposed to ongoing sea-level rise and subsidence.

Hypothesis Testing

A one-way ANOVA was used to test whether mean transport-vulnerability scores differ significantly across the five coastal cities. (Table 3)

Table 3. One-way ANOVA of transport vulnerability by city

Source: Authors' computation using SPSS, 2026.

The computed F-statistic (5.342) is significant at $p = .002$, which is below the conventional 0.05 threshold. The null hypothesis (H_0) is therefore rejected in favour of the alternative hypothesis (H_1): there is a statistically significant difference in transport vulnerability among the five coastal cities. This is consistent with the descriptive pattern in Table 2, where flooding (45.2%) and intense rainfall (22.0%) together account for 67.2% of transport-sector vulnerability, and where Lagos and Mombasa cities combining high physical exposure with comparatively limited drainage and planning capacity record the highest vulnerability shares, while Alexandria, which has invested more heavily in hard coastal defences, records the lowest.

Adaptation Strategies

Addressing this vulnerability requires a multi-pronged approach spanning investment in drainage and coastal defences, improved urban planning to protect floodplains, and the integration of climate projections into all future transport-infrastructure projects. Adaptation measures in the five cities can be classified as large-scale "hard" engineering, "soft" nature-based solutions, and policy reform; many of which are supported by international partners such as the World Bank, the African Development Bank (AfDB) and the French Development Agency (AFD). Alexandria's adaptation strategy relies primarily on hard coastal engineering. In 2015 the city built concrete barriers to reduce coastal-flood potential and protect the Qaitbay Fortress from the Mediterranean, complemented by a 69-kilometre reed belt intended to trap sand and form a natural barrier. With support from the Green Climate Fund, the government is constructing offshore breakwaters using thousands of large concrete blocks, alongside beach-nourishment works to counter erosion. Complementary measures include:

1. Integrated coastal defence and managed retreat where protection is not cost-effective, prioritising protection of critical transport nodes while planning relocation for the most vulnerable neighbourhoods;
2. Wave-attenuating barriers and dune/beach restoration near transport corridors, including the Corniche;
3. Monitoring of ground subsidence and saltwater intrusion, factored into pavement and bridge maintenance cycles;
4. Linking transport adaptation to housing upgrades and coastal-defence works (sea barriers, beach replenishment).

Dakar's adaptation is characterised by strong coastal protection and the integration of resilience into major new infrastructure projects. The Programme de Protection et de Valorisation du Littoral (PPVL), supported by the AFD and the World Bank, is building rock groynes and sea walls to protect the Corniche-Ouest highway and vulnerable neighbourhoods such as Biscuiterie. The Hann Bay Rehabilitation Project addresses pollution while also improving coastline resilience for adjacent roads and communities. New transport infrastructure notably the Train Express Regional (TER) and the Dakar Bus Rapid Transit (BRT) system is being designed with elevated trackbeds and roadbeds in flood-prone areas, adequate drainage for extreme rainfall, and heat-resilient materials. The Senegalese National Agency for Civil Aviation and Meteorology (ANACIM) operate

flood and storm-surge forecasting systems that allow authorities to close vulnerable roads and deploy emergency response ahead of extreme events. Complementary measures include:

1. A mix of hard and soft coastal protection (protective dikes combined with dune restoration and mangrove replanting);
2. Upgraded peri-urban feeder roads with culverts and retention ponds;
3. Priority routing for emergency vehicles on elevated/retrofitted corridors, plus ferry supplements for coastal neighbourhoods;
4. Local investment in storm-drain maintenance alongside larger World Bank/IDA-backed stormwater and climate-adaptation financing (approximately US\$290 million for Senegal's stormwater management).

Lagos's adaptation strategy focuses on protecting high-value coastal assets while managing urban flooding through a mix of private and public initiatives. The Eko Atlantic City Sea wall is an 8.5-kilometre hard-engineering structure of concrete and accropode units that reclaims land from the Atlantic to protect the new financial district and, by extension, parts of Victoria Island, from storm surge and sea-level rise. The Lagos State Climate Change Action Plan sets out a policy framework requiring new transport projects to account for future flood levels and storm-surge impacts, while drainage-upgrade projects (such as the Ikeja Drainage Upgrade and Sanitation Project, supported by the World Bank) target key commercial and transport hubs. Mangrove restoration in areas such as Lekki and Badagry provides a nature-based buffer against storm surge and erosion. Complementary measures include:

1. Elevating and flood-proofing critical links (coastal roads, primary bridges) using raised alignments, scour protection and resilient pavement materials;
2. Hybrid coastal protection combining seawalls with upstream nature-based measures (mangrove restoration, wetland buffers);
3. Drainage retrofits on key corridors, including increased culvert capacity, detention basins and smart stormwater gates;
4. Redundancy and modal shift, prioritising resilient bus corridors and river/sea ferry options where roads are repeatedly cut, supported by real-time water-level sensors and SMS alerts to operators and commuters.

Mombasa's adaptation strategy focuses on protecting critical port infrastructure and main transport corridors from coastal erosion and urban flooding. The World Bank-funded Mombasa Resilience Project addresses drainage rehabilitation, solid-waste management (to reduce drain blockage) and flood modelling. Mangrove and ecosystem restoration led by the Kenya Forest Service and organisations such as WWF-Kenya protects coastlines including Tudor Creek, dissipating storm-surge energy and reducing erosion around infrastructure such as the Kipevu link road. The Kenya Ports Authority is investing in climate-proofing the Port of Mombasa, including raising berths and container yards and improving drainage. The 48.5-kilometre Dongo Kundu Bypass provides a more resilient, inland alternative to the flood- and erosion-prone coastal Mombasa-Malindi Road. Complementary measures include:

1. Strategic port-access elevation and drainage improvements to keep freight moving during high tides;
2. An urban stormwater masterplan with retention basins protecting major corridors;
3. Nature-based shoreline protection and beach nourishment to reduce erosion impacts on coastal roads;
4. Strengthened inter-agency coordination between the port authority, county roads department and disaster-management agencies for rapid response.

Durban was the first city on the African continent to adopt a climate action plan consistent with the IPCC's 1.5-degree target. Following the 2022 floods, eThekweni Municipality adopted a "Build Back Better" approach: the M4 and M19 corridors were reconstructed as climate-resilient lifelines, the Prospecton Road and uMlazi canal systems were fortified, and bridges such as Shallcross and Coedmore were rebuilt to withstand more extreme events. Durban's CRISP spatial-planning approach avoids routing new transport infrastructure through highest-risk zones and strengthens coastal roads with slope stabilisation, improved drainage and vegetated buffers. Since 2017, with support from the U.S. EPA's Educational Partnerships for Innovation in Communities (EPIC) programme, Durban has operated a community-based flood early-warning system like a partnership between the city, the University of KwaZulu-Natal, and residents that shares forecast information via WhatsApp and in-person outreach. Piloted in the Quarry Road West community along the Palmiet River, the system was credited with preventing loss of life in roughly 400 dwellings washed away during the April 2022 floods.

Conclusion

This study set out to compare transport-sector vulnerability to climate change and the adaptation strategies adopted across five major African coastal cities. The evidence shows that flooding and intense rainfall are, by a wide margin, the dominant drivers of transport vulnerability in these cities, jointly accounting for 67.2% of the aggregate vulnerability index, with sea-level rise, storm surge, high wind and extreme weather contributing the remainder. Lagos, Mombasa and Durban emerge as the most vulnerable cities, reflecting a combination of high physical exposure (low-lying coastal and deltaic terrain, rapid subsidence, intensifying rainfall) and constrained drainage and planning capacity, while Dakar and, in particular, Alexandria record comparatively lower vulnerability, consistent with Alexandria's longer history of hard coastal-engineering investment. The one-way ANOVA confirms that these differences are statistically significant ($F = 5.342$, $p = .002$), supporting rejection of the null hypothesis and confirming that transport vulnerability varies meaningfully by city rather than by chance.

The five cities also show distinct adaptation profiles rather than a single common model. Alexandria relies substantially on hard engineering such as breakwaters, seawalls and beach nourishment to protect its coastline and critical infrastructure. Dakar combines coastal protection with resilience-by-design in major new transit projects such as the TER and the BRT. Lagos pairs large-scale land reclamation (Eko Atlantic) with drainage upgrades, mangrove restoration and a dedicated climate-policy framework. Mombasa concentrates on protecting port logistics and providing route redundancy through the Dongo Kundu Bypass. Durban stands out for combining ecosystem-based adaptation, resilient reconstruction standards and a community-based early-warning system that has demonstrably saved lives. Taken together, the findings suggest that effective transport-sector adaptation in African coastal cities depends less on any single intervention type than on combining physical protection, resilient design standards, and community-level early warning and response capacity and that institutional capacity and financing remain the binding constraints on scaling these measures beyond isolated flagship projects.

Recommendations

Based on the findings, the following recommendations are proposed to strengthen climate-resilient transport in African coastal cities:

First is to scale up international climate finance. Countries and firms with the largest cumulative contribution to global greenhouse-gas emissions should be held accountable for a proportionate share of international climate-finance commitments directed at adaptation in the most exposed coastal cities. Second is to strengthen regional cooperation and knowledge-sharing. Because climate impacts and transport corridors often transcend municipal and national boundaries, African states and city networks should formalise mechanisms for sharing data, lessons and technology for example, adapting Durban's community-based early-warning model for other coastal cities. Third is to build sustainable financing for maintenance. Adaptation investments fail without recurrent maintenance budgets; cities should establish dedicated, ring-fenced financing mechanisms for the upkeep of drainage systems, seawalls and resilient road infrastructure. Fourth is to accelerate the gap between policy and implementation. Several cities already have adaptation-relevant policy frameworks (e.g., the Lagos State Climate Change Action Plan) that are not fully implemented; dedicated implementation units and monitoring frameworks should be established to close this gap. Fifth is to expand community-based early-warning approaches. Durban's WhatsApp-based, university-community partnership model should be evaluated for replication and scaling in other high-risk neighbourhoods across the five cities and beyond. Sixth is to integrate informal-settlement upgrading into transport adaptation. Because the most severely affected populations are often in informal or under-serviced settlements, adaptation planning should explicitly incorporate settlement upgrading alongside road and drainage investment. Seventh is to invest in institutional and technical capacity. Training and institutional strengthening for local transport and planning agencies is needed to design, procure and maintain climate-resilient infrastructure. Eighth is to adopt GIS and remote-sensing tools for monitoring. Systematic use of geospatial and remote-sensing technologies would allow cities to track flood risk, subsidence and erosion over time, and to evaluate the effectiveness of adaptation interventions so that strategies can be adjusted as conditions change.

Declarations

AUTHORS' CONTRIBUTION

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Jimoh, J. B., and Ajagbe, C. A., data analysis was done by Agbaje, F. O. The first draft of the manuscript was written by Jimoh, J.B. and all authors commented on previous version of the manuscript. All authors read and approved the final manuscript.

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DATA AVAILABILITY STATEMENT:

All the data generated during this research is available with the corresponding author and can be supply on request.

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Tables

Table 1. Coastal cities and climate change factors (score / % of city total)

City	SLR	High wind	Extreme weather	Storm surge	Flooding	Intense rain	Coastal erosion	Landslide	Sand dune	Salt water	Coral reef	Beach retreat
Alexandria	3500 (15.6%)	2000 (14.8%)	-	3500 (24.1%)	7000 (11.8%)	3000 (10.0%)	3000 (31.6%)	2000 (28.6%)	-	500 (50%)	-	500 (100%)
Dakar	4000 (17.8%)	4500 (33.3%)	-	4000 (27.6%)	9500 (16.0%)	5000 (16.7%)	3500 (36.8%)	-	500 (100%)	500 (50%)	-	-
Lagos	7000 (31.1%)	2000 (14.8%)	1000 (11.8%)	1500 (10.3%)	16000 (26.9%)	9000 (30.0%)	500 (5.3%)	2500 (35.7%)	-	-	-	-
Mombasa	7000 (31.1%)	4000 (29.6%)	500 (5.9%)	500 (3.4%)	10000 (16.8%)	7000 (23.3%)	2000 (21.0%)	1000 (14.3%)	-	-	1000 (100%)	-
Durban	1000 (4.4%)	10000 (7.4%)	7000 (82.3%)	5000 (34.5%)	17000 (28.6%)	6000 (20.0%)	500 (5.3%)	1500 (21.4%)	-	-	-	-
Total	22500	13500	8500	14500	59500	30000	9500	7000	500	1000	1000	500
% of total	13.4%	8.0%	5.0%	8.6%	35.4%	17.8%	5.6%	4.2%	0.3%	0.6%	0.6%	0.3%

Source: Authors' rating and computation, 2026.

Table 2. Transport-sector vulnerability index by coastal city

City + VR	Flooding	Intense rainfall	SLR	Storm surge	Coastal erosion	Landslide/ subsidence	High wind	Extreme weather	Total	Total x VR	%
Alexandria (VR=9)	14000	3000	6000	3000	3000	4000	3000	-	36000	324000	11.9
Dakar (VR=7)	25000	17000	5000	7000	4000	-	5000	-	63000	441000	16.1
Lagos (VR=9)	51000	31000	5000	4000	-	7000	5000	-	103000	927000	33.9
Mombasa (VR=8)	28000	16000	14000	-	3000	5000	7000	1000	74000	592000	21.7
Durban (VR=7)	36000	7000	-	10000	-	2000	2000	7000	64000	448000	16.4
Total	154000	74000	30000	24000	10000	18000	22000	8000	340000	2732000	100.0
% of total	45.2	22.0	9.0	6.7	2.9	5.6	6.5	2.1	-	-	-

Source: Authors' rating and computation, 2026.

A one-way ANOVA was used to test whether mean transport-vulnerability scores differ significantly across the five coastal cities. (Table 3)

Table 3. One-way ANOVA of transport vulnerability by city

Source of Variation	Sum of Square	df	Mean Square	F	Sig.
Between Groups	36,857,307.88	3	12,285,769.29	5.342	.002
Within Groups	154,100,438.60	67	2,300,006.55		
Total	190,957,746.48	70			

Source: Authors' computation using SPSS, 2026.

Figures

FIGURE FOR CLIMATE CHANGE AND TRANSPORTATION IN AFRICA: ASSESSING VULNERABILITY AND ADAPTATION STRATEGIES IN COASTAL CITIES: A COMPARATIVE STUDY OF ALEXANDRIA, DAKAR, LAGOS, MOMBASA AND DURBAN

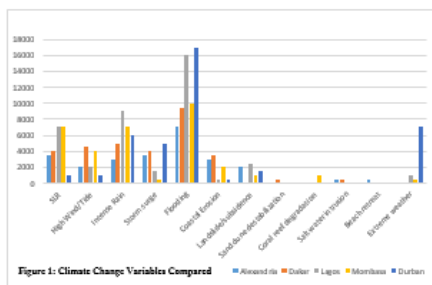


Figure 1

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