Tanzania: Rapid Climate Risk Assessment and Adaptation Investment Opportunity Mapping

Infrastructure, Energy & Manufacturing

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GLOBAL CENTER ON ADAPTATION

CGAP

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ABOUT THE GLOBAL CENTER ON ADAPTATION

The Global Center on Adaptation (GCA) is an international organisation, hosted by the Netherlands, which works as a solutions broker to accelerate action and support for adaptation solutions from the international to the local, in partnership with the public and private sector, to ensure we learn from each other and work together for a climate resilient future.

ABOUT AFRICA ADAPTATION ACCELERATION PROGRAM

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EXECUTIVE SUMMARY

Introduction

The **Infrastructure, Energy, and Manufacturing (IEM) sectors are central to Tanzania's economic transformation and inclusive development agenda**, yet they face growing exposure to climate-related hazards that threaten asset integrity, service delivery and productivity. Rising temperatures, changing precipitation patterns and more frequent extreme events are already affecting coastal zones, urban centers and key transport and energy corridors, increasing the probability of costly disruptions to power, logistics and production of important manufacturing goods. As Tanzania pursues industrialization and urban expansion, aligning investment with climate resilience is essential to safeguard development gains and to attract private capital into adaptation-ready infrastructure and enterprises. **This report is intended for local and international investors, commercial banks, development finance institutions, and other financiers seeking to expand private sector participation in climate adaptation financing in Tanzania.**

There is clear evidence that the sectors of Infrastructure, Energy, and Manufacturing[1] are priority sectors for attracting private finance in Tanzania: (i) Infrastructure systems face high exposure, with major road and rail corridors intersecting flood-prone basins and coastal zones, and national flood mapping showing thousands of kilometers of transport assets located within 1:50-year flood areas (e.g., over 2,000 km of roads exposed under projected conditions) (ii) Energy remains highly vulnerable and economically critical, with hydropower representing two-thirds of national installed capacity and highly sensitive to drought, declining SPEI values, and rising temperatures that reduce thermal generation efficiency (iii) Manufacturing is a major employer and borrower segment for Tanzanian banks (nearly 10% of loan books), with key subsectors such as food and beverage, textiles, and non-metallic minerals highly sensitive to heat stress, water scarcity, and supply-chain disruptions. These sectors therefore combine high climate risk, high economic importance, and strong potential for commercially viable adaptation investment.

Climate Hazards and Sensitivities

Tanzania faces a diverse and evolving climate risk profile shaped by strong regional contrasts and rapid urbanization. Projections indicate a clear warming trend across all regions, with mean annual temperatures rising by 1.5–2.0°C by mid-century, and the largest increases expected in central and semi-arid zones such as Dodoma, Singida and Shinyanga. These areas are projected to experience a sharp rise in the number of extreme-heat days (>35°C), intensifying heat stress on IEM systems. Coastal urban areas, including Dar es Salaam, Tanga and Zanzibar, will experience compounding effects where high humidity magnifies heat discomfort and raises demand for cooling solutions.

Rainfall patterns are also changing, with greater seasonal variability and more intense rainfall events, especially in coastal and north-eastern regions, which experience baseline maximum daily rainfall of 80–120 mm, rising further under mid-century projections. These shifts are already overwhelming stormwater systems in fast-growing urban centers. National flood mapping shows that built-up areas face relatively low exposure during a 1:50-year flood event, however, this may be as a result of the fine-scale that global flood models are based on to represent pluvial flooding (with a particular focus on major river systems). As a result, flooding risks associated with medium sized rivers that often impact informal settlements, is not adequately captured. Low-income settlements (often located on floodplains, poorly drained terrain or reclaimed wetlands) remain particularly vulnerable.

Coastal hazards present an additional layer of systemic risk. Sea-level rise, projected to accelerate through mid-century, threatens Dar es Salaam, Zanzibar, Mtwara and Bagamoyo, increasing the likelihood of chronic inundation, saltwater intrusion, and erosion of coastal housing and supporting infrastructure. Exposure zones less than 5 m above sea level extend across major coastal districts, with storm surge models indicating deeper and more frequent inundation by 2040–2060. Informal systems and communities are already experiencing periodic tidal flooding and waterlogging, undermining foundations,

[1] For the purpose of the analysis, Infrastructure was disaggregated into 5 sub-sectors (Transport; Housing; Water and Wastewater; Solid Waste Management; ICT and Telecommunications), hence creating a total of 7 sectors for the analysis (with Energy and Manufacturing). The full IEM scope and sectors are presented in the Introduction section.

degrading sanitation systems, and accelerating structural infrastructure failure. Projected flood extents under RCP4.5 show significant increases in inundated areas across multiple basins, with several regions experiencing more than 0.5 m flood depths during 1:50-year events.

Drought conditions will continue to affect central, northern and parts of southern Tanzania, where rising temperatures and higher evapotranspiration increase seasonal water stress. These patterns create knock-on risks for industries relying on water-intensive processes and heighten pressure on surface and groundwater systems servicing growing urban populations. Projected SPEI declines across central and northern catchments indicate worsening multi-season drought, with several regions shifting into moderate drought categories (SPEI −1.5 to −1). Fire risk is also rising in peri-urban areas bordering savannah and woodland, including zones around Dodoma, Arusha and Mbeya, where hotter and drier conditions increase the likelihood of uncontrolled bushfires affecting informal housing clusters.

Emerging Climate Risk Narratives

The combined effect of rising temperatures, intensifying rainfall, coastal pressure and declining seasonal water reliability gives rise to three major system climate risks that shape Tanzania's adaptation priorities:

- Energy reliability under changing hydrology and growing heat stress: Hydropower continues to play a central role in Tanzania's generation mix, meaning shifting rainfall patterns and rising temperatures directly influence generation stability. Projected 1.5–2.0°C temperature increases by mid-century raise evaporation rates and reduce seasonal water availability in central and northern catchments, increasing pressure on existing hydro assets and transmission corridors. Hydropower nodes show high sensitivity to drought, with projected declines in mean SPEI values across key basins and increased evaporation risk indicated by rising days above 35°C. In coastal and inland industrial zones, higher temperatures also reduce the efficiency of thermal generation and distribution equipment, contributing to recurring outages. This creates a structural vulnerability for both grid-connected manufacturers and urban households.
- Urban flooding and coastal inundation threatening housing, services and economic activity: Intensifying rainfall events, especially in Dar es Salaam, Tanga, Mwanza and Morogoro, continue to overwhelm urban stormwater systems, with national mapping underestimating real exposure due to missing fine-scale pluvial flood dynamics. Projected increases in maximum daily rainfall (Dar es Salaam rising by 7%, and other hotspots such as Mogorogo rising by as much as 14% under mid-century projections) heighten flood risk. Along the coast, sea-level rise and storm surges place shoreline settlements in Dar es Salaam, Zanzibar, Bagamoyo and Mtwara at acute risk of chronic inundation, salinization of shallow groundwater and structural degradation of housing and services. These combined pressures make flooding and coastal hazards a defining risk driver for Tanzania's housing stock.
- Rising temperatures reducing productivity and stressing social infrastructure: Projected warming of 1.5–2.0°C and a sharp increase in extreme-heat days are expected across central regions (including Dodoma, Singida and Shinyanga) and low-lying coastal zones, exacerbating heat exposure for households, schools, health facilities and labor-intensive industries. Limited vegetation cover and poor urban design in informal settlements accelerate heat build-up. This can increase health risks and reduce indoor habitability. In manufacturing, high internal heat loads (particularly in food processing and textiles) combine with ambient heat to reduce worker productivity and increase absenteeism. Heat-exposed manufacturing nodes show high sensitivity scores, with several regions projected to experience >40°C peak temperatures. Urban heat stress also accelerates material degradation in roofing, pavements and low-cost structures, raising maintenance needs and lifetime asset costs.

Priority Sectors for Adaptation Investment in Tanzania

Analysis identified Housing and Manufacturing as the two most relevant sectors for adaptation for Tanzanian Commercial Banks. This was based on the (i) concentration of commercial bank lending today (ii) assessment of future commercial bank lending, driven by policy, regulation and political commitments (iii) the impact potential of lending to these sectors from the perspective of gender-responsive and inclusive adaptation outcomes. These two sectors represent key concentrations of climate risk for Commercial Banks but simultaneously opportunities to play a catalytic role in building Tanzanian climate resilience.

Adaptation opportunities in the Manufacturing sector fall into four categories:

1. Energy alternatives: Diversifying and decentralizing the energy mix through investments in low-emission, climate-resilient generation technologies. Key opportunities include:
    - Combined PV + Battery Energy Storage Systems (BESS), which store solar power for peak use, improving reliability on a hydro-dominated grid.
    - Microgrids powered by renewables already seen as a regional leader in micro-grid development, this is an area where Tanzania could expand localized, climate-resilient electricity access for industrial zones and underserved areas outside the formal power grid.
2. Measures that help protect manufacturing assets from floods and sea-level rise: Flood risk management measures for coastal areas can protect sites from inundation and manage operational risks. Measures include hard engineering solutions such as culverts and tide gates as well as the use of Nature Based Solutions and emergency and rapid deployment flood management measures.
3. Measures that manage wildfire: In areas where fire risk and manufacturing output overlap opportunities exist to deploy:
    - Vegetation management, including firebreaks, which deduce wildfire and grassfire risk by clearing brush, trimming vegetation, and maintaining defensible spaces around factory sites.
    - Fire-resistant thermal insulation and retrofits, slowing fire spread and protecting critical machinery.
    - Emergency preparedness & training (worker drills, evac. plans), to strengthen response to fires and extreme weather, reduces injury risk, and improves business continuity.
4. Manufacturing solutions that manage extreme heat risks: Reducing the workforce's exposure to extreme heat, protecting output, productivity and workers' health with benefits for retention and reduction in sick-days. These include
    - Shifting work timing and formulation/re-scheduling of heat emitting process to cooler periods, meaning higher output per labor hour (less heat-related slowdown/absenteeism) and fewer safety incidents.
    - HVAC for cooling and dehumidification to keep process rooms, packing lines, and electronics/instrumentation within acceptable standards.
    - Isolated cold rooms inc. independent feeds & auto-close doors to reduce heat ingress during peak-temperature periods, stabilize product quality, and cut refrigeration energy loads.

In the Housing sector opportunities to build adaptive capacity exist in five complementary pathways:

1. Green and grey measures that build resilience to flood events, which include:
    - Installing flood doors/gates, installations at street level to reduce flow of flood water into properties, protecting them from flood damage
    - Sustainable Urbain Drainage Systems (SuDS), green infrastructure solutions to help manage stormwater by slowing and infiltrating runoff
    - Mangrove and coastal ecosystem restoration (Nature-based coastal defense) to reduce tidal surge impacts, and naturally protect coastal areas from flooding and erosion
2. Measures for sea level rise adaptation to address risks faced by Tanzania's coastal settlements. These include:
    - Elevated housing & flood-resilient design (raised foundations, stilts, plinths) to reduce housing flood risk
    - Using structural waterproofing techniques such as using water-resistant materials and construction techniques such as cement-stabilized masonry, sealed renders, damp-proof courses and gasketed doors/windows to create a barrier against tidal inundation and surge-driven water ingress
3. Measures for adaptation to extreme heat, which pose serious health and safety risks, including:
    - Passive and efficient cooling such as cross-ventilation, ceiling fans, shading devices, reflective roofing, and insulation to help moderate indoor temperatures without heavy energy use.
    - Targeted ventilation and air conditioning in critical or communal buildings such as health facilities & daycare centers to reduce heat stress and maintain comfort in extreme heat
4. Measures to enhance the housing sector's adaptation to wildfires, local & on-site water reserves such as water tanks and community hydrants can provide immediate firefighting resources before municipal services arrive.
5. Cross-cutting financial tools & risk intelligence measures to enhance overall housing sector resilience. These include:

- **Multi-hazard parametric insurance products** covering loss and damage from flooding, heat, storms and wildfires can help households recover quickly from disasters.
- **Housing improvement micro-finance (loans) for climate resilience upgrades** to support renovation works such as roof fixing, floor improvements, structural reinforcement, water-resistant retrofits, and sanitation upgrades; and serve to formalize land titles.
- **Multi-hazard early warning systems (flooding, fire, storms) & Digital Alerts**, which are subscription-based or service-oriented digital alert platforms tailored for homeowners, residential communities, and housing associations, providing real-time warnings for floods, storms, fires, and heat.

Tanzania's **gender equality and social inclusion (GESI)** context shapes both vulnerability and opportunity within the Infrastructure, Energy, and Manufacturing sectors. Although this report does not present a dedicated GESI assessment, it identifies where climate risks and adaptation opportunities intersect with existing gender and social disparities. Women face persistent economic barriers: 73% are financially included but access to formal credit remains constrained, and only 15–20% hold land titles, limiting their ability to invest in productive assets. Informality dominates the labor market (76% of the workforce), with women disproportionately concentrated in petty trade, food and beverage processing, basic services, and micro-manufacturing. Youth represent 63% of the population yet experience much higher unemployment (~13% compared to a 3–4% national average) and limited access to technical skills needed in manufacturing and energy. Persons with disabilities have very low formal employment rates (3–4%), and fewer than 10% of public buildings meet accessibility standards. Investments that strengthen energy reliability, introduce cooling technologies, and expand access to decentralized renewable power can directly enhance productivity, income stability, and safety for women, youth, and other marginalized groups. Moreover, opportunities for inclusive adaptation can be fostered through youth entrepreneurship in emerging green industries - such as solar energy services, climate-smart manufacturing, and risk intelligence.

These adaptation priorities are strongly aligned with Tanzania's national climate commitments. The National Adaptation Programme of Action (NAPA) identifies water, energy, coastal zones, and infrastructure as priority sectors for urgent adaptation investment, including actions to strengthen drainage, protect coastal settlements from sea-level rise, and improve resilience of energy systems to drought and extreme heat. The Updated NDC (2021) commits to expanding renewable energy generation, improving climate-resilient housing, and strengthening early-warning systems, with explicit targets such as reducing greenhouse gas emissions economy-wide between 30-35% by 2030. The NDC also highlights the need to protect vulnerable groups—women, youth, and low-income households—particularly in flood-prone coastal cities like Dar es Salaam and Tanga. By targeting housing and manufacturing, the adaptation solutions identified in this report directly operationalize these national priorities, supporting Tanzania's long-term strategy to build a climate-resilient, inclusive, and economically competitive economy.

Report Structure and Next Steps

The findings from this analysis provide a foundation for understanding **how climate risks intersect with Tanzania's infrastructure, energy, and manufacturing systems**. The following sections of the report examine in greater detail the spatial distribution of hazards, sectoral sensitivities, and the implications for key economic assets. They also present the evidence base and prioritization process that guided the identification of adaptation opportunities, highlighting where targeted investments, particularly in housing and manufacturing, can enhance resilience, safeguard economic growth, and create pathways for inclusive, climate-smart development. Many of these interventions are **technically maturing and show strong potential to be commercially viable**, aligning with Tanzania's socio-economic development priorities while offering tangible entry points for private finance.

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INTRODUCTION & BACKGROUND SETTING

Project context and objectives

This report forms part of a multi-phase assignment commissioned by the Global Center on Adaptation (GCA) to identify and scale climate adaptation investment opportunities within infrastructure, energy and manufacturing sectors in Tanzania, Kenya, Zambia, and the Democratic Republic of the Congo (DRC).

The overall aim of the assignment is to generate a robust evidence base on climate risks, identify a range of viable adaptation investment solutions, and position private finance to play a catalytic role in strengthening resilience across these countries. Recognising that private finance includes a diverse range of institutions with differing characteristics this study focuses on domestic Commercial Banks in the four countries of analysis.

This report focuses on Tanzania and captures analysis from Phase 2 of the assignment, building on Phase-I Inception. It brings together a spatially explicit climate risk analysis, the identification of key infrastructure systems, and the mapping of relevant adaptation solutions. This analysis connects hazards with sector specific sensitivities in infrastructure, energy and manufacturing sectors in each country, before analysing spatial exposure and then seeking to match risks with adaptation solutions that are technically mature, locally relevant, productivity-enhancing, gender-responsive and socially inclusive. In doing so, the assignment recognises that climate risks and adaptation opportunities are not experienced equally and seeks to identify solution pathways that deliver both resilience and inclusion benefits.

Insights from this phase directly feed into the remaining deliverables. Phase 3 will quantify the market opportunity size for a set of 4-5 shortlisted solutions, map value chains in greater detail, and assess the market structures that will influence uptake. Phase 4 will explore their financial and commercial viability, exploring whether they present a compelling business case for Commercial Banks. Finally, Phase 5 will synthesize evidence, from climate and market analysis through to ROI, into a set of investment briefs to help GCA, financial institutions and other interested stakeholders scale private-sector adaptation finance.

By clarifying the risks, exposures, and most promising solution pathways, this report serves as the analytical backbone for the phases that follow, ensuring that market sizing, financial analysis, and strategy development are firmly grounded in national level climate realities.

Report Structure

This report captures the assignments findings for Tanzania. A summary of our approach to the technical climate risk analysis is provided in Approach and Methodology, including details on methodological limitations and sources agreed on inception of the project. A succinct framing of the key Gender, Equity and Social Inclusion context, and its relevance for the assignment is also provided in Analytical Framework. The report is then broken down into the following sections.

1. Climate Hazard Mapping

   Establishes the climatological baseline and forward-looking projections, covering major hazards such as extreme temperatures, droughts, and floods. It highlights where these hazards occur across regions and provinces, comparing reference periods (1986–2005) with mid-century projections (2041–2060) under RCP 4.5 and RCP 8.5 scenarios.

2. Sector Sensitivity Analysis

   Identifies the key systems within each sector and breaks these down to identify key sub-systems and nodes. The nodes are then analysed against key climate hazards to identify levels of vulnerability at the nodal level.

3. Assessing Infrastructure, Energy and Manufacturing Risk Pathways

   Uses the identified levels of system sensitivity and exposure to climate driven hazards in the seven core sub-sectors of Infrastructure, Energy and Manufacturing to map out the key system level risks and provides sub-sector analysis.

4. Identifying Climate Adaptation Solutions

   Identifies adaptation solution themes and specific interventions relevant to the priority system risks. This section applies a structured prioritisation framework to filter solutions based on technical maturity, commercial viability, policy support and potential for beneficial impacts on women, youth and socially excluded groups, resulting in a shortlist of opportunities.

Approach and Methodology

The Climate Risk and Vulnerability Assessment (CRVA), undertaken for this assignment, is a rapid climate hazard, exposure, and sensitivity analysis of selected IEM subsectors in Tanzania (including Zanzibar). It is designed to provide a robust analytical foundation for identifying a strategically focused and investable portfolio of climate adaptation opportunities across these subsectors. The primary aim of the CRVA is to identify opportunities that:

- Address tangible climate vulnerabilities within critical IEM systems, ensuring that interventions target real and pressing risks;
- Demonstrate clear commercial potential, offering viable investment opportunities for both private sector actors and development finance institutions; and
- Align with national adaptation priorities while remaining consistent with the mandates and operational frameworks of international financing entities.

In line with the guidance of the GCA, the CRVA applies a dual adaptation framing, including:

- Adaptation *of* assets – interventions that enhance the resilience of infrastructure, energy, manufacturing systems themselves against climate-related hazards; and
- Adaptation *through* assets – investments that deliver broader climate resilience benefits across people, systems, and value chains.

While both approaches are considered, the CRVA places primary emphasis on adaptation through assets, focusing on interventions where climate-smart investments can generate system-wide resilience dividends, strengthening the broader operational and socio-economic environment.

The methodology integrates a top-down climate hazard analysis with bottom-up assessments of system vulnerability and investment potential. This hybrid approach enables the identification of adaptation measures that are simultaneously:

- Climate-informed, reflecting current and projected hazard dynamics; and
- Commercially viable, providing a strong basis for investment prioritisation.

Bridging climate risk assessment and investment planning will ensure that the CRVA informs adaptation opportunities are not only technically sound but also actionable and aligned with both policy frameworks and market realities.

Analytical Framework

The CRVA is based on the conceptual framework of climate risk defined by the Intergovernmental Panel on Climate Change which describes climate risk as the interaction between climate-related hazards, the exposure of systems or assets, and their vulnerability to these hazards. Hazards, exposure, and vulnerability are dynamic, varying in magnitude, likelihood, and over time due to socio-economic conditions and human decision-making. This framework emphasizes that climate risk is best understood as the combined effect of these three interlinked components, as illustrated in Figure 1.

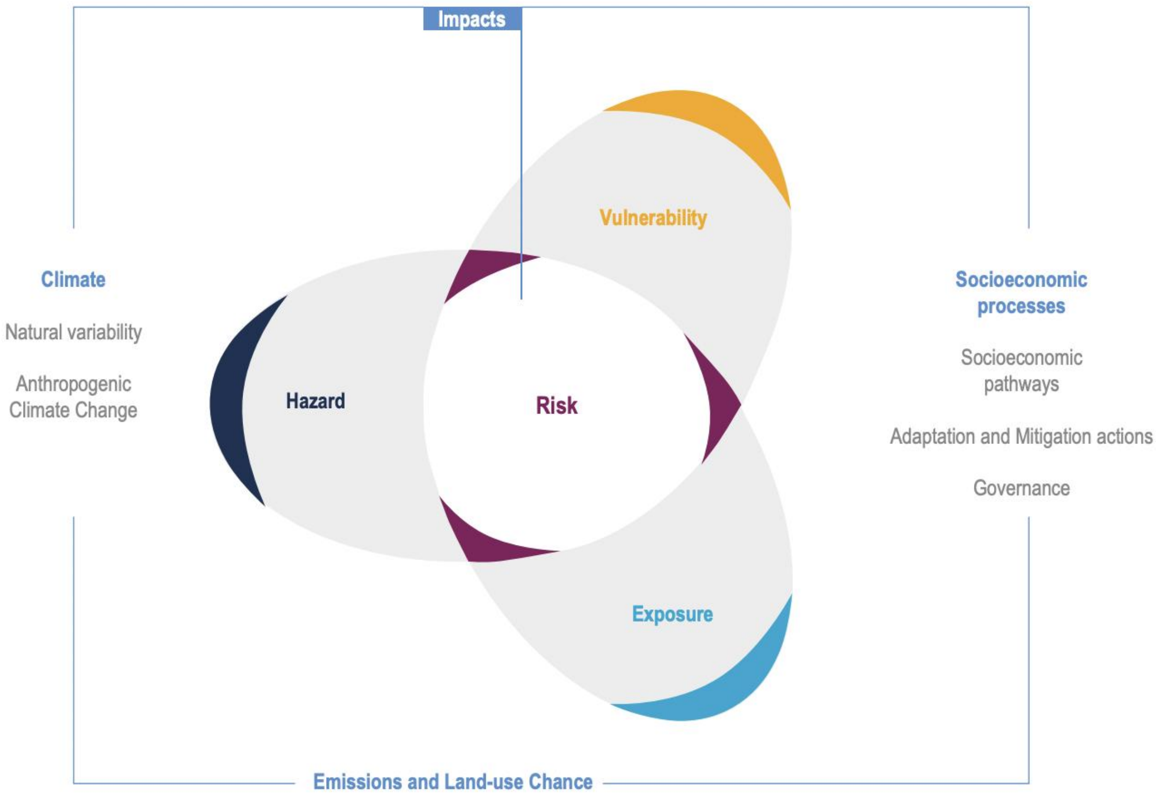


Figure 1: IPCC Conceptual Framing of Climate Risk as a Combination of Hazards, Exposure, and Vulnerability Source: IPCC AR6, Report of WGII on Impacts, Adaptation, and Vulnerability, 2022

For the purposes of this CRVA, the following definitions have been applied:

- Hazard – The potential occurrence of a climate-related event or trend that could negatively affect people, infrastructure, ecosystems, or services. In the context of this study, hazards include direct climate variables (such as precipitation, temperature, and wind) as well as secondary impacts relevant to the IEM sectors, including flooding (fluvial, pluvial and coastal), landslides, drought, heat stress, and fire risk.
- Exposure – The presence of IEM assets and systems (such as power generation and transmission infrastructure, transport networks, water supply and wastewater systems, manufacturing facilities, and ICT networks) in locations that could be impacted by the identified hazards. Exposure is assessed through spatial analysis, mapping where critical assets intersect with hazard-prone areas, including floodplains, drought-prone regions, and geologically sensitive slopes.
- Vulnerability – The susceptibility of IEM assets and systems to be adversely affected by hazards, influenced by factors such as design, construction quality, operational practices, maintenance standards, and adaptive capacity. Vulnerability analysis evaluates how sensitive these components are to identified hazards and their ability to withstand or recover from climate-related impacts.

Methodological Structure

The methodology for this CRVA is structured around four interconnected and mutually reinforcing components, designed to systematically assess climate risk and identify actionable adaptation opportunities across the IEM sectors. These components provide a clear analytical pathway from hazard identification to investment prioritisation, ensuring that proposed interventions are both climate-informed and commercially viable. The four components are:

1. Climate Hazard and Exposure Assessment – Characterising the nature, frequency, intensity, and spatial distribution of climate-related hazards relevant to the IEM sectors. This step establishes

the foundation for understanding where and how climate events may impact key assets and systems.

2. Sensitivity Analysis (Sector–System–Node Framework) – Mapping out the sensitivity of each sector, system, and individual node to these hazards. This framework enables a detailed understanding of which components are most vulnerable and why.
3. Risk Pathway Analysis – Evaluating how exposure and sensitivity combine to produce climate risk, including the identification of critical vulnerabilities, cascading effects across interconnected systems, and potential points of systemic failure. This step provides insight into where resilience-building interventions are most needed.
4. Opportunity Identification and Investment Prioritisation – Translating the risk assessment into actionable adaptation opportunities for key elements of Infrastructure, Energy and Manufacturing of relevance for Commercial Banks. This component involves identifying interventions that strengthen system resilience and prioritising them based on relevance for conditions in Tanzania.

Each of these components is described in detail in the sections that follow, illustrating the comprehensive and integrated approach used to link climate risk assessment with practical adaptation planning and investment decision-making.

Climate Hazard Assessment

A rapid but spatially robust climate hazard analysis was undertaken across Tanzania, focusing on hazards with the greatest relevance to IEM systems in the country. The assessment integrates historical baselines, current hazard dynamics, and future projections to identify areas where climate-related risks are intensifying and where they intersect with key infrastructure, energy, and manufacturing assets. A summary of the climate hazards and the justification for their selection is provided in Table 1.

Table 1: Hazards Assessed and Justification

Hazard Type	Description and Justification
Extreme Precipitation and Pluvial Flooding	Characterized using mean maximum daily rainfall and 25-year return period maximums, this hazard captures intense rainfall events that can overwhelm urban drainage systems, leading to pluvial flooding and flash floods. These events pose significant risks to infrastructure such as roads, bridges, and wastewater systems, which are critical for industrial operations. In the energy sector, heavy rainfall can damage substations and disrupt power distribution. For manufacturing, flooding can halt operations, damage equipment, and interrupt supply chains.
Fluvial Flooding	Based on JRC flood maps (baseline) and WRI Aqueduct projections (future), this hazard addresses riverine flooding. It is particularly relevant for infrastructure located near rivers or in low-lying urban areas. Transport networks, housing, water supply, wastewater treatment, and hydropower facilities are vulnerable. Flooding can damage roads and railways, disrupt energy generation and transmission, and affect manufacturing facilities through inundation and logistical delays.
Sea-Level Rise and Coastal Flooding	Sea-level rise is an important secondary impact of climate change and can impact any infrastructure of resources located in low-lying areas along the coast and along estuaries. A rise in sea level also means that coastal flooding impacts related to storm surges will extend further inland, as will rising groundwater tables and salinity impacts on freshwater resources. This is assessed using an assumed impact zone of land which is less than 5m above sea level. The Japanese Aerospace Exploration Agency (JAXA) digital elevation model (DEM) is used to identify this zone.

Hazard Type	Description and Justification
Extreme Heat	Assessed using acute heat (10-year return period maximums) and chronic heat (annual days >35°C). High temperatures reduce the efficiency of thermal and hydropower systems, increase cooling demands, and accelerate wear on electrical components. In manufacturing, heat stress affects worker productivity, increases operational costs due to cooling needs, and shortens the lifespan of sensitive machinery. Infrastructure such as roads and rail systems may suffer from thermal expansion and material degradation.
Drought	Evaluated using accumulated annual precipitation and the SPEI-12 index to identify prolonged water stress. Drought directly impacts hydropower generation by reducing reservoir levels and river flows. In manufacturing, water scarcity can disrupt processes that rely on water for cooling, cleaning, or as a raw material. Drought also affects agriculture-based supply chains, which feed into agro-processing and food manufacturing industries. Infrastructure dependent on water availability, such as sanitation and cooling systems, is also at risk.
Extreme Wind	Measured via peak gusts with a 25-year return period, this hazard is relevant for above-ground infrastructure such as transmission lines, telecommunication towers, and industrial facilities. High winds can cause structural damage, topple pylons, and disrupt energy distribution. In manufacturing zones, wind damage can affect warehouse integrity, logistics hubs, and outdoor storage areas, especially where wind-resistant design standards are lacking.
Fire Risk	Assessed using climatic dryness indices and historical fire occurrence data. Fire risk is particularly relevant in peri-urban and rural zones near vegetated areas. For energy infrastructure, wildfires can damage transmission lines, substations, and fuel storage facilities. In manufacturing, fires pose a direct threat to facilities located near combustible vegetation or reliant on biomass inputs. Fire risk also compounds other hazards by reducing air quality and increasing operational downtime.

The CRVA relies on a combination of high-resolution historical data and regional climate projections to characterise climate hazards and inform risk analysis across the IEM sectors. Baseline climate conditions (1986–2005) and historical climate conditions were derived from a suite of reanalysis and satellite-based observational datasets, providing spatially continuous and consistent representations of key climate variables across the study countries. Specifically:

- CHIRPS – High-resolution precipitation data (0.25°) used to quantify rainfall patterns, extreme precipitation events, and drought occurrences.
- CHIRTS-Daily – Temperature data (0.25°) employed to assess heat extremes and long-term temperature variability.
- ERA5 Reanalysis – Wind and additional meteorological variables, providing comprehensive coverage of atmospheric dynamics relevant to hazard assessment (e.g., extreme wind events, storms).

These baseline datasets establish a robust reference against which current and projected climate conditions can be compared, forming the foundation for exposure and vulnerability analyses.

Future climate projections (2041–2060) were obtained from the Africa CORDEX ensemble, consisting of 16 bias-corrected regional climate model simulations under both RCP4.5 (medium emissions scenario) and RCP8.5 (high emissions scenario). These projections provide:

- Spatially detailed estimates of future changes in temperature, precipitation, and other variables;
- Multi-model ensembles that capture uncertainty and variability across models; and
- Inputs suitable for evaluating sector-specific and cross-sectoral climate risks.

All spatial analyses were conducted at the provincial or equivalent administrative level, enabling direct alignment with existing investment planning, infrastructure mapping, and national adaptation frameworks. This approach ensures that hazard and exposure data can be practically applied for prioritising interventions and investment opportunities in the IEM sectors.

By combining historical baselines with ensemble-based projections, the CRVA captures both current exposure patterns and emerging climate risks, supporting evidence-based adaptation planning and risk-informed investment decisions.

Sector–System–Node Sensitivity Assessment

To capture the complex interdependencies and multi-dimensional nature of climate risk, the CRVA employs a hierarchical assessment framework that evaluates risk at three interconnected levels:

- Sectors – The broad economic or service domains under study, namely Energy, Infrastructure, and Manufacturing.
- Systems – Major operational components within each sector, such as Power Generation, Transport Networks, or Water Supply Systems.
- Nodes – Specific assets or critical points within each system, for example reservoirs, substations, road surfaces, or data centres.

Each node is assessed for sensitivity to identified climate hazards through a combination of:

- Literature review, to draw on sector-specific research and global best practices;
- Sectoral datasets, providing information on asset locations, design, and operational characteristics; and
- Expert judgment, leveraging in-country and regional expertise to interpret hazard impacts and sectoral vulnerabilities.

A description of each of the sectors as well as the systems and nodes that form part of this analysis is as follows:

Energy Sector

The energy sector analysis is structured around three primary systems: generation, transmission, and distribution. Within generation, multiple technologies are considered as separate sub-systems, reflecting the diverse energy mix across the study countries:

- Hydropower – Evaluated at the level of catchments, reservoirs, and generation infrastructure, considering risks such as variable rainfall, drought, and flooding.
- Solar – Assessed for insolation patterns, panel efficiency, and inverter systems, including the impacts of extreme heat and dust.
- Thermal (coal, diesel, natural gas) – Focused on plant infrastructure, cooling systems, and fuel supply, accounting for heat stress, water availability, and operational disruptions.
- Wind, Geothermal, and Bioenergy – Included as relevant per national context, with sensitivity assessments tailored to location-specific hazards.

Infrastructure Sector

Given its diversity, the infrastructure sector is disaggregated into sub-sectors most relevant for climate adaptation investments:

- Transport – Roads, railways, ports, and harbours, including supporting structures such as bridges, culverts, and stormwater systems.
- Housing – Affordable and social housing, with attention to building materials, structural resilience, and occupancy vulnerability.
- Water and Wastewater – Water supply networks, wastewater treatment, desalination plants, stormwater management, and flood protection infrastructure.

- Solid Waste Management – Collection, recycling, landfills, and waste-to-energy systems, including transport routes and disposal sites.
- ICT and Telecommunications – a) Mobile Networks b) Core Networks, Data Centres and Network Operations Centres, c) Transmission and Backhaul including fiber optic cables and cable landing stations.

Manufacturing Sector

The manufacturing sector is analysed along the full production and supply chain, with nodes assessed for sensitivity to climate-related hazards that could disrupt operations or supply continuity:

- Raw Material Acquisition – Agricultural, forestry, and mining inputs, including dependence on climate-sensitive production areas.
- Processing and Fabrication – Industrial processes, assembly lines, and manufacturing facilities, with focus on heat stress, water availability, and operational resilience.
- Distribution – Storage, packaging, and logistics networks, including transport routes and storage facilities susceptible to flooding, extreme heat, or other hazards.

A generic model of a manufacturing system (**Error! Reference source not found.**) illustrates the typical flow from inputs to outputs, highlighting critical nodes that are particularly vulnerable to heat stress, water scarcity, and supply-chain disruptions. This model provides a practical basis for assessing systemic risk and prioritising climate adaptation investments across manufacturing operations.

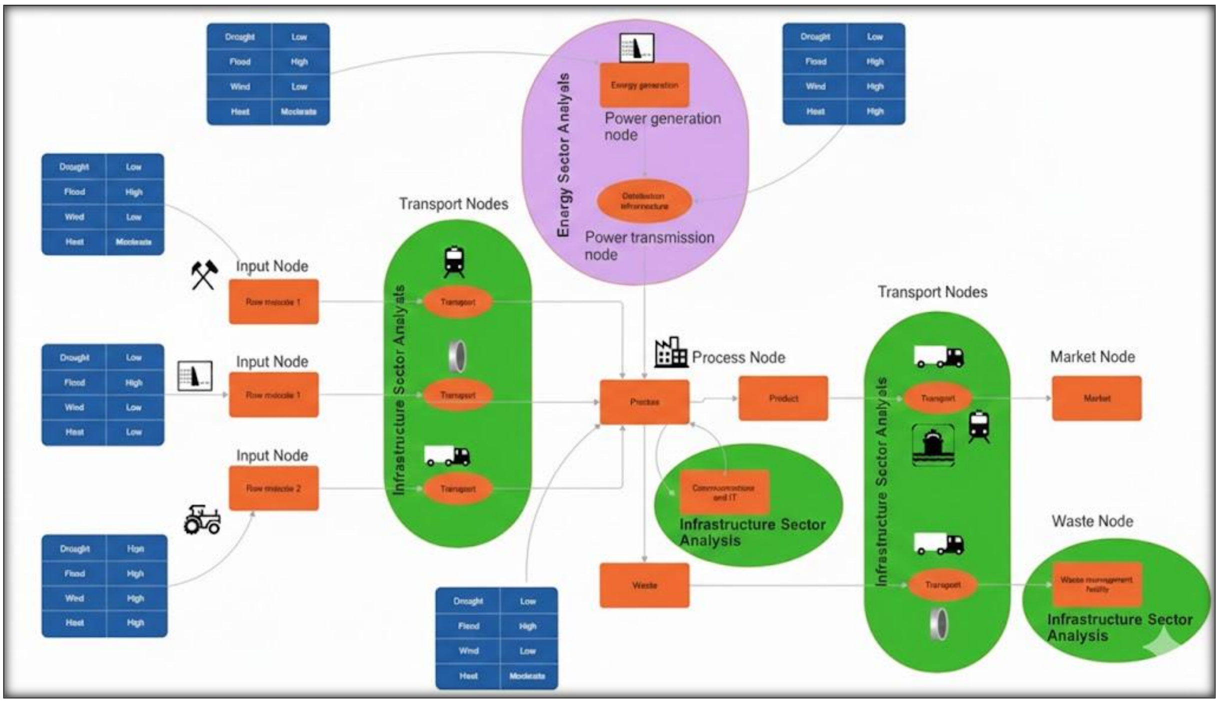


Figure 2: Generic model of a manufacturing system illustrating inputs, processes and outputs

Risk Pathway Analysis

Building on the preceding hazard exposure and sensitivity assessments, the CRVA evaluates vulnerability pathways across IEM systems to understand how climate hazards translate into system-level risks. This analysis provides insights into where and how climate impacts can disrupt critical operations, identifying opportunities to strengthen resilience. The key analytical steps include:

1. Assessing Vulnerability Pathways – Focus has been given towards understanding how specific climate hazards, such as extreme rainfall, prolonged drought, and heat stress affect the functionality and performance of IEM systems. For example, reduced rainfall can lower hydropower generation, while extreme heat may reduce the efficiency of thermal power plants. The assessment also considers how disruptions in one system can cascade across sectors,

amplifying risks, for instance, electricity shortages in the energy sector can affect water pumping and treatment, transport operations, and manufacturing processes. Additionally, the analysis identifies feedback loops and compounding effects, where initial failures in one part of the system exacerbate vulnerabilities elsewhere, highlighting the interconnected nature of systemic risk. Beyond internal sectoral linkages, the assessment examines, where relevant transboundary dependencies and systemic vulnerabilities. IEM systems and networks depend on regional systems and cross-border infrastructure corridors, meaning that climate-related disruptions beyond national borders such as flooding, drought, or infrastructure damage can therefore create cascading effects on domestic systems, influencing connectivity, supply reliability, and service continuity.

2. Overlaying Hazard and System Data - Spatial overlays of hazard intensity and the locations of critical systems and nodes were used to identify exposure hotspots where assets face elevated climate risk. This high-level analysis provides a basis for prioritising adaptation interventions in the areas most vulnerable to climate hazards.
3. Identifying Resilience Gaps - The CRVA evaluates reliability and efficiency risks associated with climate hazards, including potential service interruptions, operational downtime, and supply chain impacts. At a high level, it also identifies critical points of failure where disruptions could have significant socio-economic consequences, such as major transport corridors, energy infrastructure, or water systems.
4. Quantifying Systemic Risk - The CRVA considers multi-hazard exposure and sectoral interdependencies to understand how risks may extend beyond individual assets. This approach highlights key cross-sectoral vulnerabilities and provides a risk-informed basis for prioritising adaptation measures that strengthen resilience across systems and sectors.

This structured approach allows the CRVA to move from identifying hazard-prone locations to understanding how climate events affect system performance, and ultimately to prioritising interventions that reduce both localized and systemic climate risks across the IEM sectors.

Opportunity Identification and Investment Prioritisation

The final stage of the CRVA translates the vulnerabilities identified across IEM systems into practical adaptation investment opportunities. This process focuses on pinpointing interventions that not only enhance climate resilience but also offer commercial benefits. This includes determining where strategic interventions can strengthen system resilience, such as diversifying energy sources with renewables, mitigating the impacts of heat stress on key sectors, or incorporating flood- and climate-resilient designs into housing or transport.

Recognising that the energy, infrastructure, and manufacturing sectors are deeply interconnected, the CRVA includes a cross-sectoral analysis to map how vulnerabilities in one system (e.g., electricity supply) can cascade into others (e.g., manufacturing production or transport reliability). Understanding these interdependencies is critical to designing resilient and bankable adaptation investments that address systemic risks rather than isolated vulnerabilities. This relationship is illustrated in Figure 3.

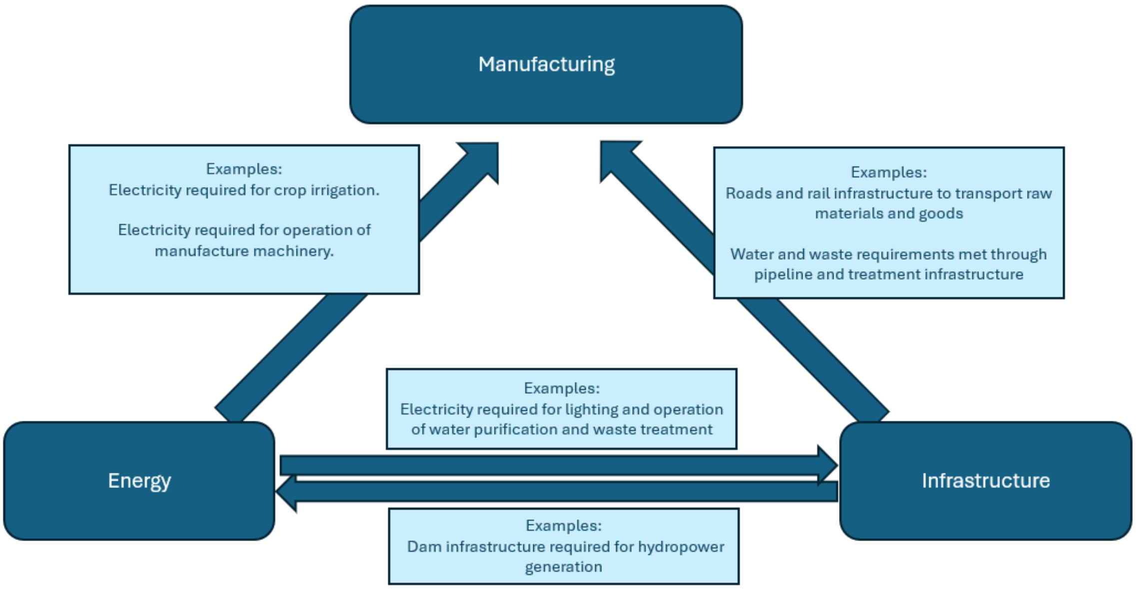


Figure 3: Illustration of the interconnectedness of the three focal sectors

Data Sources and Limitations

The CRVA for Tanzania relies primarily on existing datasets and secondary literature; no new downscaling or primary data collection was undertaken. Spatial consistency and quality were maintained through cross-validation of global and regional datasets. However, key limitations include:

1. Variable data resolution across counties and regions - This introduces variability in how precisely hazards can be characterised at sub-national scales. As a result, investment-relevant insights are framed at national or provincial levels rather than at specific sites. For private-sector audiences, this means the assessment is designed to identify priority adaptation themes rather than prescriptive location-specific interventions.
2. Limited local-scale hazard validation data - Sparse and inconsistent ground-based meteorological, hydrological, and hazard-impact records reduce the ability to validate modelled projections with observed local conditions. Consequently, confidence levels for hazards such as localised flooding, landslides, and urban heat remain constrained, and the projections should be interpreted as indicative. This underscores the importance of prioritising flexible, no-regret adaptation options.
3. Uneven availability of asset-level geospatial information - Limited or outdated datasets on the exact location, condition, or characteristics of infrastructure, energy systems, and manufacturing facilities constrain the ability to model exposure at the asset level. Accordingly, recommendations focus on sector-level opportunity areas rather than asset-specific investment cases.

These limitations are addressed by integrating multiple data and information sources (GCA roadmaps, AfDB climate profiles, World Bank CCDRs, ThinkHazard, EarthMap, GRI, and national datasets) and by applying consistent analytical assumptions across all countries.

In addition to the climate change data described earlier in the report, spatial data used to represent the physical locations of infrastructure and the boundaries of relevant zones, administrative areas and included the following:

- Tanzanian National Geospatial Datasets
  - Provincial and national level administrative boundaries
  - Road network distribution
  - Rail network
  - Hydrological data; Rivers, Lakes, Wetlands, Catchments
- Humanitarian Open Street Map Team (HOTOSM) data sourced from the Humanitarian Data Exchange (managed by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA)) for:

- Populated places - polygons and points
- Road Network distribution (surface attributes)
- Modelled distributions of high voltage transmission lines

The locations (coordinates) and specifications of hydropower plants were obtained from reports by the Tanzanian Energy and Water Utilities Regulatory Authority (EWURA) and the Tanzania Electric Supply Company (TANESCO), and captured spatially by the project team using high-resolution aerial imagery in a GIS environment. The positions of major bridges were identified by intersecting the road network with river datasets in GIS and then digitising bridge locations from high-resolution satellite imagery.

Tanzania: Gender Equality and Social Inclusion (GESI) Overview

Tanzania has a strong policy foundation for inclusion, including the Tanzania Climate Change Gender Action Plan (2013), the National Gender Policy (2000), and frameworks under the Ministry of Community Development, Gender and Children. Despite these commitments, gender and social inequalities remain pronounced within urbanizing areas, the informal economy, and climate-exposed infrastructure and industrial zones.

Persistent Gender, Youth and Inclusion Gaps

Despite steady progress, significant disparities persist across access, employment, and participation in climate-relevant sectors:

- 73% of Tanzanian women are now financially included, yet access to formal credit remains restricted due to collateral requirements (Finscope Tanzania, 2023).
- Only 15–20% of land titles are held by women, limiting their ability to secure loans for industrial equipment, commercial premises, or renewable-energy productive assets (Landlinks, 2023).
- 76% of Tanzania's workforce is informal, with women disproportionately concentrated in petty trade, food and beverage processing, basic services, and micro-manufacturing (NBS Tanzania, 2025)
- Youth represent 63% of the population but face significantly higher unemployment (~13% vs. 3–4% national average) and limited access to technical and vocational skills required in manufacturing and energy industries (ILO Tanzania, 2023).
- Persons with disabilities (PWDs), estimated at ~8% of the population, face low formal employment rates (3–4%) and limited access to safe, inclusive infrastructure; fewer than 10% of public buildings meet accessibility standards (UNDP, 2016).

Climate change compounds these inequalities. Women-led MSMEs and youth-run enterprises are highly exposed to energy disruptions, extreme heat in industrial facilities, and damage to transport and water systems. Urban flooding in cities such as Dar es Salaam and Mwanza affects informal settlements where women and youth predominate, increasing vulnerability, lost work time, and exposure to GBV. Rising temperatures intensify occupational risks for workers in manufacturing, construction, and utility services, sectors where informal labour and limited workplace protections are common.

Sector-Relevant GESI Dimensions

Access & Affordability

- Evidence from UN Women indicates that women-led microenterprises in Tanzania disproportionately experience productivity losses during energy outages, particularly where business activities depend on refrigeration, lighting, or digital services (UN Women, 2021).
- Mini-grid and solar home system adoption remains lower among women due to higher upfront costs and restricted access to credit (World Bank, 2021).
- Urban flooding disrupts mobility and access to public services (e.g., transport, water points), with UN-Habitat highlighting informal settlements in Dar es Salaam and Mwanza as particularly affected (UN Habitat, 2021).

Employment & Livelihoods

- ILO labour market profiling shows that women and youth are concentrated in labour-intensive manufacturing subsectors, including food processing, apparel, and small-scale assembly, which are more sensitive to heat and water shortages (ILO Tanzania, 2023).
- UNEP evidence on heat stress indicates that rising temperatures reduce safe working hours in manufacturing facilities lacking cooling systems, which heightens risks for low-wage and informal workers (UNEP , 2023).
- Climate-related disruptions of transport and energy infrastructure affect employees in construction materials and light industry through lost working hours and irregular production cycles (World Bank , 2024).

MSME Participation

- Women-owned MSMEs face higher barriers accessing industrial machinery, energy-efficient equipment, and adaptation finance, linked to lower collateral ownership and credit access (World Bank, 2021).
- Manufacturing MSMEs report challenges related to unreliable power supply, which raises operational costs and reduces competitiveness (AfDB, 2025).
- UN Women and IRENA identify opportunities for inclusive green entrepreneurship in solar servicing, e-mobility maintenance, waste-to-energy, and clean cooking value chains, with women and youth overrepresented in micro-enterprise segments (UN Women, 2021).

Social Inclusion & Gender

- UN-Habitat identifies that informal settlements in Dar es Salaam, Tanga and Mwanza are disproportionately exposed to flooding, with many women-headed households concentrated in flood-prone areas (UN Habitat, 2021).
- Lack of gender-disaggregated labour and infrastructure data poses barriers to climate-responsive planning (ILO Tanzania, 2023).
- UNFPA reports that disruptions to basic services (transport, energy, water) during climate shocks increase GBV risks, particularly for women travelling longer distances for services (UNFPA, 2024).

Resilience & Sustainability

- IPCC AR6 identifies East African cities and industrial zones as highly exposed to extreme heat, affecting worker productivity, especially in indoor manufacturing environments (IPCC, 2025).
- UNEP evidence shows that productivity losses from heat are most acute for female-dominated processing and packaging work where cooling or ventilation is limited.
- UNECA highlights that inclusive access to early warning systems, climate information, and resilient infrastructure remains limited for low-income groups, women, and persons with disabilities (UNECA, 2023).

Implications for Investable Adaptation Opportunities

GESI considerations highlight specific adaptation opportunities in Tanzania that are gender-responsive and have the potential to be commercially relevant:

Energy

- Mini-grids, rooftop solar, and solar + BESS systems can reduce downtime for MSMEs, especially in sectors highlighted by IRENA as sensitive to power interruptions (IRENA Off-grid Impacts).
- Heat-resilient and flood-resilient modifications to solar infrastructure improve reliability in urban informal environments noted by UN-Habitat as flood-prone.
- Clean energy for productive use - including energy-efficient motors, cooling, and industrial equipment — supports the participation of women and youth who dominate micro- and small-scale manufacturing (ILO Tanzania, 2023) (UN Women, 2021).

Infrastructure

- Upgrading urban drainage, climate-resilient transport links, and pedestrian infrastructure improves mobility for low-income workers, persons with disabilities, and women-headed households affected by flooding.
- Improvements in water systems, including storage and flood-proof distribution, reduce service disruptions linked by UN Women and UNFPA to increased time burdens and safety risks for women during climate shocks.
- Nature-based drainage, small-bridge upgrades and feeder roads enhance access between informal settlements and industrial clusters - supporting the workforce mobility identified by World Bank and AfDB as essential for Tanzanian urban productivity.

Manufacturing

- Investments in heat-safe workplaces - such as improved ventilation, reflective roofing, and low-energy cooling - align with UNEP findings on rising heat impacts in indoor labour settings.
- Water-efficiency solutions (recycling, efficient washing, process water management) reduce exposure to climate-related water shortages affecting industrial operations (World Bank , 2024).
- Renewable-powered industrial equipment and efficient cold storage address operational challenges experienced by MSMEs due to energy instability (AfDB, 2025).
- Targeted financing for women-led manufacturing MSMEs supports inclusive industrialization goals identified by UN Women and ILO, while improving resilience to climate and energy shocks.

CLIMATE HAZARD ASSESSMENT

Tanzania's socio-economic development is increasingly shaped by the dual pressures of climate variability and the need for resilient, inclusive growth. As a rapidly developing economy in East Africa, Tanzania's IEM sectors form a critical backbone of its industrialisation and economic diversification efforts, yet they remain highly vulnerable to climate-induced disruptions. The following chapter outlines the contextual backdrop against which climate hazards interact with sectoral dependencies, setting the stage for the identification of investment opportunities that will enable climate resilience through infrastructure and climate resilience of infrastructure.

Background and Context

Tanzania covers approximately 947,300 km² and features diverse topography, including the central plateau, coastal lowlands, and highlands such as Mount Kilimanjaro (5,895 m) and Mount Meru (4,566 m). The country borders eight nations and has an extensive Indian Ocean coastline, which supports major economic hubs like Dar es Salaam and Zanzibar. Inland, Lake Victoria, Tanganyika, and Nyasa and river basins such as the Rufiji sustain agriculture and hydropower generation (Sindato, 2024).

Tanzania's climate is predominantly tropical but moderated by altitude, resulting in distinct rainfall patterns across the country. The northern and eastern regions experience a bimodal regime, with short rains (*vuli*) occurring from October to December and long rains (*masika*) from March to May. In contrast, the central, southern, and western areas follow a unimodal pattern, characterized by a single rainy season that typically spans from November or December through April.

The Intertropical Convergence Zone (ITCZ) and Indian Ocean monsoon systems drive rainfall variability. Coastal areas are hot and humid year-round (Luhanga, 2018). Recent decades show clear climate shifts: mean annual temperature has risen by ~1°C since 1960, and projections indicate increases of 2–3°C by mid-century and up to 4–5°C by 2100, depending on emissions scenarios (Luhanga, 2018). Rainfall patterns are becoming more erratic, with intensified rainfall events causing floods and prolonged dry spells leading to droughts. Extreme events such as the 2015–16 El Niño floods and recurrent droughts have disrupted agriculture, hydropower generation, and infrastructure.

Climate vulnerability is unevenly distributed. Coastal cities like Dar es Salaam face heightened exposure to flooding and sea-level rise, while semi-arid regions such as Dodoma and Singida are prone to drought. Rural smallholders, especially women (who contribute over 70% of agricultural labour), are disproportionately affected due to reliance on rainfed farming and limited adaptive capacity (Tukae Mbegalo, 2018). Urban areas experience additional stress from rapid population growth and inadequate drainage systems (Johansson, 2024). Roads and bridges are highly vulnerable to washouts and landslides during flooding events, while prolonged heat accelerates pavement deterioration, reducing asset lifespans. The energy sector, which relies heavily on hydropower, is particularly sensitive to rainfall variability; drought conditions lower reservoir levels and lead to power rationing, whereas floods can damage transmission infrastructure and disrupt grid stability. Manufacturing industries, including agro-processing and construction, depend on reliable water and energy supplies. Extreme weather events disrupt supply chains, damage facilities, and reduce labour productivity during heatwaves, compounding operational and economic challenges

Understanding these spatial and sectoral vulnerabilities is critical for designing climate-resilient investments. The following chapters will examine Tanzania's key climate hazards, including drought, flooding, temperature extremes, and wind and assess their implications for infrastructure, energy systems, and manufacturing operations, with a focus on adaptation strategies and sustainable development.

Figure 4: Altitudinal map of Tanzania (Source: Grida)

Climate Hazard Assessment Results

As previously noted, this hazard analysis establishes the foundation for evaluating both exposure and sensitivity. Central to this assessment is an understanding of how climate hazards are expected to evolve over time, as well as their spatial relationship to the infrastructure under review (exposure). Sensitivity refers to the extent to which systems, or specific components within those systems, are likely to be affected by these hazards. The analysis includes a detailed examination of projected changes in extreme temperature, extreme precipitation, fluvial flooding, drought, fire conducive conditions and extreme wind. Each hazard has been assessed for its potential impact on IEM systems and the individual components that comprise them.

Extreme Temperature

Chronic exposure to extreme temperatures was assessed across Tanzania using the variable of number of days in a year where the maximum temperature reaches or exceeds 35^{0}C. Three classes of chronic exposure have been defined for the purposes of visualizing the extent of exposure across Tanzania. These are as follows:

1. Low exposure – less than 50 days a year
2. Moderate exposure – between 50 days and 100 days a year
3. High exposure – more than 100 days a year

Historically, Tanzania's chronic exposure to extreme temperatures has been limited. This limited exposure is largely confined to the lower Rufiji Valley and to the low lying coastal areas, particularly in the northern parts of the coast, as illustrated in Figure 5. These areas are characterized by low elevation, which amplify heat extremes and prolong hot periods. The lowland areas in eastern Tanzania exhibit mean annual temperatures of up to 26 °C. In contrast, large parts of the interior are high plateaus. The Kigoma region slopes from about 1,750 meters down to the 800-meter shoreline of Lake Tanganyika. These highlands in the central and northwest of the country benefit from higher elevation and cooler temperatures, resulting in significantly lower exposure to very hot conditions. The highlands exhibit a mean annual temperature of 18 °C, while the semi-arid central plateau exhibits a mean annual temperature of 23 °C

This geographic contrast is foundational to understanding the spatial distribution of climate hazards. It also has direct implications for infrastructure vulnerability where systems located in lowland zones are inherently more exposed to thermal stress, while those in higher-altitude regions may be less affected, at least under current climate conditions.

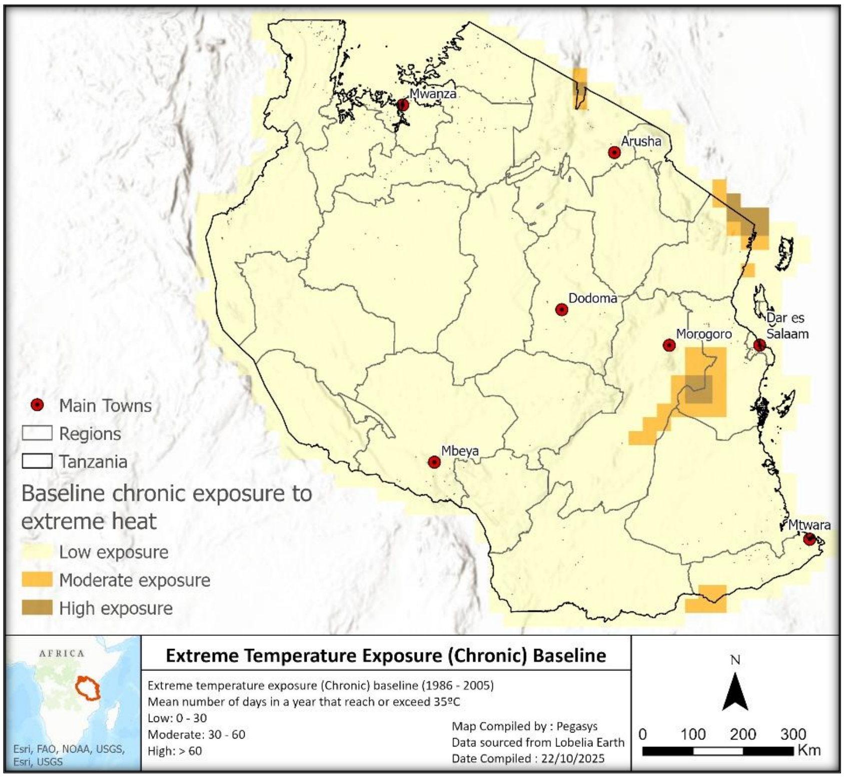


Figure 5: Baseline (1986 – 2005) distribution of chronic exposure to extreme temperatures

Baseline Heat Extremes

Tanzania experiences varying extreme heat conditions across its regions. Coastal and northeastern provinces such as Pwani, Tanga, and Morogoro see hottest-day temperatures of 36–37°C once every 10 years, with peaks surpassing 39°C, especially in Arusha and Pwani. The offshore islands of Unguja and Pemba (Zanzibar) have a milder climate, with 10-year extremes of 34–35°C and almost no days exceeding 35°C. The central plateau regions (Dodoma, Singida, Tabora) and western zones (Katavi, Shinyanga) experience moderate heat extremes, with peak temperatures around 34–37°C and 2 to 12 days annually above 35°C. The southern and northern highlands, including Mbeya, Njombe, Arusha, and Kilimanjaro, are generally cooler, though Arusha presents a unique anomaly with up to 100 days per year above 35°C, likely influenced by the nearby Lake Natron basin.

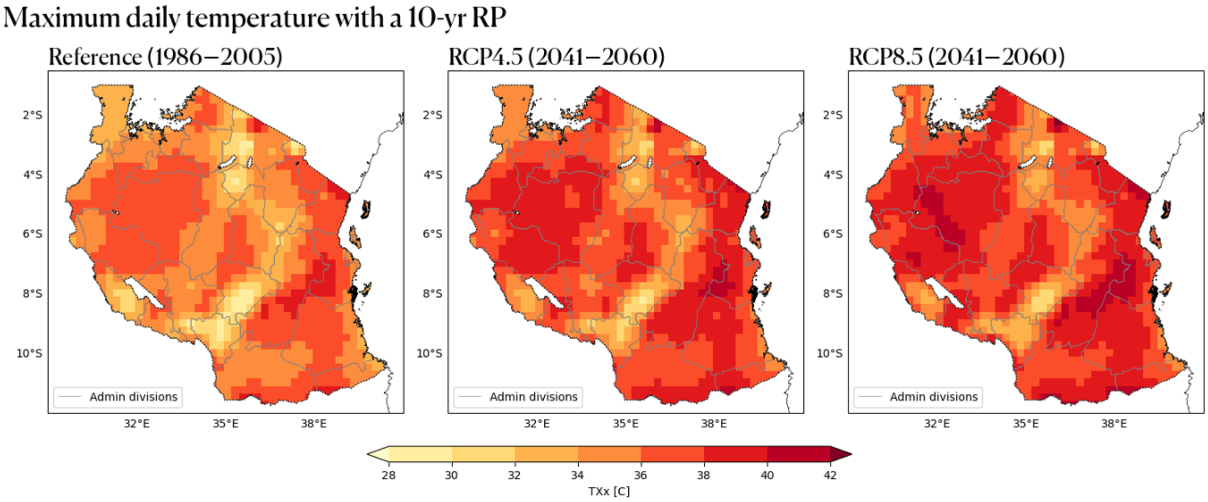


Figure 6: Comparison of the maximum daily temperature with a 10-year return period during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

Projected Intensification of Heat Risk

Under future climate scenarios, Pwani is projected to become a major heat hotspot, with 10-year extreme temperatures reaching 39°C and localized peaks up to 41°C. Under the high-emission RCP8.5 scenario, the number of days above 35°C between Pwani and Morogoro there may exceed 160 annually. Eastern Tanga will also remain a significant hotspot but less extreme.

Tabora is expected to see a sharp rise in heat extremes, with 10-year peak temperatures reaching 39°C and localized highs of 40°C under RCP8.5. Hot days are predicted to increase dramatically from about 4 to an average of 44 days per year, with some locations experiencing up to 73 days above 35°C.

Arusha generally will have few very hot days, but localized areas near Lake Natron will face the highest heat stress in Tanzania, with up to 179 hot days yearly under RCP4.5, rising to 203 under RCP8.5. Extreme temperatures there could peak at 42°C.

The southern highlands—Mbeya, Njombe, and Iringa—will experience maximum temperatures around 34–36°C, with localized extremes reaching 39°C in low-lying areas. Days above 35°C could reach 46 under RCP4.5 notably near Iringa and Dodoma.

Offshore islands will warm, with 10-year extremes reaching 36–37°C, and Pemba showing the largest increase in very hot days, rising from almost none to 25-40 days annually under RCP8.5.

Overall, extreme heat will intensify across Tanzania, with the coastal regions, central plateau, and northern highlands most affected. These changes will increase stress on communities, reduce agricultural yields, shorten growing seasons, and increase irrigation needs for heat-sensitive crops like maize and beans. Livestock health may decline in coastal and lowland zones, while highland areas will face new challenges adapting to sustained heat.

As presented in Figure 7, under RCP 4.5, chronic exposure to extreme heat will be greatest in the coastal lowlands with isolated areas of exposure like around Lake Natron also showing high exposure. The lower Rufiji River Valley strongly dominates the extent of exposure.

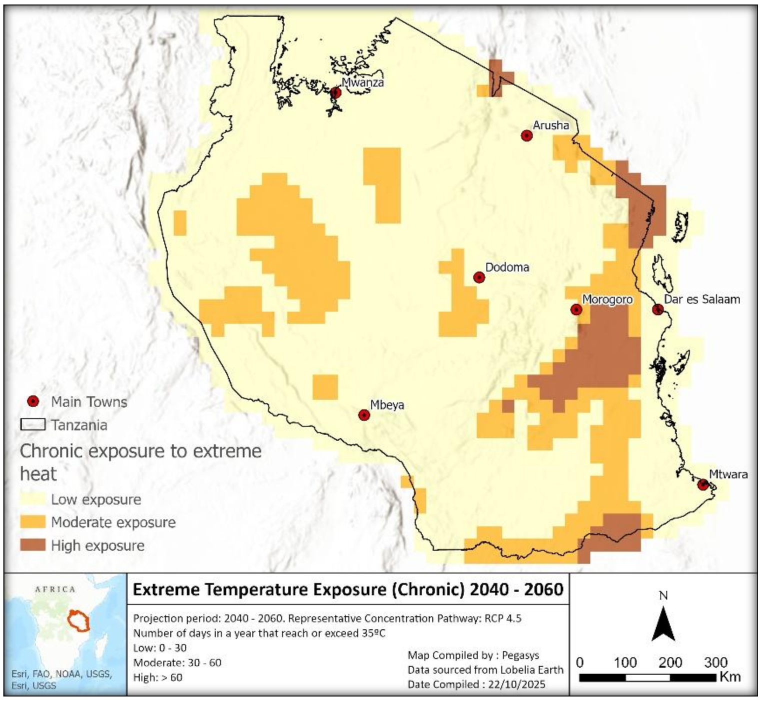


Figure 7: Projected (2040 – 2060) distribution of chronic exposure to extreme temperatures

Emerging Risk Zones and Strategic Planning

Regions that historically experienced minimal extreme heat, such as the northern and eastern highlands (as presented in Figure 8), are projected to begin experiencing a week or more of days above 35°C by 2050. While these areas will remain relatively cooler, the emergence of extreme heat events introduces new vulnerabilities for infrastructure systems that may lack adequate thermal adaptation. This shift underscores the importance of forward-looking infrastructure planning.

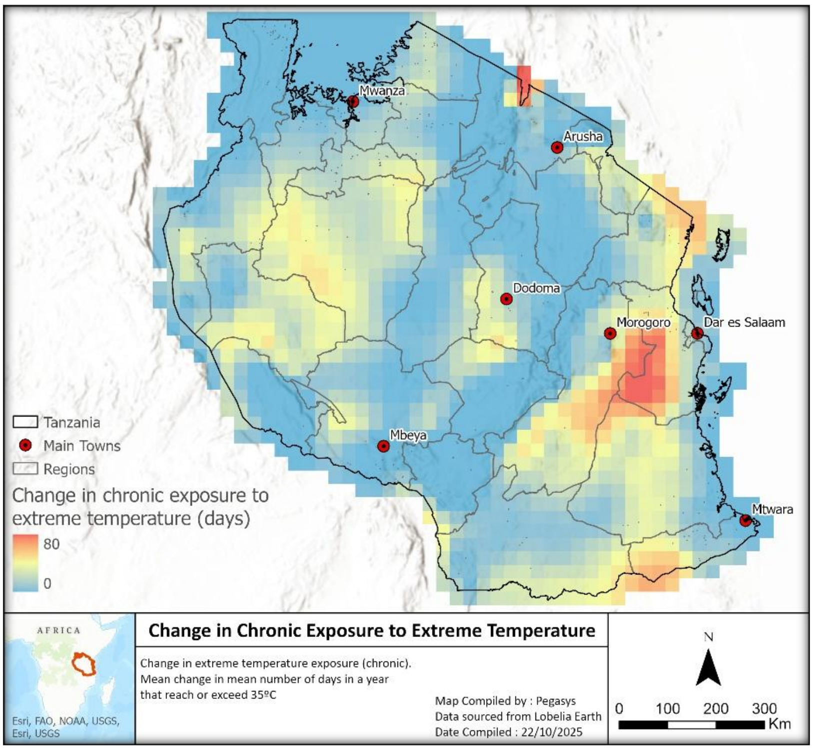


Figure 8: Projected change in the distribution of chronic exposure to extreme temperatures

Key insight: Major towns such as Dodoma, Morogoro, and Dar es Salaam shift into high-heat zones with sharp increases in days above 35°C, intensifying stress on communities, agricultural processes and labour productivity.

Historical Distribution of Extreme Precipitation

Extreme precipitation patterns, represented by the annual mean maximum daily rainfall, are strongly influenced by Tanzania's diverse topography and regional climate systems. As shown in Figure 9, baseline exposure (1986–2005) to extreme precipitation is not uniform across the country but concentrated in specific zones. The southern highlands, particularly around Mbeya and Ruvuma, exhibit the highest exposure, with mean maximum daily rainfall exceeding 45 mm, placing these areas in the high-risk category. This is largely due to orographic uplift in mountainous terrain, which enhances convective activity and rainfall intensity.

Similarly, the eastern coastal belt, including Dar es Salaam, Morogoro, and Mtwara, shows extensive high-exposure zones. These areas are influenced by the Indian Ocean monsoon and sea-breeze convergence, which drive intense rainfall events during the long rains (*masika*) and short rains (*vuli*). The combination of low-lying coastal plains and high rainfall intensity increases flood risk for urban infrastructure and transport corridors.

In contrast, central Tanzania, including Dodoma, and parts of the Lake Zone (Mwanza) exhibit lower exposure, with mean maximum daily rainfall typically below 35 mm per day. These regions are characterized by semi-arid conditions and less pronounced topographic variation, which limits convective rainfall development. Moderate exposure zones (35–45 mm) are scattered across the northern highlands near Arusha and Kilimanjaro, where elevation contributes to localized heavy rainfall events.

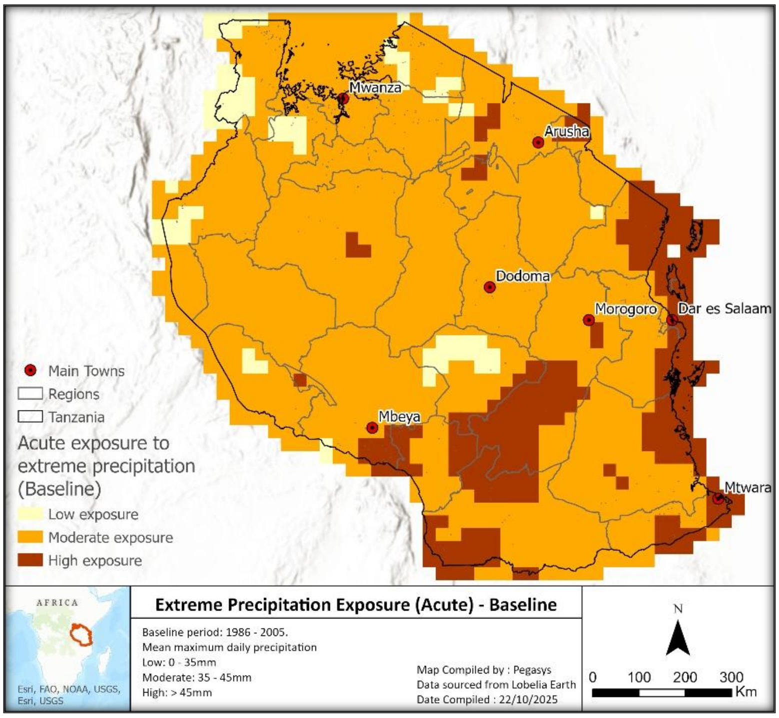


Figure 9: Baseline distribution of acute exposure to extreme precipitation

Projected Intensification and Regional Shifts

Looking ahead to the mid-century period (2040–2060), projections under RCP4.5 indicate a general increase in extreme precipitation across most of Tanzania, with the most pronounced changes occurring in the southern highlands and coastal corridor. As illustrated in Figure 10, high-exposure zones expand inland from the coast and intensify in the south. The Mbeya–Ruvuma belt is projected to experience daily extremes exceeding 50 mm, while coastal areas such as Dar es Salaam and Mtwara remain highly exposed.

Percentage changes in mean maximum daily rainfall, presented in Figure 11, reinforce these trends. Southern and coastal regions exhibit increases of up to +30%, while northern highlands show gains of 10–20%. Even modest increases in extreme rainfall can have outsized impacts on infrastructure systems, particularly where drainage capacity is limited or assets are already operating near design thresholds.

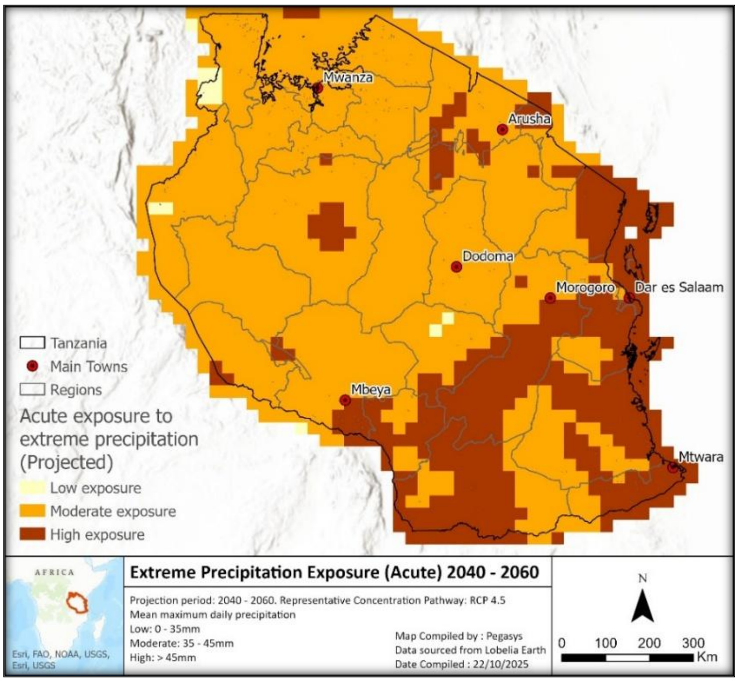


Figure 10: Projected medium term (2040 – 2060) distribution of acute exposure to extreme precipitation

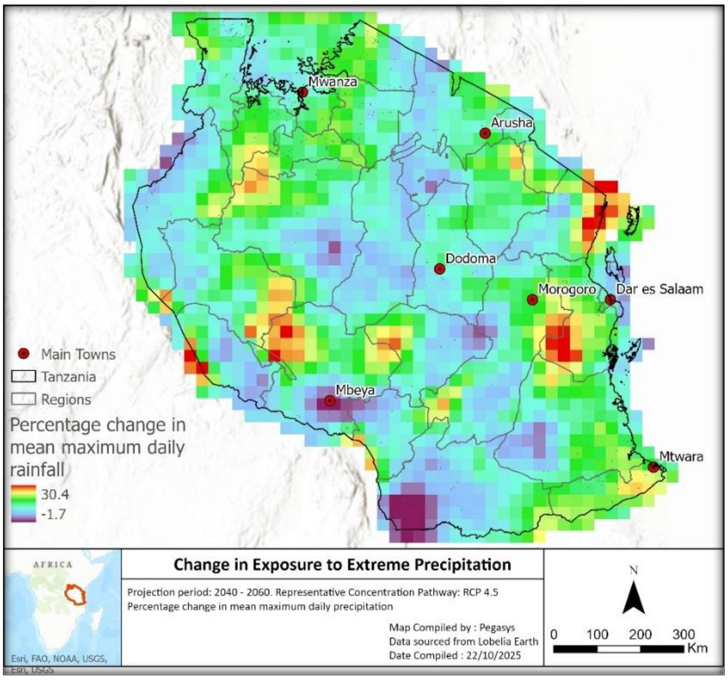


Figure 11: Projected change in distribution of acute exposure to extreme precipitation

Figure 12 illustrates the projected 1-in-25-year daily maximum precipitation for 2040–2060 under RCP4.5. The most extreme rainfall events are concentrated in the northeastern coastal zone, particularly east of Arusha toward Tanga, where single-day totals exceed 300 mm, with localized peaks approaching 367 mm. Zanzibar and offshore islands also show exceptionally high values, likely influenced by cyclonic systems and oceanic convection, making them critical hotspots for flood risk. The southern highlands, including Mbeya and Ruvuma, remain another major high-exposure area, with projected extremes above 300 mm driven by orographic uplift. The eastern coastal belt, encompassing Dar es Salaam, Morogoro, and Mtwara, records high extremes in the range of 250–300 mm, posing significant challenges for urban drainage and infrastructure resilience. In contrast, the northern highlands (Arusha and Kilimanjaro) exhibit moderate extremes of 150–200 mm, while the central plateau (Dodoma) remains relatively low at 40–100 mm, and the Lake Zone (Mwanza) shows moderate values around 100–150 mm.

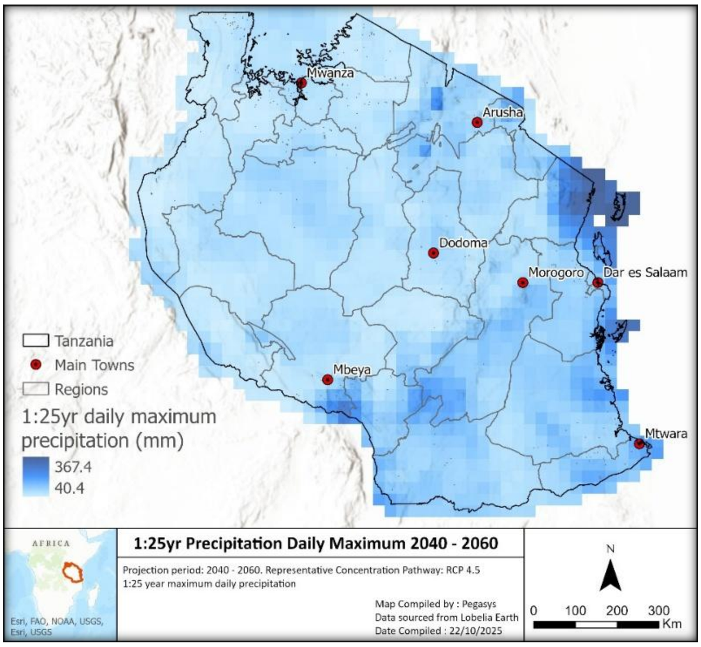


Figure 12: Distribution of rainfall depths associated with the 25-year return period rainfall event

Fluvial (River) flooding

As presented in Figure 13, Tanzania's hydrological network is strongly influenced by its topography. A major watershed runs roughly from Mbeya in the south, through Dodoma, and up to Arusha in the north, dividing the country into two distinct drainage systems. East of this divide, rivers flow toward the Indian Ocean, forming large coastal basins such as the Rufiji, Pangani, and Wami-Ruvu systems. West of the divide, a complex network of rivers drains into the Great Rift Valley lakes, including Lake Tanganyika, Lake Victoria, and Lake Nyasa, while the central region contains internally draining basins feeding volcanic depressions and Lake Natron. The Rufiji River, together with its largest tributary, the Great Ruaha, is Tanzania's most significant river system and a critical hydroelectric power resource.

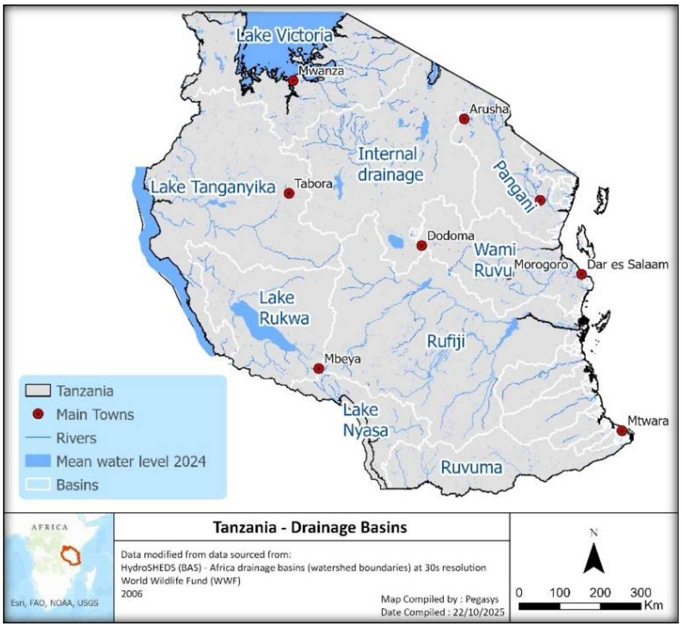


Figure 13: Map of principal river basins in Tanzania, together with the main river network in the country

To assess baseline flood risk (in addition to the historical flood events mentioned above), flood extent and water depth data from the European Joint Research Centre (JRC) Flood Maps were analyzed for a 50-year return period event. These maps, with a 100 m resolution, provide a broad view of inundation patterns under current climate conditions (Figure 14). As presented in this map, Tanzania is highly susceptible to fluvial flooding, particularly in coastal and urban areas such as Dar es Salaam, due to its geographic and climatic conditions. Flooding is often triggered by intense and unpredictable rainfall events, which, as highlighted earlier, are projected to intensify under climate change. Rising sea levels further compound flood risk in low-lying coastal zones.

Urban centres face a pronounced flooding-poverty nexus, where informal settlements located in floodplains experience recurrent inundation even during average rainfall events (World Resources Institute, 2025). In Dar es Salaam, inadequate drainage infrastructure exacerbates vulnerability, leading to frequent damage to roads, housing, and sanitation facilities. For example, the April 2018 flood event affected nearly 12,000 people, destroyed dozens of houses and latrines, and severely damaged hundreds more, while also disrupting electricity supply and public services, impacting businesses and livelihoods (Rentschier, 2021).

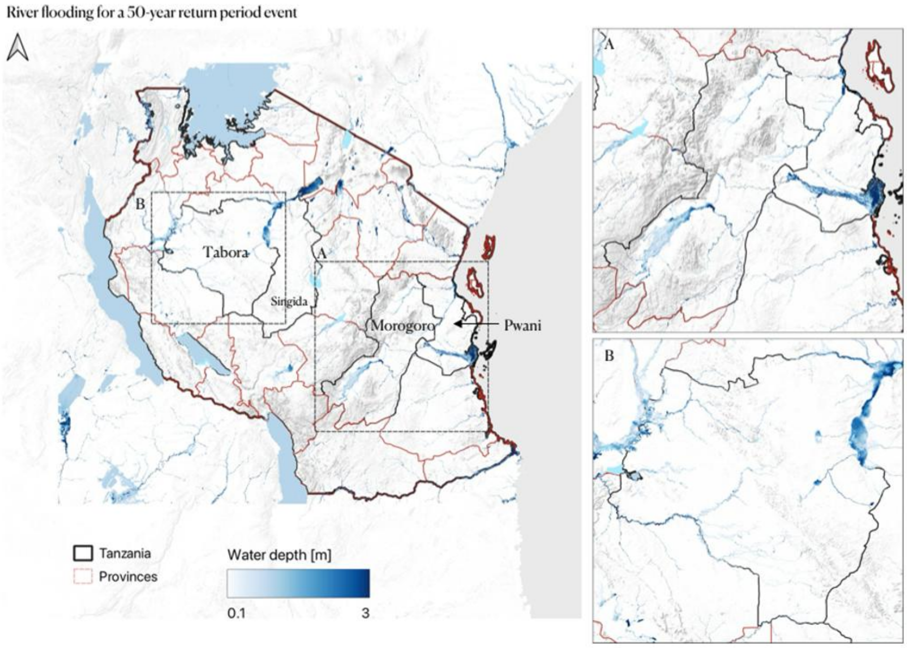


Figure 14: Flood Map for 1 in a 50 year river flooding event for the historical period. The provinces highlighted in (A) and (B) are the ones with the largest exposure (largest area with at least 0.5m of floodwater expected).

Projections of future flood extents under the RCP 4.5 scenario for the period 2040–2060 were obtained from the World Resources Institute's *Aqueduct Floods* dataset (Ward, 2020). The analysis compared areas experiencing flood depths greater than 0.5 m between the baseline and projected periods, as shown in Error! Reference source not found.. This analysis revealed that although a number of areas showed decreases in flooding extents, the areas that are shown to have an increase in flooding extents included Arusha, Lindi, Manyara, Mbeya, Morogoro, Mtwara and Tanga. The increase in flooding extents for these areas ranged from 1.2 to 5.4%.

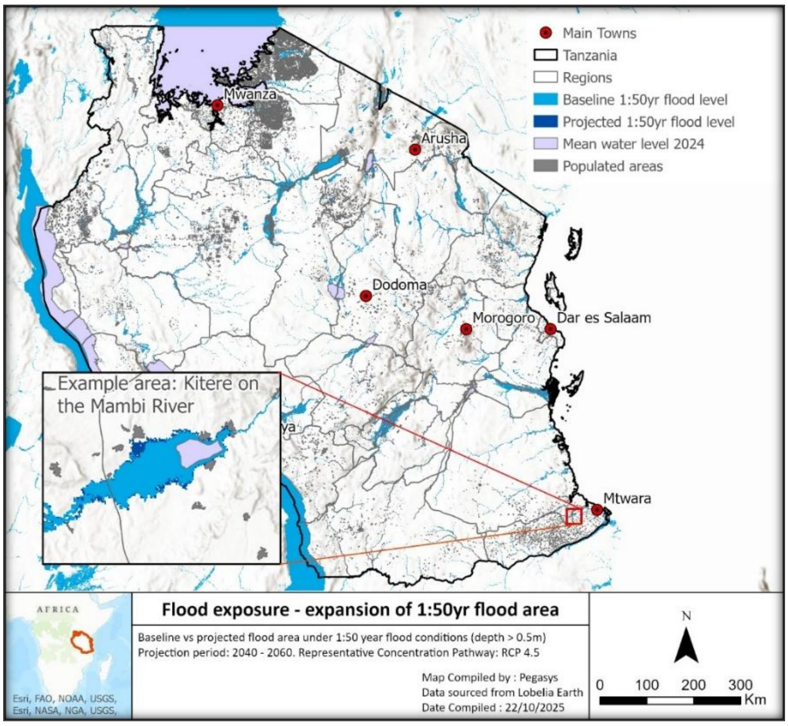


Figure 15: Projected Flood Extents (2040 – 2060) based on RCP4.5

Key insight: Flood extents expand significantly across coastal and riverine regions, with several basins showing >0.5 m flood depths. Urban centres like Dar es Salaam face heightened pluvial and fluvial flood exposure.

Sea-level rise and coastal flooding

In response to rising global temperatures, sea levels along the Tanzanian coast are expected to increase. Under the RCP6.0 scenario, compared to levels in 2000, the median climate model forecasts a sea level rise of 11 cm by 2030, 21 cm by 2050, and 41 cm by 2080 (GIZ, 2021). Whilst these increases seem small, the effect of this increase when paired with storm surges and with saline intrusion into fresh groundwater reserves is an important consideration. It is also important to consider the number of coastal livelihoods potentially affected, such as salt farms and aquaculture, particularly in flat low-lying areas like the edges of estuaries which are most susceptible to these impacts. This rise therefore poses significant risks to coastal communities in Tanzania, also potentially compromising water quality for domestic use and negatively affecting coastal biodiversity.

Given the synergistic impacts of sea level rise and storm surges as described, this exposure assessment has identified all areas lower than 5m above sea level as being potentially impacted by sea level rise in various ways. This was mapped by extracting areas falling below 5m above sea level from the JAXA ALOS World 3D - 30m (AW3D30) digital elevation model version 4.1 (Figure 16). Such areas are seen to be prevalent in important urban areas like Dar es Salaam and Bagomoyo.

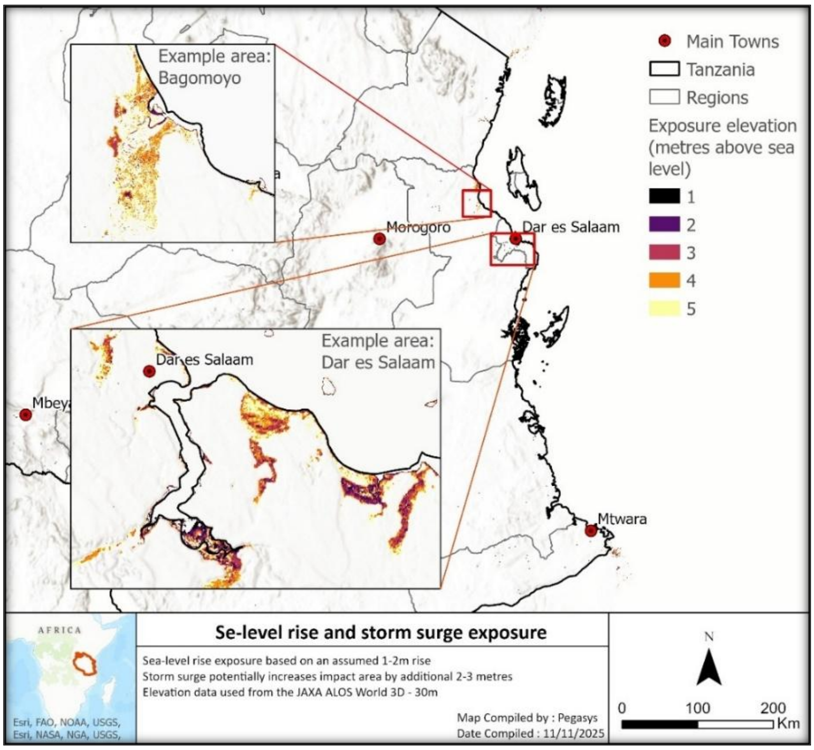


Figure 16: Sea level rise and storm surge exposure zones for the coastline of Tanzania.

Key insight: Coastal cities including Dar es Salaam, Bagamoyo, and Zanzibar face expanding inundation zones, with low-lying settlements at increasing risk of chronic flooding and salinity intrusion.

Drought

Drought exposure in Tanzania is shaped by pronounced rainfall gradients and topographic variation. The country's climate features bimodal rainfall in the north and east and unimodal rainfall in the central, southern, and western regions, but the spatial distribution of precipitation remains highly uneven. Rainfall tends to be more abundant in the coastal belt (Dar es Salaam, Pwani, Tanga), the southwestern highlands (Njombe, Mbeya, Songwe), and the islands of Zanzibar and Pemba, while the central plateau (Dodoma, Singida, Tabora) and northern semi-arid zones (Arusha, Manyara) receive significantly less, as shown in Figure 17. Elevation and terrain further influence these patterns, with highland areas benefiting from orographic uplift and coastal zones from maritime moisture, while interior plateaus remain drier and more exposed to seasonal water deficits.

These climatic and geographic factors define the zones of heightened drought risk. Central plateau provinces, where rainfall is both lower and more variable, are particularly susceptible to prolonged dry spells. During the reference period (1986–2005), Tanzania's annual precipitation exhibited a clear elevation-driven gradient (Figure 17). The islands of Zanzibar and Pemba recorded the highest average annual precipitation, exceeding 1,700 mm, followed by highland regions such as Njombe (1,428 mm) and Ruvuma (1,318 mm). In contrast, the central plateau provinces, including Dodoma (709 mm), Manyara (736 mm), and Singida (750 mm), were significantly drier. Transitional zones such as Tabora (1,016 mm) and Shinyanga (928 mm) sit between wetter western regions and the arid central belt, showing moderate rainfall levels.

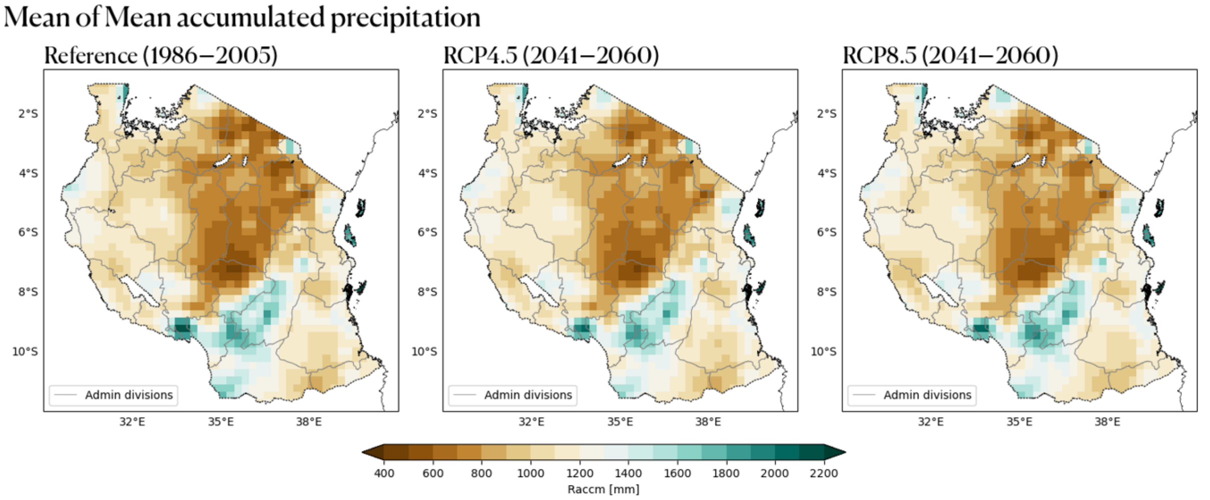


Figure 17: Comparison of the mean annual accumulated precipitation during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios

Projected Changes in Precipitation and Drought Severity (2041–2060)

Future drought exposure in Tanzania is expected to intensify, driven primarily by temperature-induced evapotranspiration rather than declining rainfall. As shown in Figure 18, projections under RCP4.5 and RCP8.5 indicate widespread negative SPEI12 values (Standardized Precipitation Evapotranspiration Index for a 12-month accumulation period), signalling increased drought stress across much of the country.

Under RCP4.5, most regions exhibit SPEI values between –0.5 and –1.2, corresponding to mild to moderate drought conditions. The most affected areas include the southwestern highlands (Njombe, Mbeya, Songwe) and parts of the western rift zone (Katavi, Kigoma), where SPEI drops below –1.2, indicating moderate drought risk despite historically high rainfall. Central plateau provinces such as Dodoma and Singida remain vulnerable, with SPEI values near –0.9, even as annual precipitation shows slight increases.

Under RCP8.5, drought severity intensifies further. Large portions of the western rift zone and southern highlands approach or exceed –1.5, crossing into the "severely dry" category in localized areas. This marks a significant shift for regions traditionally considered water-secure. Coastal areas, including Dar es Salaam, Pwani, and Lindi, also show worsening drought stress, with SPEI values around –1, reflecting heat-driven moisture loss despite stable or slightly rising rainfall totals.

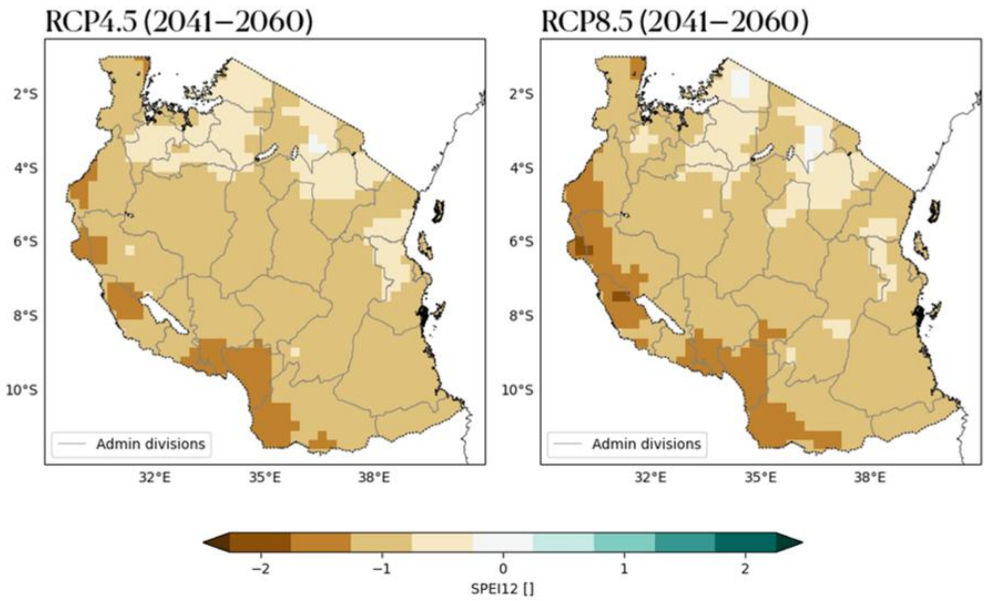


Figure 18: Projected mean of SPEI values (multi-scalar drought index) for an accumulation period of 12 months under RCP4.5 and RCP8.5 scenarios for 2041-2060

Extreme wind

Tanzania's exposure to extreme wind is closely tied to its diverse topography and coastal orientation. Mountain ranges, rift escarpments, and highland plateaus create localized zones where wind speeds are amplified through orographic acceleration and funneling effects, while coastal and island regions experience strong gusts due to maritime exposure. In contrast, more sheltered inland basins and low-lying valleys tend to record subdued wind conditions. These geographic contrasts define the baseline distribution of wind extremes across the country and are critical for identifying areas that are at risk from wind-related hazards.

During the historical reference period (1986–2005), the strongest extreme wind gusts were recorded in island and coastal regions and along highland escarpments (see Figure 19). Notable hotspots include:

- Pemba and Unguja (Zanzibar), where maximum gusts exceeded 19 m/s, reflecting unsheltered maritime exposure.
- Mafia Island (Pwani region), which recorded gusts above 20 m/s, among the highest nationally.
- Inland highlands such as Manyara, Mbeya, Njombe, and Iringa, where terrain-driven funneling produced gusts between 15–17 m/s, with localized extremes surpassing 22 m/s near rift escarpments.
- Coastal mainland areas, including Mtwara and Dar es Salaam, also registered high gust values (around 16–17 m/s) due to onshore winds during extreme events. In contrast, more sheltered inland regions such as Kagera and Geita exhibited the mildest wind conditions, with maximum gusts generally below 14 m/s, though localized extremes occasionally exceeded 17 m/s.

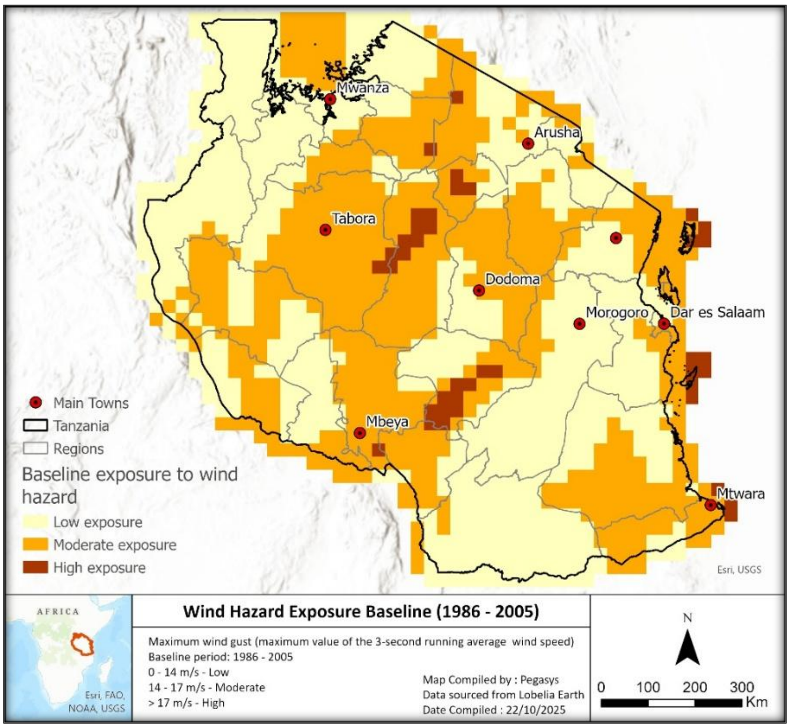


Figure 19: Baseline (1986 – 2005) distribution of exposure to extreme wind

Projected Changes in Wind Extremes (2041–2060)

Projections for the mid-century period under RCP4.5 suggest a modest but widespread increase in extreme wind speeds across Tanzania (see Figure 20 and Figure 21). The spatial pattern of exposure remains largely consistent with the baseline, but localized intensification is evident in several regions. The most notable relative increases occur in:

- Southwestern Highlands (Mbeya, Njombe, Iringa): Wind hazard exposure rises by up to 20%, with high passes and escarpments experiencing gusts exceeding 21–22 m/s during 25-year return period events.

- Western Rift Zone (Katavi, Rukwa, Kigoma): Increases of 15–18% are projected, with localized gusts approaching 19 m/s, driven by funneling effects along rift valleys.
- Northern Highlands (Manyara, Arusha): Exposure climbs by 12–16%, with areas near Babati reaching extremes of ~23 m/s under RCP8.5.
- Coastal and Island Regions (Pemba, Unguja, Mafia, Mtwara): Maritime exposure keeps wind intensity high, with projected increases of 11–14% and gusts remaining near 19–20 m/s.

While absolute changes in wind speed appear moderate, even small increases can significantly elevate the risk of damage, particularly for IEM systems not originally designed to withstand higher wind loads. This is critical for energy transmission lines, transport corridors, and coastal infrastructure, which often traverse exposed terrain.

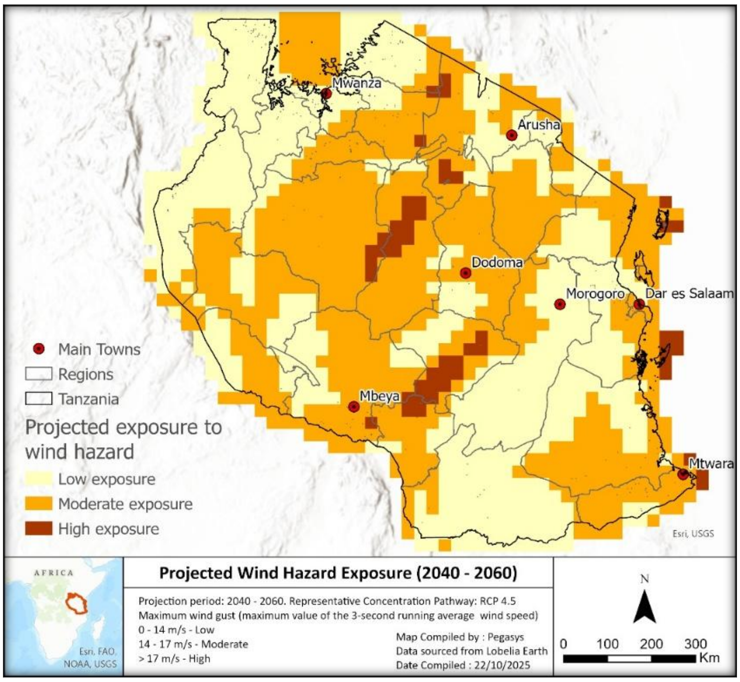


Figure 20: Projected medium term (2040 – 2060) distribution of exposure to extreme wind

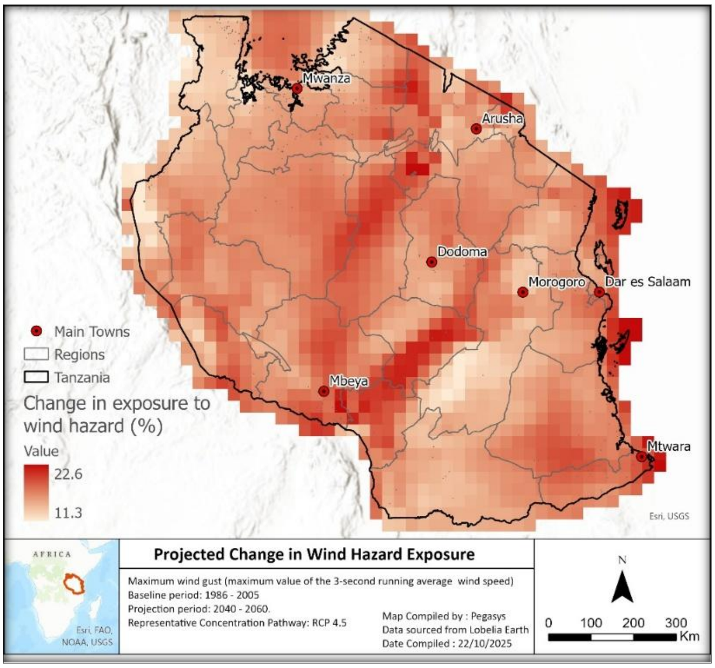


Figure 21: Projected change in the distribution of exposure to extreme wind

Fire

Wildfire is an important threat to almost all terrestrial infrastructure, to agriculture and to livelihoods. A number of climatic variables influence the threat of wildfire. These include temperature, soil moisture levels, humidity and wind. Climate change influences fire risk by increasing temperatures, lengthening fire seasons, and intensifying fire behaviour, leading to more frequent, larger, and hotter wildfires, as well as extended periods of high fire danger. Rising global temperatures, especially in woodlands and forests, dry out vegetation, increasing its flammability, while altered rainfall patterns—triggering heavier rains and droughts—fuel vegetation growth and subsequent fire spread.

Projected Changes in Fire Threat (2041–2060)

The Fire Weather Index (FWI) is a widely used metric for assessing wildfire potential based on atmospheric conditions. It combines key variables such as temperature, relative humidity, wind speed, and precipitation to estimate how conducive the environment is to ignition and fire spread. Higher FWI values indicate drier fuels, stronger winds, and lower humidity—conditions that significantly increase wildfire risk. An FWI greater than 50 is generally considered a threshold for elevated fire danger, where fires can ignite easily and spread rapidly if fuel is available. For the purposes of defining exposure to fire risk, an area having a FWI of greater than 50 for between 50 and 100 days is classed as having a moderate fire risk, and areas exceeding 100 days are indicated as having a high fire risk.

As shown in Figure 22, wildfire exposure during the reference period was highest in the central plateau, including Dodoma, Singida, and Tabora, where large areas recorded more than 100 fire-risk days annually. Surrounding zones in Mbeya and parts of Rukwa exhibited moderate exposure (50–100 days), while coastal and northern regions, including Dar es Salaam, Arusha, and Mwanza, remained in the low-risk category (<50 days). These patterns reflect the combination of seasonal dryness, vegetation type, and fuel accumulation in semi-arid and transitional zones.

Under RCP4.5, wildfire risk intensifies across much of Tanzania (Figure 23). The central plateau remains the core high-risk zone, but exposure expands southward into Mbeya and Njombe, and westward toward Katavi and Rukwa. The number of high-risk days in these areas is projected to increase by 15–28 days annually (Figure 24), with localized hotspots in the southwest and western rift zone showing the largest gains. Coastal regions and northern highlands remain relatively low-risk but still experience slight increases in fire-prone days.

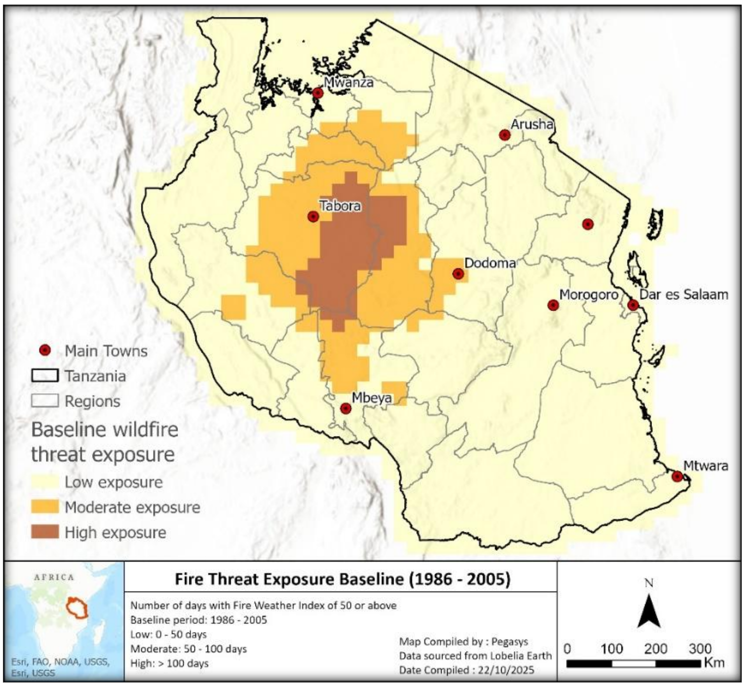


Figure 22: Baseline distribution of exposure to the threat of wildfires

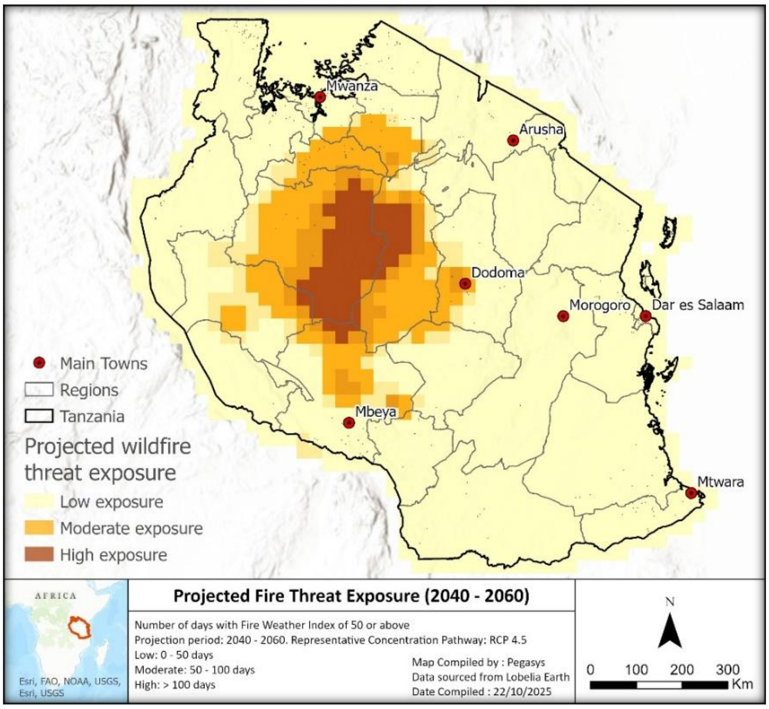


Figure 23: Projected medium term (2040 – 2060) distribution of exposure to the threat of wildfires

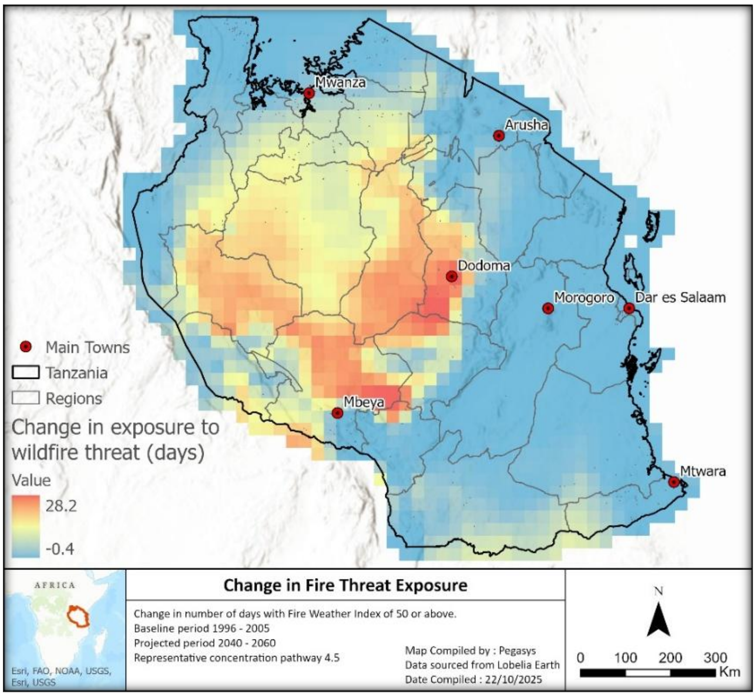


Figure 24: Projected change in the distribution of exposure to the threat of wildfires

Climate hazard summary

A summary of the climate hazard assessment for Tanzania is provided as follows.

Key findings:

Extreme Heat. Extreme heat will become a widespread challenge across Tanzania. While the central plateau (Dodoma, Singida, Tabora) and coastal lowlands will remain among the hottest areas, exposure will expand into regions historically less affected, including parts of the southwestern highlands – which will experience maximum temperatures around 34–36°C, with localized extremes reaching 39°C in low-lying areas. Days above 35°C could reach 46 under RCP4.5 notably near Iringa and Dodoma. Rising temperatures will significantly increase heat stress for agriculture, livestock, and human health, even in elevated zones such as Arusha and Mbeya, which will lose much of their natural thermal protection.

Drought. Drought risk in Tanzania is projected to intensify moderately by mid-century. Annual rainfall totals are expected to remain broadly stable or even increase slightly, but higher evapotranspiration driven by rising temperatures will reduce water availability. The western rift zone (Katavi, Kigoma) and southern highlands (Njombe, Mbeya) emerge as future drought hotspots, with SPEI values dropping below –1.2, while the central plateau remains persistently vulnerable. Even wetter regions such as Kagera and coastal areas will experience growing water stress, underscoring the need for adaptive water management.

Extreme Wind. Extreme wind speeds are projected to increase modestly, with the strongest relative rises in highland and escarpment zones such as Manyara, Mbeya, Njombe, and Iringa (with exposure rising by up to 20%) and in coastal and island regions (Pemba, Unguja, Mafia – with projected increases of 11–14%). Localized gusts during 25-year return period events may exceed 20–23 m/s in exposed areas. While absolute increases are small, these changes heighten risks for energy transmission lines, transport corridors, and roofing systems, particularly in mountainous and coastal zones.

Sea Level Rise. Sea levels along Tanzania's coast are projected to rise significantly under the RCP6.0 scenario: 11 cm by 2030, 21 cm by 2050, and 41 cm by 2080 compared to 2000 levels. While these increments appear modest, their combined effect with storm surges and saline intrusion poses serious threats to freshwater reserves, coastal biodiversity, and water quality for domestic use. Low-lying areas—particularly estuary edges and flat coastal zones—are most vulnerable, impacting livelihoods such as salt farming and aquaculture.

Extreme Rainfall. Projections for 2040–2060 under RCP4.5 indicate a widespread increase in extreme precipitation across Tanzania, with the most significant changes in the southern highlands and coastal corridor. High-exposure zones will expand inland, and areas such as the Mbeya–Ruvuma belt are expected to experience daily extremes above 50 mm, while Dar es Salaam and Mtwara remain highly exposed. Southern and coastal regions could see increases of up to 30%, and northern highlands gains of 10–20%. Even modest increases in extreme rainfall pose substantial risks for IEM systems, particularly where drainage systems are limited or assets are already near design thresholds..

River Flooding. Under RCP4.5 for 2040–2060, projections from the WRI Aqueduct Floods dataset indicate that flood extents will increase across nearly all major basins. The Rufiji River system, which supports hydropower and agriculture, is particularly vulnerable, along with urban floodplains in Dar es Salaam. Expanding flood zones represent systemic risks to transport networks, energy infrastructure, and settlements, with cascading impacts on economic activity and service delivery.

Fire. Projections for RCP4.5 indicate that the number of days with severe fire threat (FWI > 50) will increase across Tanzania by up to 28 days annually, with the most significant rises in the central plateau (Dodoma, Singida - where large areas recorded more than 100 fire-risk days annually) and southwestern highlands (Mbeya, Njombe). These areas already experience seasonal dryness, and fuel accumulation could lead to high-intensity wildfires, posing risks to electricity transmission lines, telecom towers, and rural infrastructure. Coastal and northern regions remain lower risk but will also see slight increases.

SECTOR SENSITIVITY ANALYSIS

Understanding the risks posed by climate change to Tanzania's IEM sectors requires a detailed examination of the systems that underpin these domains. Each sector comprises a network of interrelated systems, which can be further disaggregated into sub-systems and ultimately into nodes (i.e., distinct units that vary in their sensitivity to specific climate hazards). Nodes may take the form of tangible assets, such as physical infrastructure or equipment. These can be individual installations (e.g., the Kidatu Hydropower Station), or classes of infrastructure (e.g., transmission powerlines). Alternatively, nodes may represent intangible elements such as institutions, operational processes, or human actors. This granularity is essential for identifying where vulnerabilities lie and how climate stressors may propagate through sectoral systems.

As outlined in our methodology, to capture the complexity and interdependence of climate risk across the IEM sectors, the Climate Risk and Vulnerability Assessment (CRVA) adopts a hierarchical framework that evaluates sensitivity at three interconnected levels:

- Sectors – The overarching economic and service domains under consideration linked to IEM.
- Systems – Core operational components within each sector, such as power generation facilities, transport networks, and water supply systems.
- Nodes – Specific assets, institutions, or operational points within each system, including reservoirs, substations, road surfaces, data centres, and regulatory bodies.

The following chapter presents a structured overview of the IEM sectors in Tanzania, detailing the systems and nodes that form the basis of the sensitivity analysis. By mapping these components within the national context, the assessment aims to identify critical exposure points and inform targeted adaptation strategies.

Infrastructure

The infrastructure sector in Tanzania encompasses a diverse array of systems that are foundational to economic development and public service delivery. For the purposes of this CRVA, the analysis focuses on five key sub-sectors, including transport (roads, rail and ports), affordable and social housing, water and wastewater systems, solid waste management, and ICT/telecommunications. Each of these systems comprises critical nodes that vary in their sensitivity to climate-related hazards. The following sections present a structured assessment of these sub-sectors, examining their constituent systems and nodes in relation to projected climate risks.

Transport

Transport infrastructure is a cornerstone of Tanzania's connectivity and trade, particularly given its strategic position as a coastal gateway for East and Central Africa. Within this sector, road, rail and port systems have been identified as the most critical sub-systems due to their role in facilitating domestic mobility of people, goods, and services and regional integration.

Roads

Tanzania's road network is extensive compared to many neighbouring countries, with strategic connectivity provided by trunk roads (approximately 8 200 km) and regional roads (approximately 40 000 km), which link Tanzanian urban centres to each other and to key border crossings with Kenya, Uganda, Rwanda, Burundi, Zambia, and Mozambique. These corridors also connect the coast to economically vital inland regions such as Dodoma, Mwanza, and Arusha, as well as to the Central Corridor serving landlocked countries (see Figure 25). Secondary and tertiary roads extend this network, providing local access and supporting rural mobility. A significant proportion of these secondary and tertiary roads remain unpaved, which increases vulnerability to climate hazards.

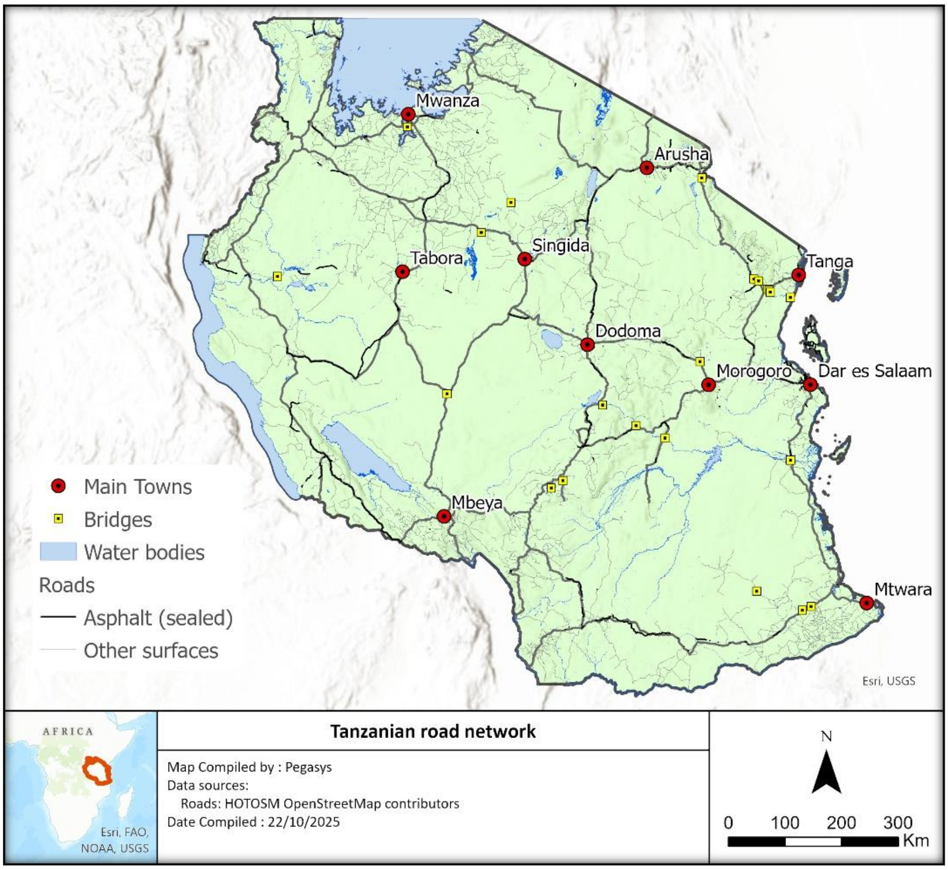


Figure 25: Tanzania road network (HOTOSM data 2025) and important bridges

Key nodes in the road transport sub-system

The road transport sub-system in Tanzania comprises a range of nodes that determine its resilience to climate hazards. These include different road types, including paved asphalt roads, engineered gravel roads, and non-engineered earth tracks, each with distinct vulnerabilities. Paved roads generally offer higher durability but can suffer from heat-induced rutting and structural damage during flooding. Gravel roads are prone to erosion and loss of bearing capacity under heavy rainfall, while earth tracks often become impassable during wet seasons, isolating rural communities and disrupting local economies.

Beyond road surfaces, critical infrastructure components such as bridges, culverts, pavements, and stormwater drains play a vital role in maintaining connectivity. Bridges are highly exposed to scour and overtopping during floods, while culverts can fail or overflow when blocked by debris, leading to upstream flooding and road collapse. Pavements and shoulders deteriorate under prolonged saturation, and stormwater systems often struggle with overflow during extreme rainfall events. River crossings, accommodated through bridges and ferries along major rivers such as the Rufiji, Pangani, and Malagarasi, are critical nodes, particularly in coastal and riverine areas prone to flooding and storm surges. Strategic structures like the Kigamboni Bridge in Dar es Salaam and the Dr John Magufuli Bridge across the Mwanza Gulf on Lake Victoria are essential for national and regional trade.

Key sensitivities to climate-related hazards

Road infrastructure in Tanzania is exposed to a range of climate hazards, with sensitivity varying by node type and engineering quality:

- Heavy rainfall and flooding: All road types are vulnerable, with impacts ranging from surface erosion and pothole formation to complete structural failure. Bridges are particularly at risk during high-flow (flood) events.
- Landslides: Triggered by intense rainfall, landslides can obstruct or destroy road segments, especially in hilly terrain.
- Stormwater infrastructure: Drains and culverts are susceptible to blockage and overflow, exacerbating flood impacts on adjacent roads.

A summary of road related nodes and the hazards and sensitivities associated with these hazards are provided in Table 2.

Table 2: Node-specific hazard sensitivity for Road Systems

Node	Hazard	Sensitivity
Asphalted roads	Extreme temperatures	Extreme temperatures can cause asphalt to soften, and under pressure from vehicle traffic (heavily loaded trucks in particular) cause the road surface to crack, allowing water to penetrate and weaken the base layers ultimately forming potholes.
	Prolonged periods of heavy rainfall	Prolonged periods of heavy rainfall can result in the development of potholes as rainwater penetrates cracks, weakens the structure below the road surface, and, combined with traffic stress, leads to surface collapse and pothole development. Prolonged periods of heavy rainfall can also result in the erosion of soil and gravel on the edges of roads, ultimately undermining the road structure and leading to the road edge crumbling.
	Riverine (Fluvial) Flooding	Riverine flooding can submerge road sections, soften or wash away sub-base layers, and undermine embankments. Fast-moving water and debris can erode road foundations, cause pavement uplift or collapse, and result in full washouts, particularly where roads run parallel to rivers or cross floodplains.
	Droughts	Prolonged periods of drought can result in the drying out of soils and shrinkage of clay sub-soils. This sub-surface movement can result in the cracking of road surfaces which over time will allow water to penetrate the road surface and potholes to develop.
	Landslides	Landslides can bury road sections, displace pavement layers, or destabilize underlying soils. In steep or saturated terrain, slope failures may sever road connectivity entirely and require major reconstruction rather than routine maintenance.
Unsealed roads	Prolonged periods of heavy rainfall	Depending on the surface material applied and on the nature of the material making up the road, prolonged periods of heavy rain combined with mechanical disturbance by vehicles may result in the road turning to mud and becoming unpassable.
	Riverine (Fluvial) Flooding	Riverine flooding can submerge road sections, soften or wash away sub-base layers, and undermine embankments. Fast-moving water and debris can erode road foundations, and result in full washouts, particularly where roads run parallel to rivers or cross floodplains.

Node	Hazard	Sensitivity
	Landslides	Landslides can bury road sections, displace unsealed surface layers, or destabilize underlying soils. In steep or saturated terrain, slope failures may sever road connectivity entirely and require major reconstruction rather than routine maintenance.
Bridges	Extreme temperatures	Extreme heat can also cause bridges to expand, placing stress on the joints and potentially leading to structural damage.
	Riverine (Fluvial) Flooding	Riverine flooding can significantly compromise bridge safety and functionality by increasing scour around piers and abutments, weakening foundations, and exerting high hydraulic and debris-impact forces on structural elements. Prolonged high flows or overtopping can undermine embankments, damage approach roads, and in severe cases lead to partial or complete structural failure.
	Extreme winds	Depending on the size and structure of the bridge, extreme winds can pose a major threat to bridges, through aerodynamic forces that can induce vibrations, swaying, twisting, and oscillations in the structure. These effects can compromise the stability and structural integrity of a bridge.

Rail

Tanzania's railway system spans a total of 3,676 km and is divided between two main operators. Rail Asset Holding Company (RAHCO) owns 2,701 km, which Tanzania Railways Limited (TRL) operates, while the Tanzania-Zambia Railway Authority (TAZARA), jointly owned by Tanzania and Zambia, operates the remaining 975 km inside Tanzania. TAZARA's full network extends 1,860 km, connecting Dar es Salaam to New Kapiri Mposhi in Zambia.

RAHCO's network uses a meter gauge (1,000 mm) and consists mainly of two main lines: the Central Line (Dar es Salaam to Tabora to Kigoma) and the Tanga Line (from Tanga to Moshi and Arusha). These are linked by a connector line between Ruvu Junction and Mnyuzi Junction. Additionally, RAHCO maintains four branch lines, including Kilosa-Kidatu and Manyoni-Singida. The RAHCO rail system can carry up to 5 million tons of freight annually.

TAZARA uses a broader gauge (1,067 mm) compatible with Central and Southern African rail networks and is designed to carry 5 million tons of freight yearly, split evenly between both directions, along with 3 million passengers. The two systems serve 14 of Tanzania's 22 mainland regions, playing a critical role in freight and passenger transport across Tanzania and into Zambia.

Operationally, the railway system faces challenges such as aging infrastructure and service disruptions but remains a vital corridor for agricultural exports, minerals, and passenger movement. Investments and rehabilitation efforts have aimed at improving track conditions, expanding capacity, and enhancing reliability to support Tanzania’s economic growth and regional integration.

Importantly, an electric high-speed Standard Gauge Railway (SGR) with passenger and cargo services was officially inaugurated on June 14, 2024. This line connects Dar es Salaam, the commercial hub, to Dodoma, the capital. This 440- to 541-kilometer line features electric trains operating at high speeds and is part of a larger initiative to modernize and expand the railway network in Tanzania.

Key nodes in the railway transport sub-system

Key nodes in the rail transport system include railway lines, bridges, signalling and control equipment, rolling stock, shunting yards, depots, and stations. In electrified contexts, overhead line equipment would also be relevant.

Key sensitivities to climate-related hazards

The above mentioned nodes (components) are variably sensitive to climate-related hazards, with flooding and landslides posing the most significant threats. Infrastructure located in flood-prone areas is particularly vulnerable to inundation, which can damage or destroy tracks, signalling systems, and rolling stock. The severity of impact depends on the specific node and its design characteristics, but in extreme cases, flooding can lead to complete infrastructure failure. Similarly, landslides triggered by heavy rainfall can obstruct or demolish rail lines, resulting in costly repairs and prolonged service disruptions. These risks underscore the importance of spatial hazard mapping and node-specific vulnerability assessments. A summary of rail-related nodes and their associated hazard is provided in Table 3.

Table 3: Node-specific hazard sensitivity for Railway Systems

Node	Hazard	Sensitivity Description
Railway lines	Extreme temperatures	Steel rails expand and contract with temperature fluctuations. Fishplate joints allow limited movement, but excessive heat increases compression forces, risking joint failure. High temperatures also weaken fastening systems.
	Flooding	Flooding can erode ballast and subgrade materials, destabilize track alignment, and corrode metal components. Severe inundation may wash away sections of track and compromise long-term structural integrity.
	Landslides	Landslides triggered by heavy rainfall can obstruct or destroy rail lines, damage embankments, and disrupt drainage systems, leading to service interruptions and costly repairs.
Signalling and controls	Prolonged heavy rainfall	Water ingress can interfere with electrical systems, causing signal failures, short circuits, and compromised safety protocols. Vulnerability increases in poorly sealed or low-lying installations.
	Flooding	Submersion of control cabinets and relay boxes can lead to electrical failure and data loss. Recovery may require full replacement of affected components.
	Landslides	Landslides can sever cable connections, damage control infrastructure, and isolate signalling nodes from the network.
Bridges	Extreme temperatures	Thermal expansion stresses joints and bearings. Chronic exposure can lead to fatigue in metal components, increasing the risk of structural failure.
	Extreme winds	Aerodynamic forces can induce oscillations, swaying, and torsion. These effects may compromise bridge stability, especially in long-span or elevated structures.
	Flooding	High river levels and flash floods can scour foundations, weaken piers, and dislodge structural elements. Debris carried by floodwaters may impact and damage bridge superstructures.
	Landslides	Landslides near bridge abutments or access roads can undermine foundations, block approaches, and destabilize surrounding terrain.
Shunting yards	Extreme temperatures	High heat affects mechanical operations, including track switches and coupling systems. Prolonged exposure may degrade materials and reduce operational reliability.
	Flooding	Yard tracks and equipment can be submerged, leading to corrosion, electrical faults, and operational delays. Waterlogged ground may impair traction and movement.

Node	Hazard	Sensitivity Description
	Landslides	Yards located near unstable slopes may be affected by debris flow, obstructing operations and damaging rolling stock or infrastructure.
Overhead Line Equipment (OLE)	Extreme Winds	Extreme winds can cause conductor oscillation, breakage, and misalignment of support structures, leading to power outages and service disruption.
	Flooding	Water ingress into substations and feeder stations can cause short circuits and prolonged outages.
	Extreme Temperatures	Heat can cause conductor sagging, reducing clearance and increasing risk of contact with vegetation or structures.

Ports

Tanzania's port infrastructure plays a critical role in regional trade and economic development, serving as a gateway for East and Central Africa. The country's major seaports include Dar es Salaam Port, the largest and busiest, handling over 90% of Tanzania's international trade; Tanga Port, which serves northern Tanzania and parts of Kenya; and Mtwara Port, strategically positioned to support southern regions and the export of minerals such as coal and natural gas. Dar es Salaam Port is undergoing significant modernization to increase its capacity beyond 30 million tons annually (Report, 2022), while Tanga and Mtwara ports are being upgraded to handle growing volumes of bulk cargo and containerized goods. Inland ports along Lake Victoria (Mwanza), Lake Tanganyika (Kigoma), and Lake Nyasa (Mbamba Bay) also provide vital connectivity for domestic and regional trade.

The port system is managed primarily by the Tanzania Ports Authority (TPA), which oversees operations, maintenance, and development. These ports are essential for the movement of agricultural products, minerals, fuel, and manufactured goods, supporting Tanzania's role as a regional logistics hub. However, the infrastructure faces challenges such as aging facilities, congestion, and exposure to climate hazards, particularly in low-lying coastal areas. Recent investments aim to improve resilience through dredging, expansion of berths, and modernization of cargo handling systems.

Key nodes in the port transport sub-system

Key nodes in Tanzania's port infrastructure encompass a range of interconnected components that ensure efficient cargo handling and vessel operations. Berths and quay walls form the structural backbone for docking and loading activities, while cargo handling equipment such as cranes, gantries, and conveyor systems enable the transfer of goods between ships and storage areas. Supporting these operations are storage facilities, including warehouses, container yards, and tank farms for bulk liquids, which are critical for managing cargo flows. Connectivity to inland destinations relies on access roads and rail links, which facilitate the movement of goods beyond the port. Safe navigation is maintained through navigation aids and signalling systems, while reliable operations depend on power supply infrastructure and overhead line equipment in electrified cargo systems. Finally, drainage and stormwater systems play a vital role in managing runoff and preventing flooding within port precincts, safeguarding both infrastructure and operational continuity..

Key sensitivities to climate-related hazards

Port infrastructure is highly sensitive to flooding, storm surges, and extreme winds, which pose the most significant threats to coastal facilities. Flooding and sea-level rise can damage quay walls, inundate storage areas, and disrupt power systems. Storm surges and high winds threaten cranes, gantries, and overhead line equipment, causing structural failures and operational delays. Extreme temperatures can affect mechanical systems and accelerate material degradation, while heavy rainfall can overwhelm drainage systems, leading to localized flooding. Inland ports face additional risks from fluctuating lake levels and landslides in surrounding terrain. These vulnerabilities underscore the need for spatial hazard mapping and node-specific adaptation measures. A summary of rail-related nodes and their associated hazard is provided in Table 4.

Table 4: Node-specific hazard sensitivity for Port Systems

Node	Hazard	Sensitivity Description
Berths and Quay Walls	Flooding	Inundation and erosion weaken structural integrity; prolonged exposure accelerates concrete and steel degradation.
	Storm Surge	High-energy waves and debris impact can damage quay walls and mooring structures.
	Extreme Winds	Wind-driven waves increase stress on berths and docking systems.
Cargo Handling Equipment	Extreme Winds	Cranes and gantries vulnerable to tipping or structural failure; wind gusts disrupt lifting operations.
	Flooding	Electrical systems in cranes and conveyors short-circuit when submerged; corrosion accelerates wear.
Storage Facilities	Flooding	Warehouses and tank farms risk inundation, damaging goods and causing chemical leaks.
	Extreme Temperatures	Heat affects stored goods and accelerates material degradation in tanks and containers.
Access Roads & Rail Links	Flooding	Washouts and erosion disrupt cargo movement; prolonged saturation weakens pavement.
	Landslides	Slopes near port access routes may collapse, blocking transport corridors.
Navigation Aids & Signals	Heavy Rainfall	Water ingress damages electronics; visibility issues compromise navigation safety.
	Extreme Winds	Wind displaces buoys and damages signal towers.
Overhead Line Equipment	Extreme Winds	High winds cause conductor oscillation and breakage, disrupting power supply to cranes.
	Flooding	Submersion of substations and feeder stations leads to outages and equipment failure.
	Extreme Temperatures	Heat causes conductor sagging, reducing clearance and increasing risk of contact with structures.
Drainage Systems	Heavy Rainfall	Overload leads to localized flooding; sediment accumulation reduces capacity.

Affordable and social housing

Access to affordable and social housing plays a critical role in improving individual and community well-being. Secure housing not only provides shelter but also supports health, hygiene, and educational outcomes by enabling access to clean water, sanitation, electricity, and protection from environmental stressors such as heat and disease vectors (World Bank, 2021). In Tanzania, the provision of affordable housing is central to inclusive development, yet it is increasingly challenged by climate-related hazards that disproportionately affect low-income and marginalized populations. Affordable and social housing developments are often situated on lower-cost land, which tends to be more exposed to environmental risks. These locations, typically in low-lying areas, floodplains, or poorly drained terrain, are particularly vulnerable to climate extremes. As climate change intensifies, the sensitivity of housing systems to hazards such as flooding, heatwaves, storms, sea-level-rise and droughts is expected to increase, compounding existing vulnerabilities and placing additional strain on infrastructure and public services.

Several climate hazards pose systemic risks to affordable and social housing, including:

- Flooding: Housing developments in flood-prone areas face high exposure to both pluvial and fluvial flooding. Flood events can damage structural components, disrupt water and sanitation services, and displace residents. Projections suggest that climate change may triple the number of homes at risk in some regions by 2050.
- Sea Level Rise: Coastal settlements and housing developments near shorelines are increasingly threatened by rising sea levels, which can lead to chronic inundation, saltwater intrusion into groundwater, and permanent loss of habitable land. Informal settlements in Dar es Salaam and Zanzibar are especially at risk.
- Extreme heat and heatwaves: Marginalized communities often experience elevated temperatures due to poor urban design, limited vegetation, inadequate insulation, and lack of cooling infrastructure. These conditions increase health risks and mortality during heatwaves.
- Storms and high winds: Increased frequency and intensity of storms can damage roofs, walls, and utility systems, leading to displacement and costly repairs that low-income households struggle to afford.
- Wildfires: In fire-prone regions, housing constructed with flammable materials such as thatch or timber is highly vulnerable. Fire events can destroy homes and pose serious safety risks.

Key nodes and sensitivities

Affordable and social housing systems consist of multiple interconnected nodes, each with distinct sensitivities to climate hazards. These nodes include raw materials, construction processes, utility services (water, sanitation, electricity), and structural components (foundations, walls, roofs). Table 5 summarizes these nodes and their associated hazard sensitivities.

Table 5: Node-specific hazard sensitivity for Affordable and Social Housing

Node	Hazard	Sensitivity Description
Raw materials	Variety	Climate hazards may disrupt supply chains, increase production costs, or reduce material availability.
Construction	Prolonged heavy rainfall	Extended rainfall can delay construction schedules, cause pluvial flooding at sites, and create unsafe or sub-optimal working conditions. Waterlogging may also damage partially completed structures and materials.
	Extreme temperatures	High temperatures reduce construction productivity due to heat stress risks for workers. Prolonged exposure may also affect curing times for concrete and compromise material performance.
Water and sanitation	Prolonged heavy rainfall	Rainfall-induced erosion can expose underground pipework, increasing the risk of mechanical damage and long-term degradation.
	Floods	Flooding can displace or rupture underground water and wastewater pipes. Severe events may destroy entire networks, leaving homes without clean water and exposing communities to raw sewage and contamination.
Electricity	Floods	Flooding can erode and expose underground electrical conduits, leading to short circuits, equipment failure, and power outages. Submerged electrical components such as circuit breakers are highly vulnerable to damage.
Structure – foundations	Prolonged heavy rainfall	Saturated soils and surface runoff can erode foundation bases, weakening structural integrity. Repeated exposure may lead to subsidence or uneven settlement.
	Floods	Fluvial flooding can wash away soil around foundations, leading to structural instability. In extreme cases, foundation failure may result in partial or total building collapse.

Node	Hazard	Sensitivity Description
Structure – roof	Extreme wind	High winds can dislodge roofing materials such as tiles or corrugated sheets. Poor construction and lightweight materials increase vulnerability. Entire roofs may be lost in severe wind events.
	Hail storms	Large hailstones can puncture or shatter roofing materials. Damage severity depends on material type, with brittle or lightweight roofs being most susceptible to complete failure.
	Fire	Roofing materials such as thatch and timber are highly flammable. Wildfires can ignite roofs directly or via embers, leading to rapid structural loss. Fire-resistant materials and design are critical for mitigation.
Structure – walls	Floods	Floodwaters can erode supporting foundations and saturate wall materials. In severe cases, hydrostatic pressure and erosion may cause wall collapse and total building failure.
	Extreme wind	Well-constructed brick and mortar walls are generally resilient, but walls built with inferior materials may suffer cracking, detachment of windows or doors, and partial collapse under high wind loads.
	Fire	Wall materials vary in fire resistance. Timber-framed structures are especially vulnerable, while masonry may resist ignition but still suffer thermal damage and loss of structural integrity.

Water and wastewater

Water and wastewater infrastructure in Tanzania plays a vital role in safeguarding public health, supporting urban development, and ensuring environmental sustainability. These systems vary significantly between urban and rural contexts, with centralized treatment facilities serving major cities and decentralized sanitation technologies more common in peri-urban and remote areas. For the purposes of this assessment, water supply services and wastewater services are considered separately, as described below.

Water supply services

Access to safe and reliable water supply in Tanzania is concentrated in major urban centers such as Dar es Salaam, Dodoma, Arusha, and Mwanza, where centralized treatment facilities operate. These plants typically employ conventional purification processes including sedimentation, filtration, and chlorination to meet potable water standards. For example, the Lower Ruvu Water Treatment Plant, which supplies Dar es Salaam, has undergone upgrades (under the Millennium Challenge Corporation) to increase capacity and improve resilience to climate variability (expanding from 180 to 270 million litres per day).

Water utilities such as the Dar es Salaam Water and Sewerage Authority (DAWASA) and regional water authorities manage extensive infrastructure networks comprising raw water intake systems, pumping stations, treatment facilities, and distribution pipelines. These systems are critical for urban water security but are increasingly exposed to climate-related hazards such as drought, flooding, and extreme temperatures, which threaten operational continuity and service deliver.

Key Nodes in the Water Supply System

Where formal water supply services exist, the system is composed of the following key nodes:

- Water source: Reservoirs, rivers, or boreholes from which raw water is extracted.
- Pumping infrastructure: Mechanical systems that convey water to treatment plants and distribution networks.
- Treatment facilities: Units for sedimentation, filtration, and disinfection (typically chlorination).
- Distribution network: Underground pipelines and storage tanks that deliver treated water to end users.

Each of these nodes is sensitive to climate hazards such as drought (affecting water availability), flooding (damaging infrastructure), and extreme temperatures (impacting mechanical and chemical processes).

Node	Hazard	Sensitivity Description
Water supply rivers	Drought	Drought can significantly reduce the water available for abstraction from rivers. It can also reduce the quality of the water as contaminants become more concentrated.
	Flood	Floods can significantly reduce the quality of water in the river and increase treatment costs.
Groundwater aquifers	Drought	Drought can result in reductions in aquifer recharge and reductions in the quantity of water available to be abstracted from boreholes.
	Intense precipitation	Intense precipitation can result in increased percolation of surface pollutants into shallow, unconfined aquifers, resulting in groundwater resources becoming contaminated and a danger to users.
	Sea-level rise	Sea-level rise can result in the ingression of saline water into shallow coastal unconfined aquifers such as the one informally supplying many residents in Dar es Salaam (untreated), reducing the quality of the water and potentially making it unusable.
Run-of-river pumps	Flood	Floods can result in significant damage to or complete destruction of pumping infrastructure. Floods can also result in debris and sediment damaging the pumps.
	Extreme temperatures	Excessive heat can cause pump motors to overheat, reducing operational efficiency and increasing failure risk.
Distribution pipe network	Prolonged heavy rainfall	Saturated soils and surface runoff can expose underground pipes through erosion, increasing vulnerability to UV degradation and mechanical damage.
	Floods	Flooding can damage or destroy pipes crossing rivers or expose and damage underground piping located close to rivers.
	Extreme temperatures	High temperatures may accelerate material degradation, particularly in plastic piping, and affect joint integrity.
Treatment facility	Floods	Floods can result in significant damage to or complete destruction of treatment infrastructure.
	Extreme temperatures	Excessive heat can cause pump motors and other electrical equipment to overheat, reducing operational efficiency and increasing failure risk. Excessive heat can also impact the purification process, with decay of chlorine and other disinfectants accelerated and losing efficiency.

Waste water services

Centralised wastewater treatment in Tanzania is similarly concentrated in urban areas, with stabilization ponds being the predominant technology. These ponds, either aerated or conventional, treat sewage biologically over extended retention periods. In Dar es Salaam, multiple wastewater treatment plants (WWTPs) operate within the city limits, including facilities at Vingunguti and Kurasini, which process millions of litres of sewage daily. In other cities such as Mwanza and Arusha, municipal sewer systems convey wastewater to large stabilization ponds located on the outskirts, supported by pump stations that manage flow volumes.

For urban households not connected to centralized sewer networks, sanitation is managed through decentralized systems such as septic tanks and pit latrines. Septic tanks are periodically emptied by vacuum trucks and transported to WWTPs where available, while pit latrines are often unmanaged for extended periods. In rural and peri-urban areas, wastewater management relies on simpler technologies including soak-away pits, on-site chlorination at boreholes, and pit latrines, which are more prevalent in low-density and informal settlements where infrastructure investment is limited.

Tanzania is actively pursuing upgrades to its wastewater infrastructure, including the development of its first modern wastewater treatment plant in Dar es Salaam. The project, located in Mbezi Beach, is being implemented by DAWASA in partnership with Metito, a global water engineering firm. It is financed by the Government of Tanzania and the World Bank and incorporates advanced technologies such as activated sludge processes, anaerobic digesters for biogas production, and Combined Heat and Power (CHP) systems to reduce energy consumption by up to 40%. The plant will treat 16,000 m³/day of wastewater, improve sludge quality, and minimize environmental pollution.

Key nodes and sensitivities

Wastewater infrastructure in Tanzania comprises distinct nodes with varying sensitivity to climate hazards. These nodes differ between urban and rural contexts, whereby in Urban centres, the nodes includes sewer networks, pump stations, stabilization ponds and in peri-urban and rural areas, nodes include septic tanks, pit latrines. Table 6 below summarizes the climate hazard sensitivities associated with each node.

Table 6: Node-specific hazard sensitivity for Water and Waste Water

Node	Hazard	Sensitivity Description
Sewer network	Prolonged heavy rainfall	Saturated soils and surface runoff can expose underground pipes through erosion, increasing vulnerability to UV degradation and mechanical damage. Infiltration may also overload the system.
	Floods	Flooding can inundate sewer lines, causing backflow, pipe displacement, and contamination of surrounding areas.
	Extreme temperatures	High temperatures may accelerate material degradation, particularly in plastic piping, and affect joint integrity.
	Landslides	Landslides can sever or crush underground sewer lines, leading to service disruption and costly repairs.
Pump stations	Floods	Fluvial flooding can submerge pump stations, damaging electrical and mechanical components. Severe events may result in total equipment loss and building damage.
	Extreme temperatures	Excessive heat can cause pump motors to overheat, reducing operational efficiency and increasing failure risk.
	Landslides	Landslides may destabilize pump station foundations or destroy above-ground infrastructure.
Stabilization ponds	Prolonged heavy rainfall	Stormwater ingress can exceed pond capacity, leading to overflow and discharge of untreated effluent.
	Floods	Floodwaters may breach pond embankments, releasing untreated sewage and damaging biological treatment processes.
	Extreme temperatures	High temperatures (>35°C) can disrupt aerobic digestion, promote algal blooms, and reduce treatment efficiency.
	Landslides	Landslides can damage pond embankments, disrupt flow channels, and compromise structural integrity.
Septic tanks	Floods	Flooding can infiltrate septic systems, causing overflow, contamination, and structural damage to tanks and soak-away pits.
	Sea-level rise	Sea-level rise is accompanied by rising groundwater levels, which can result in subterranean septic tanks becoming flooded.
	Drought	Reduced water availability may impair flushing and decomposition processes, leading to odour and hygiene issues.

Node	Hazard	Sensitivity Description
	Landslides	Ground movement can crack or displace tanks, leading to leakage and environmental contamination.
Pit latrines	Floods	Flooding can cause latrines to overflow, contaminating nearby water sources and posing serious public health risks.
	Sea-level rise	Sea-level rise is accompanied by rising groundwater levels, which can result in pit latrines becoming flooded.
	Drought	Dry conditions may reduce decomposition rates and increase odour and vector attraction.
	Landslides	Pit collapse or structural failure may occur in unstable terrain, rendering latrines unusable and hazardous.

Solid waste

Tanzania generates an estimated 12.1 to 17.4 million tonnes of municipal solid waste (MSW) annually, equivalent to 0.66 to 0.95 kilograms per capita per day ((United Republic of Tanzania – Vice Presidents Office, 2020). On average, each person produces between 241 and 347 kilograms of waste per year. The main waste sources are households (75%), followed by industries and commercial areas (20%), markets (3.5%), institutions (0.5%), and street sweeping (0.5%). Waste generation in the country is growing at about 5% annually.

The composition of MSW consists predominantly of organic material, with food waste making up 37% and garden and wood waste accounting for 30%, totaling 50-70% biodegradable content. Other components include papers (11%), plastics (7%), glass (4%), textiles (2%), ash (8%), and metals and tins (1%). Some waste fractions include e-waste, used lead-acid batteries, and waste tires. Less than half of the waste generated is collected, with around 3% disposed of by open burning, 30% buried, and 17% dumped haphazardly in the environment. Household waste storage is often inadequate, with many using containers such as salvaged drums, tins, and various types of bags. Solid waste collection in Tanzania is carried out mainly by private companies (55%), local government authorities (25%), and community-based organizations (CBO) (20%).

Key nodes and sensitivities

The solid waste management system in Tanzania comprises several critical nodes, each with distinct vulnerabilities to climate hazards. Within the collection system, key nodes include depots housing equipment and vehicles, the collection vehicles themselves, and the workers responsible for waste collection. These nodes operate under different institutional arrangements, including local government authorities, private companies, and community-based organizations (CBOs). Once collected, waste is transported either to an engineered landfill facility, which are limited and primarily located in major urban centres such as Dar es Salaam and Arusha, or to un-engineered open dump sites, which remain common in peri-urban and rural areas.

At engineered landfill facilities, critical nodes include the landfill liner system, which prevents leachate contamination; the waste body; machinery used for waste distribution and compaction; stormwater drainage systems; and leachate and methane monitoring and management systems. These components are highly sensitive to hazards such as extreme rainfall, flooding, heat stress, and fire, which can compromise structural integrity and environmental safety. In contrast, open dump sites have fewer nodes, however, these nodes include the waste body itself and, in some cases, basic machinery for spreading waste. These sites are particularly vulnerable to flooding, wind dispersal of waste, spontaneous combustion during heatwaves, and contamination of surrounding soil and water resources.

The sensitivities associated with these nodes are summarized in Table 7, Table 8 and Table 9, which detail how climate hazards such as extreme precipitation, flooding, heatwaves, fire, and high winds impact operational continuity, environmental safety, and public health.

Table 7: Node-specific climate hazard sensitivity for Solid Waste Collection

Node	Hazard	Sensitivity
Collection Vehicles	Heavy rainfall, resulting in pluvial flooding,	Extreme precipitation results in the reduced mobility of vehicles as roads around depots, dumps and in collection areas become impassable, resulting in delays in collection. Extreme rainfall also means that vehicles experience greater wear and tear and mechanical breakdowns, particularly if rainfall is accompanied by hail.
	Extreme heat	Extreme heat may potentially result in a loss of vehicle operational time due to older vehicles overheating.
Labour	Extreme heat	Heat stress can result in reduced productivity and higher rates of absenteeism. Increased temperatures can also result in increases in diseases as warmer conditions favour the life cycles of flies and other vectors.
	Extreme precipitation	Labour productivity is reduced as working conditions deteriorate. Extreme precipitation and pluvial flooding makes working conditions unsafe.
Depots	Extreme precipitation	The most important sensitivity of depots to extreme rainfall is that the roads and outdoor working areas become un-usable. This reduces productivity and increases maintenance costs.

Table 8: Node-specific climate hazard sensitivity for solid waste management at improved landfill facilities

Node	Hazard	Sensitivity
Landfill liner	Extreme heat	Heat accelerates liner degradation, reducing containment effectiveness.
	Extreme precipitation	Saturation and erosion compromise liner integrity, increasing leachate leakage risk.
Landfill compactors	Extreme heat	Overheating reduces operational efficiency and lifespan of machinery and vehicles.
	Extreme precipitation	Machinery can become immobilized by waterlogged terrain resulting in significant loss of productive time.
	Fire	Equipment damage during landfill fires.
Waste body	Extreme heat	Increased risk of spontaneous combustion during prolonged dry spells.
	Floods	Waste saturation leads to leachate overflow and contamination.
	Wind	Dispersal of lightweight waste (plastics, paper) into surrounding areas.
	Fire	Combustible waste accelerates fire spread, difficult to control.
Landfill stormwater systems	Floods and Extreme precipitation	Overload leads to flooding and erosion of landfill slopes.
Leachate management	Extreme heat	Evaporation alters chemical balance, reducing treatment efficiency.
	Extreme precipitation	Increased leachate volume overwhelms treatment systems.
	Fire	Damage to monitoring equipment and pipes.

Node	Hazard	Sensitivity
	Floods	Submersion of pumps and tanks disrupts leachate control.

Table 9: Node-specific climate hazard sensitivity for Solid Waste management at open dump sites.

Node	Hazard	Sensitivity
Open Dump sites	Extreme precipitation	Extreme precipitation at dump sites can result in loss of operational time as roads become impassable and the ground and the dump become saturated. Extreme precipitation will also result in increased leaching of pollutants from the dump, threatening ground and surface water resources
	Extreme temperatures	Chronic exposure to high temperatures, especially if accompanied by extended dry conditions can result in increased risk of spontaneous combustion of waste by enabling preheating of waste materials, which can accelerate self-heating to ignition temperatures.
	Flooding	Large-scale river flooding can inflict significant damage to dump sites and can result in the transportation of waste material away from the dump and into the surrounding environment. Flooding can also result in damage to infrastructure such as weigh-bridges.
	Fire	Dump sites are sensitive to wildfires since a large proportion of solid waste is combustible. Once a solid waste dump has ignited, it is very difficult to control.
	Extreme wind	High wind speeds can result in the transportation of solid waste like plastic, paper, cardboard etc. as well as dust and other particulate pollution from the dump to surrounding areas. This will incur additional costs if waste is to be retrieved and the area cleaned.

ICT Telecoms

Tanzania's Information and Communication Technology (ICT) infrastructure is a cornerstone of national development and regional connectivity, supporting digital services, e-government, financial inclusion, and trade. The system comprises mobile networks, core networks, and transmission and backhaul systems, forming an integrated web of physical and digital assets. The National ICT Broadband Backbone (NICTBB) spans approximately 7,910 km of fiber-optic cable, connecting all regions and providing cross-border links to Kenya, Uganda, Rwanda, Burundi, Malawi, and Zambia, with planned extensions to the Democratic Republic of Congo (DRC). International connectivity is enabled through submarine cable landing stations in Dar es Salaam, linking Tanzania to global networks via SEACOM, EASSy, and soon 2Africa. These assets position Tanzania as a strategic hub for East and Southern Africa's digital economy.

The ICT system is managed primarily by Tanzania Telecommunications Corporation (TTCL), alongside private operators such as Vodacom, Airtel, Tigo, and Halotel. Mobile networks provide essential voice, data, and mobile money services, supported by thousands of cell sites nationwide. Core networks include data centres and Network Operation Centres (NOCs) operated by TTCL and private firms, with the National Data Centre in Dar es Salaam serving as the backbone for e-government and cloud services. Transmission and backhaul systems consist of terrestrial fiber routes and microwave links, complemented by international submarine cables. These components are critical for economic growth but face increasing exposure to climate hazards, particularly in coastal and flood-prone areas.

Key Nodes in ICT Infrastructure

Key nodes in Tanzania's ICT system include:

- Mobile Networks: Cell towers, base stations, and hybrid power systems (grid, diesel, solar).
- Core Networks: Data centers and Network Operation Centers (NOCs) supporting government platforms, banking systems, and cloud services.
- Transmission and Backhaul Systems: Terrestrial fiber-optic routes, microwave links, and submarine cable landing stations providing international bandwidth.

Key Sensitivities to Climate Hazards

ICT infrastructure in Tanzania is highly sensitive to extreme heat, flooding, intense rainfall, storms, and sea-level rise, which pose significant risks to operational continuity. Extreme heat reduces cooling efficiency in data centres, shortens battery life, and stresses electronic components. Flooding and heavy rainfall can inundate cell sites, damage underground fiber conduits, and disrupt access roads, while extreme winds and storms threaten tower stability and antennas. Drought impacts hydropower generation, destabilizing grid supply and increasing reliance on diesel or solar backups. Coastal landing stations and data centres in Dar es Salaam face additional risks from sea-level rise and saltwater intrusion, which can damage critical equipment and disrupt international connectivity. These vulnerabilities underscore the need for spatial hazard mapping and node-specific adaptation measures. Table 10 below summarizes the climate hazard sensitivities associated with each node.

Table 10: Node-specific climate hazard sensitivity for ICT

Node	Hazard	Sensitivity Description
Mobile Networks	Extreme Heat	Reduces cooling efficiency, shortens battery and antenna lifespan, and increases maintenance costs.
	Flooding & Heavy Rain	Inundation damages ground equipment; poor drainage disrupts access and power supply.
	Extreme Winds	Storms can damage antennas, increase tower collapse risk, and cause power surges.
	Drought	Hydropower variability destabilizes grid supply, increasing reliance on diesel/solar backups.
Core Networks (Data Centres)	Extreme Heat	Elevates HVAC demand by 15–25%, stressing cooling systems and increasing energy costs.
	Flooding & Heavy Rain	Risk of site inundation and equipment damage; access disruption during storms.
	Sea-Level Rise	Coastal facilities face chronic inundation and saltwater intrusion.
Transmission & Backhaul	Flooding & Riverine Floods	Erodes or exposes buried fiber conduits; damages river crossings.
	Extreme Rainfall	Triggers slope failures along fiber corridors, especially in highland routes.
	Drought	Ground shrinkage stresses buried cables; power instability disrupts optical amplifiers.
Submarine Cable Landing Stations	Sea-Level Rise	Chronic inundation and corrosion threaten international connectivity.
	Storm Surge	High-energy waves and debris impact damage landing infrastructure.

Energy

Tanzania's energy sector is undergoing rapid transformation to meet growing demand driven by population growth and industrialization. Despite progress, electricity consumption remains among the lowest globally. In 2022, the World Bank estimated Tanzania's annual electricity consumption at 123 kWh per capita, compared to a global average of over 3,000 kWh (WorldBank, 2022). Access to electricity is still limited, with 45% of the population connected to the grid, and significant disparities between urban areas (74–82%) and rural areas (36%). The government aims to achieve 75% electrification by 2030, supported by large-scale infrastructure projects and rural electrification programs such as the Tanzania Rural Electrification Expansion Programme (TREEP), financed by the World Bank and other partners.

Energy consumption by sector is dominated by households, which account for over 70% of total energy use, primarily through traditional biomass (firewood and charcoal). Industry represents 16.4%, transport 12.2%, and agriculture 4.4%, while commercial and public services account for about 2%. This heavy reliance on biomass—over 77% of total energy supply—poses environmental and health challenges, including deforestation and indoor air pollution (NBS, 2022).

For analytical clarity, Tanzania's energy sector can be divided into two components:

- Generation – Facilities producing electricity from hydropower, natural gas, solar, wind, and other sources.
- Transmission and Distribution – Networks delivering electricity to end-users, including substations, transmission lines, and distribution systems.

This separation reflects differing infrastructure elements and vulnerability profiles. Generation facilities face hazards related to resource availability (e.g., river flows for hydropower) and technology type, while transmission and distribution networks are exposed to geographically dispersed risks such as extreme weather, flooding, and mechanical failure. Assessing these subsystems independently enables targeted climate resilience strategies.

Generation Capacity and Mix

Tanzania's installed generation capacity has expanded significantly, with the government reportedly (i.e. in 2023) targeting 5,000 MW by 2025 (TanzaniaInvest, 2023). As presented in Table 11 the generation mix is dominated by hydropower (65.3%) and natural gas (29.3%), with smaller contributions from heavy fuel oil (2%), biomass (2.1%), and emerging solar and wind projects (1.2%). The commissioning of the Julius Nyerere Hydropower Project (JNHPP) in 2025 added 2,115 MW, making it one of the largest hydropower facilities in Africa and doubling Tanzania's generation capacity. Other major hydropower plants include Kidatu (204 MW), Lower Kihansi (180 MW), Mtera (80 MW), and New Pangani Falls (68 MW), as presented in

Table 12 and Figure 26. Hydropower remains the backbone of Tanzania's renewable energy strategy, though it is highly sensitive to climate variability.

Table 11: Summary of Generating Technologies in Tanzania's National Grid

Generation Type	Installed Capacity (MW)	% of Total
Hydropower	2,676	65.3
Natural Gas	1,200	29.3
Heavy Fuel Oil (HFO)	80	2.0
Diesel	4	0.1
Biomass & Cogeneration	88	2.1
Solar and Wind	50	1.2
Total	4,098	100

Table 12: Summary of Hydropower Generation in Tanzania

Name	Installed Capacity	Catchment
Julius Nyerere Hydropower Project	2115 MW	Rufiji
Kidatu Hydropower Plant	204 MW	Rufiji
Lower Kihansi Hydropower Plant	180 MW	Rujiji
Mtera Hydropower Plant	80 MW	Rufiji
New Pangani Falls Hydropower Plant	68 MW	Pangani
Rusumo Hydroelectric Power Station	27 MW	Kagera / Congo
Hale Hydropower Plant	21 MW	Pangani
Nyumba ya Mungu Hydropower Plant	8 MW	Pangani
Uwemba Hydropower Plant	0.843 MW	Rufiji

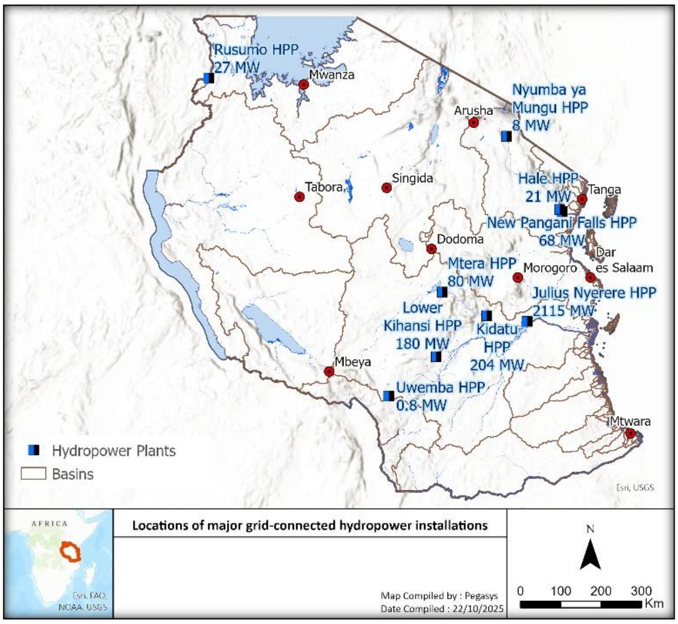


Figure 26: Locations of large grid-connected hydropower installations in Tanzania.

Key Nodes and Climate Sensitivities

Tanzania's energy generation system consists of several key infrastructure nodes pertaining to hydropower plants, natural gas stations, solar farms, and diesel generators, each with unique climate vulnerabilities. Hydropower is highly sensitive to drought, which reduces river inflows and generation capacity, and flooding, which can damage dams and spillways. Natural gas and diesel plants face risks from water scarcity affecting cooling systems and flooding that disrupts operations. Solar farms are exposed to heatwaves, which reduce efficiency, and wind or hailstorms that can damage panels. These climate sensitivities, combined with Tanzania's geographic diversity and reliance on hydropower, make resilience planning critical for energy security and economic stability. A summary of the key nodes and climate hazards that may impact on those nodes is provided in Table 13.

Table 13: Node-Specific Hazard Sensitivity for Energy Generation

Node	Hazard	Sensitivity Description
Hydropower stations	Drought	Reduced river inflows lower reservoir levels, severely limiting generation capacity and triggering load shedding.
	Floods	Excessive rainfall may cause dam overtopping or structural stress, risking equipment damage and downstream flooding.
	Sedimentation	Increased runoff during storms accelerates sediment buildup, reducing reservoir storage and turbine efficiency.
	Extreme temperatures	High temperatures increase evaporation rates, thus reducing available water and reduce cooling efficiency for auxiliary systems.
Solar PV farms	Extreme heat	Excessive heat reduces photovoltaic efficiency and accelerates panel degradation.
	Dust storms / wind erosion	Dust accumulation lowers energy output; strong winds may damage mounting structures.
	Hailstorms	Physical damage to panels and inverters can result in costly repairs and downtime.
Natural gas plants	Floods	Flooding can damage fuel storage areas, electrical systems, and access roads, disrupting operations.
	Drought	Water scarcity may impair cooling systems, reducing plant efficiency and forcing shutdowns.
	Extreme temperatures	High ambient temperatures reduce thermal efficiency and increase wear on mechanical components.
Diesel generators	Floods	Floodwaters can submerge generator units, causing electrical faults and fuel contamination.
	Heatwaves	Elevated temperatures increase risk of overheating and reduce operational lifespan.
	Fuel supply disruption	Climate-induced transport interruptions can delay fuel delivery, especially in remote areas.

Transmission and Distribution

Electricity transmission and distribution are critical components of Tanzania's power sector, enabling the delivery of electricity from generation facilities to end-users across the country. Transmission refers to the high-voltage transfer of electricity over long distances, typically from generation sites to regional substations, while distribution involves the lower-voltage delivery from substations to residential, commercial, and industrial consumers. Tanzania's transmission network operates primarily at 400 kV, 220 kV, and 66 kV, and is managed by the TANESCO. TANESCO also oversees most of the distribution infrastructure, which spans urban, peri-urban, and rural areas and operates at voltages ranging from 33 kV down to 400 V. The transmission infrastructure for Tanzania is illustrated in Figure 27.

The transmission system is interconnected with neighboring countries through the Eastern Africa Power Pool (EAPP) and Southern Africa Power Pool (SAPP), enhancing cross-border electricity trade and grid stability. Key interconnections include links to Kenya, Zambia, and Uganda, supporting regional energy security. Despite these capabilities, Tanzania's transmission and distribution networks face challenges such as aging infrastructure, limited coverage in remote areas, and vulnerability to climate hazards.

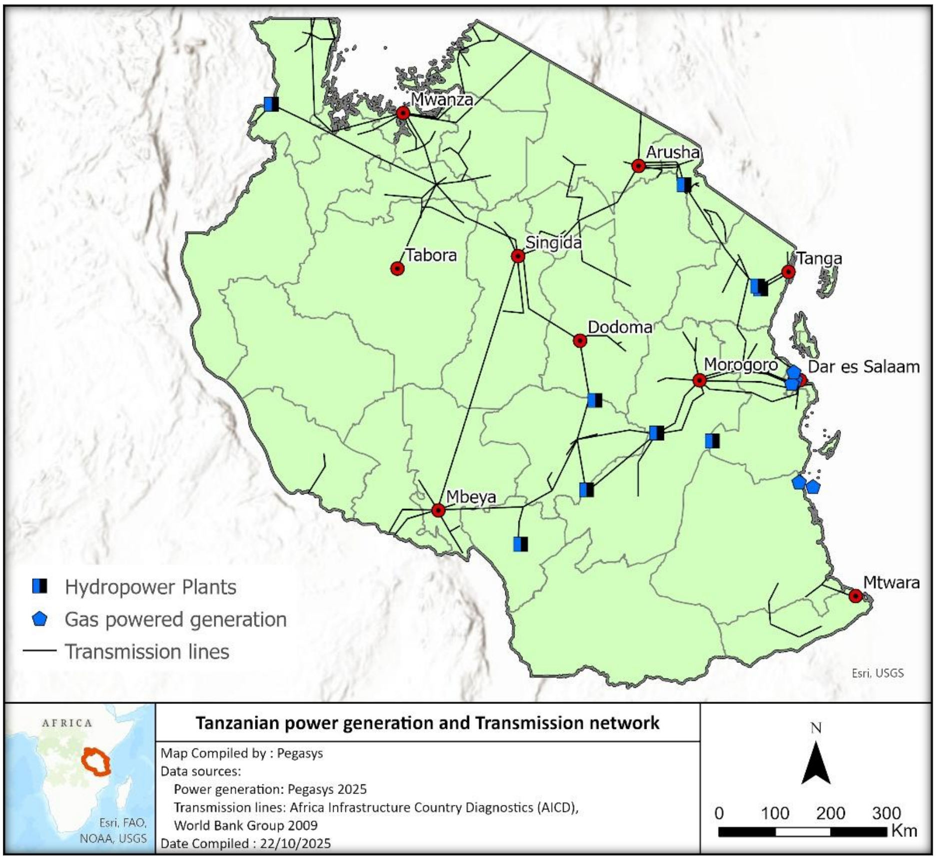


Figure 27: Power generating stations and the modelled locations of national grid power transmission lines (World Bank Group Data catalogue)

Key nodes and sensitivities

Tanzania's electricity transmission and distribution system comprises several critical infrastructure nodes, each with distinct sensitivities to climate-related hazards. These nodes include substations, high-voltage transmission lines, distribution transformers, and low-voltage networks. The vulnerability of these components varies depending on geographic location, design standards, and exposure to extreme weather events. Table 14 summarizes the climate hazard sensitivities associated with each distribution node.

Table 14: Node-specific hazard sensitivity for Energy Transmission and Distribution

Node	Hazard	Sensitivity Description
Substations	Floods	Flooding can submerge electrical equipment, causing short circuits, insulation failure, and prolonged outages.
	Extreme temperatures	High ambient temperatures may reduce cooling efficiency, leading to overheating and equipment degradation.
	Extreme precipitation as a proxy for storms / Lightning	Direct strikes or surges can damage switchgear and transformers, requiring costly repairs.
Transmission lines	High winds	Strong winds may cause line sway, conductor clashing, or pole collapse, disrupting power flow.
	Extreme precipitation as a proxy for storms / Lightning	Lightning strikes can induce voltage surges, damaging insulators and conductors.

Node	Hazard	Sensitivity Description
	Wildfires	Fires near transmission corridors can damage towers and conductors, leading to extended outages.
Distribution transformers	Floods	Water ingress can compromise insulation and cooling oil, leading to transformer failure.
	Extreme temperatures	Elevated temperatures increase thermal stress, reducing transformer lifespan and efficiency.
Low-voltage networks	Floods	Inundation of underground cables and surface-mounted components can cause corrosion and short circuits.
	Drought	Ground movement associated with desiccation of soils may sever buried cables or destabilize poles, leading to localized outages.
	Vegetation overgrowth	Increased rainfall can accelerate vegetation growth, causing contact with overhead lines and faults.

Manufacturing

Manufacturing contributes approximately 8% to Tanzania's GDP (Ministry of Industry and Trade of the United Republic of Tanzania, 2025), making it a modest but growing component of the economy. The sector is dominated by food and beverage processing, textiles and apparel, chemicals, plastics, and basic metals, with food processing accounting for the largest share due to the country's strong agricultural base. The following subsections outline the Manufacturing sector, detailing key hubs and key climate hazards that may impact the broader industry. Potential adaptation and response options presented in Section 5.

Food Processing and Beverage Manufacturing

Food and beverage manufacturing represents the largest subsector within Tanzania's manufacturing industry. This subsector plays a pivotal role in supporting food security, nutrition, and employment, making it a cornerstone of national economic resilience. Its performance is closely tied to agriculture, which employs a significant portion of the labour force. This industry relies on a diverse range of agricultural commodities. Maize is a primary annual input and is concentrated in regions such as Dodoma, Mbeya, and Rukwa. Cassava production largely limits to Coastal, Lindi, and Mtwara regions. Oilseed crops, particularly sunflower and groundnuts, are produced extensively in Singida, Dodoma, and Manyara, forming the basis for edible oil processing. Livestock products also underpin the sector, with meat and dairy processing hubs in Arusha, Dodoma, and Mwanza.

Food and beverage processing activities are concentrated in several industrial hubs. Dar es Salaam serves as the country's largest industrial centre, hosting major companies such as Bakhresa Group, Mohammed Enterprises, and Coca-Cola Kwanza, alongside new entrants like Kerry Group. Morogoro is a key agro-processing region, particularly for sugar, rice, and horticultural products, with Kilosa district emerging as a centre for spice processing. Arusha specializes in meat, dairy, and horticultural processing, serving both domestic and export markets, while Mwanza hosts beverage bottling plants and fish processing facilities, leveraging its proximity to Lake Victoria. These hubs form critical nodes in Tanzania's food value chain, each with distinct exposure to climate hazards.

Textiles and Apparel

Tanzania is among the leading cotton producers in East Africa. Cotton is a critical raw material for the domestic textile industry, supporting ginning mills and spinning factories that convert raw fiber into yarn and fabric for garment manufacturing. These intermediate products form the backbone of Tanzania's textile value chain, enabling the production of clothing for both domestic consumption and regional trade. Despite this strong agricultural base, the sector also relies on imported fabrics, primarily from Asia, to supplement local production, particularly for fashion and ready-made garments. This dual sourcing strategy reflects the growing demand for diverse textile products and the limitations of domestic capacity in meeting market needs.

Textile and garment manufacturing activities are concentrated in several key industrial hubs across Tanzania. Dar es Salaam serves as the largest centre for garment assembly and textile finishing, hosting integrated factories and export-oriented apparel producers. The city's proximity to the port facilitates access to imported fabrics and supports export competitiveness. Mwanza, located in the Lake Zone, is a major node for cotton ginning and spinning, leveraging its proximity to cotton-growing regions such as Shinyanga and Simiyu. This regional clustering reduces transport costs and strengthens linkages between agriculture and industry. Morogoro and Arusha are emerging centers for garment production and small-scale textile enterprises, serving domestic demand and niche export markets.

Chemicals and Plastics

The chemicals and plastics subsector in Tanzania plays a strategic role in supporting industrialization and agricultural productivity. It encompasses the production of industrial chemicals, fertilizers, and plastic goods for domestic consumption and regional markets. These products serve as critical inputs for sectors such as agriculture, construction, packaging, and consumer goods, making the subsector integral to Tanzania's economic development. Growth in this industry is driven by rapid urbanization, population expansion, and infrastructure. The chemicals industry in Tanzania is segmented into three main categories:

- Basic chemicals, including bulk polymers, petrochemicals, and inorganic chemicals.
- Agricultural chemicals, such as fertilizers and crop protection products.
- Specialty chemicals, including paints, coatings, adhesives, and industrial gases.

Fertilizer production has recently become a national priority. In 2025, Tanzania inaugurated the ITRACOM Fertilizer Factory in Dodoma's Nala Industrial Area, the largest in East and Central Africa. This facility aims to reduce reliance on imports, which currently account for over 90% of fertilizer demand, and strengthen food security across the region. Plastics manufacturing is concentrated in packaging, construction materials, and consumer goods. Demand is fuelled by urban growth and rising disposable incomes, although challenges such as poor recycling infrastructure and plastic waste management persist.

The chemicals and plastics manufacturing activities are concentrated in several strategic industrial hubs. Dar es Salaam serves as the largest centre for chemicals and plastics production, leveraging its proximity to the port for efficient import of raw materials and export of finished goods. The city hosts major chemical distributors and plastic manufacturers, forming the backbone of the country's petrochemical and packaging industries. Dodoma, particularly the Nala Special Economic Zone (SEZ), is emerging as a key hub for fertilizer production, which supports agricultural productivity across the central regions. Additionally, Tanga and Bagamoyo are linked to port infrastructure and industrial parks, facilitating chemical logistics and processing.

Cement and Building Materials

The cement and building materials subsector is a cornerstone of Tanzania's industrial development, supporting infrastructure expansion, housing construction, and public works. It encompasses the production of cement, concrete products, glass, ceramics, and lime, which are essential inputs for the construction industry and broader economic growth. These materials are critical for implementing large-scale infrastructure projects such as roads, bridges, and industrial facilities, making the subsector integral to Tanzania's development agenda. Growth in this industry is driven by rapid urbanization, population growth, and government investment in infrastructure. The cement and building materials industry in Tanzania is segmented into:

- Cement and clinker production, forming the backbone of construction supply chains.
- Non-metallic mineral products, including glass, ceramics, and lime for industrial and domestic applications.
- Concrete and prefabricated building components, supporting housing and commercial development.

Cement production is dominated by major players such as Twiga Cement (Heidelberg Group), Dangote Cement, and Tanga Cement. These companies operate integrated plants that produce clinker and cement for domestic markets and regional exports. Demand for cement is projected to grow steadily, driven by infrastructure projects such as the Standard Gauge Railway, port expansions, and urban housing developments.

The cement and concrete manufacturing activities are concentrated in several strategic locations that serve both domestic and regional markets. Dar es Salaam is a key hub for cement distribution and concrete product manufacturing, supplying the rapidly growing coastal construction sector. Tanga hosts one of the country's largest cement producers, Tanga Cement, strategically positioned near abundant limestone deposits and port facilities that enable efficient export and import of raw materials. Mbeya is home to large-scale cement plants that cater to southern Tanzania and neighbouring countries, supporting infrastructure development in cross-border trade corridors. Meanwhile, Mtwara is emerging as an industrial zone linked to natural gas projects and port expansion, providing a foundation for cement logistics and production in the southern coastal region. These hubs collectively form the backbone of Tanzania's construction materials industry, each benefiting from geographic advantages and access to transport infrastructure.

Key Sensitivities to Climate Hazards

Tanzania's manufacturing sector is highly sensitive to climate hazards such as drought, flooding, extreme heat, and intense rainfall, which pose significant risks to production continuity and supply chain stability. Drought reduces water availability for industrial processes and impacts hydropower generation, leading to electricity shortages that disrupt operations. Flooding and heavy rainfall can damage factory infrastructure, inundate storage areas, and block transport routes, while coastal hubs face additional risks from storm surges and sea-level rise. Extreme heat increases cooling requirements in factories, accelerates equipment wear, and reduces worker productivity, raising operational costs. These vulnerabilities are compounded by the sector's dependence on agricultural inputs, energy supply, and transport infrastructure. Table 15 below summarizes the climate hazard sensitivities associated with key manufacturing subsectors.

Table 15: Node-Specific Climate Hazard Sensitivity for Manufacturing

Subsector / Node	Hazard	Sensitivity Description
Food & Beverage Plants	Drought	Reduces water availability for cleaning and processing; impacts crop supply chains.
	Flooding	Damages storage facilities and disrupts transport of perishable goods.
	Extreme Heat	Increases spoilage risk and microbial contamination; raises cooling costs.
Textile Mills & Garment Factories	Drought	Limits water for dyeing and finishing processes.
	Flooding	Damages machinery and delays raw material transport.
	Extreme Heat	Reduces worker productivity; increases ventilation and cooling energy demand.
Chemical & Plastic Plants	Energy Disruption	Hydropower variability during drought halts production; increases reliance on diesel.
	Flooding	Risk of chemical spills contaminating waterways; damages equipment and access roads.
	Extreme Heat	Accelerates equipment wear and chemical degradation; raises maintenance costs.
Cement & Building Material Plants	Drought	Limits water for cooling and dust suppression; impacts raw material processing.
	Flooding	Damages stockpiles and transport routes; disrupts supply chains.

Subsector / Node	Hazard	Sensitivity Description
	Extreme Heat	Affects kiln performance and increases energy demand for cooling systems.

Cross-Cutting Risks

The manufacturing subsectors share several systemic vulnerabilities that amplify climate-related risks. First, energy dependency is a critical concern, as all industries rely heavily on electricity for production processes. This dependence makes them highly susceptible to hydropower variability during drought periods, which can lead to power rationing and operational disruptions. Second, transport infrastructure plays a pivotal role in supply chain continuity. Flooding and other extreme weather events frequently damage roads and rail networks, delaying the movement of raw materials and finished goods and increasing logistics costs. Finally, occupational health risks are emerging as a significant challenge. Rising temperatures contribute to heat stress among workers, reducing productivity and increasing the need for cooling systems, which in turn raises energy demand and operational expenses. These cross-cutting risks underscore the need for integrated resilience strategies across all manufacturing subsectors.

RISK PATHWAY ANALYSIS

The intersection between a system's exposure to a hazard and nodal level sensitivity to that hazard is the foundation of system level risk. Building on the critical nodes identified, this chapter examines how climate change impacts propagate across Tanzania's IEM systems. Key nodes, such as transport links, hydropower reservoirs, water treatment facilities, and urban housing, represent points of potential vulnerability. When exposed to a hazard, vulnerabilities can result in disruptions at these nodes which then often cascade through interconnected systems, with a single hazard, such as drought or extreme precipitation, simultaneously affecting energy generation, water supply, transport, and industrial operations. These cascading and cross-sectoral impacts can reduce economic output, delay infrastructure projects, and constrain essential services, highlighting the importance of system-wide risk assessment to inform investment and adaptation strategies. The following section provides a detailed analysis of these risk pathways, illustrating how climate hazard-driven risks propagate across the IEM sectors and identifying key vulnerabilities relevant for investment and adaptation planning.

As a means of concisely illustrating the distribution of sensitivity for each system (assessed in in Chapter 3), a sensitivity scoring 'heat map' is presented here for each system (see Table 16 as an example). In generating this heat map, each hazard was considered as a mild event (Mi), a moderate event (Mo) and a severe event (Se) and the sensitivity of the node to each of these categories was scored as low sensitivity (1) moderate sensitivity (2) or high sensitivity (3). Note that this scoring is not based on whether it is likely the node would be exposed to the hazard or not but asks the question "If this node were to be exposed to this hazard, how sensitive would it be?". In addition to specific hazards, a broad classification is presented of the vulnerability of the node derived from vulnerabilities cascading down from other sectors (In-Infrastructure, En-Energy, Ma-Manufacturing and Ag-Agriculture). For example, several ICT Telecom nodes are vulnerable to drought impacts on hydropower generation in the energy sector. These cross-cutting vulnerabilities and are important considerations in this risk assessment. This semi-quantitative exercise presents a visual depiction of which are the key vulnerabilities to address in the risk pathway analysis.

Infrastructure

Transport – Roads

An assessment of the sensitivities of the various nodes in the road transport infrastructure system to climate related hazards was undertaken. The results of this qualitative assessment are discussed in detail in Section 3 of this report. For the reader's convenience, a numerical representation of this assessment is given here in Table 16. The distribution of node sensitivities indicates that the most important hazards for road transport are flooding, intense precipitation, sea-level rise and extreme temperatures. Therefore, the sections that follow focus on these climate hazards.

Table 16: Road transport node sensitivities to climate related hazards

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Roads	Sealed surfaces	1	2	3	0	1	2	1	2	2	0	1	2	1	2	3	0	0	0	0	1	1	2	0	2	0
	Unsealed roads but engineered	0	1	1	0	1	1	1	3	3	1	3	3	1	2	3	0	0	0	0	0	0	1	0	0	0
	Un-engineered roads	0	1	1	0	0	0	1	2	3	1	3	3	1	2	3	0	0	0	0	0	0	0	0	0	0
	Stormwater systems	0	0	0	0	1	1	0	1	1	1	2	2	1	1	2	0	0	0	0	0	0	0	0	0	0
	Culverts	0	0	0	0	0	0	0	1	1	1	2	3	1	1	2	0	0	0	0	0	0	0	0	0	0
	Bridges	0	1	2	0	0	0	0	1	1	1	2	3	1	1	2	0	1	2	0	1	1	0	0	0	0
	Side Walk	0	1	1	0	0	0	0	1	1	1	2	3	0	1	1	0	0	0	0	0	0	0	0	0	0
	Traffic control (signage)	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	1	1	0	1	1	0	3	0	0
Number of system level "High sensitvities"		**1**			**0**			**3**			**7**			**3**			**0**			**0**			**0**	**1**	**0**	**0**

Fluvial flooding

Riverine (fluvial) flooding poses significant risks to road infrastructure, affecting not only the carriageway but also associated systems such as stormwater drainage, pavements, signage, and signalling. Although road construction practices typically aim to avoid flood-prone areas, understanding the actual risk to Tanzania's road network requires spatial analysis. To this end, the extent of Tanzania's main road network (across all surfaces) was intersected with both the baseline 1-in-50-year flood extent (water depths >0.5 m) and the projected 2040–2060 1-in-50-year flood extent (also >0.5 m). This analysis identified areas where flooding is likely to affect roads and quantified potential changes in exposure attributable to climate change (Figure 28). The corresponding numerical results are provided in Table 17.Overall, the results indicate low exposure across all classified roads, with baseline data showing just less than 530 km of surfaced roads exposed to floodwaters and just under 540 km exposed under projected future conditions.

The highest exposure occurs in the unsealed road class, which largely comprises unpaved sand or gravel surfaces. These roads are particularly susceptible to flood damage through erosion and saturation. When floodwaters infiltrate the gravel and underlying soils, their structural integrity diminishes as strength and cohesion are lost. This results in subgrade softening, instability, and reduced load-bearing capacity. Hydraulic forces can wash away binding materials, causing rutting, potholes, or even complete washouts where the surface and subgrade are eroded away. Once waterlogged, these roads become impassable due to deformation and loss of support.

It is important to note however that the national scale flood model data used, does not reflect flooding associated with smaller watercourses very well. This level of flooding is still important for unsealed road surfaces where inundation of any depth is likely to result in the road becoming waterlogged, damaged and potentially impassable for periods of time. The extent of risk to road infrastructure is thus likely under-represented in this assessment.

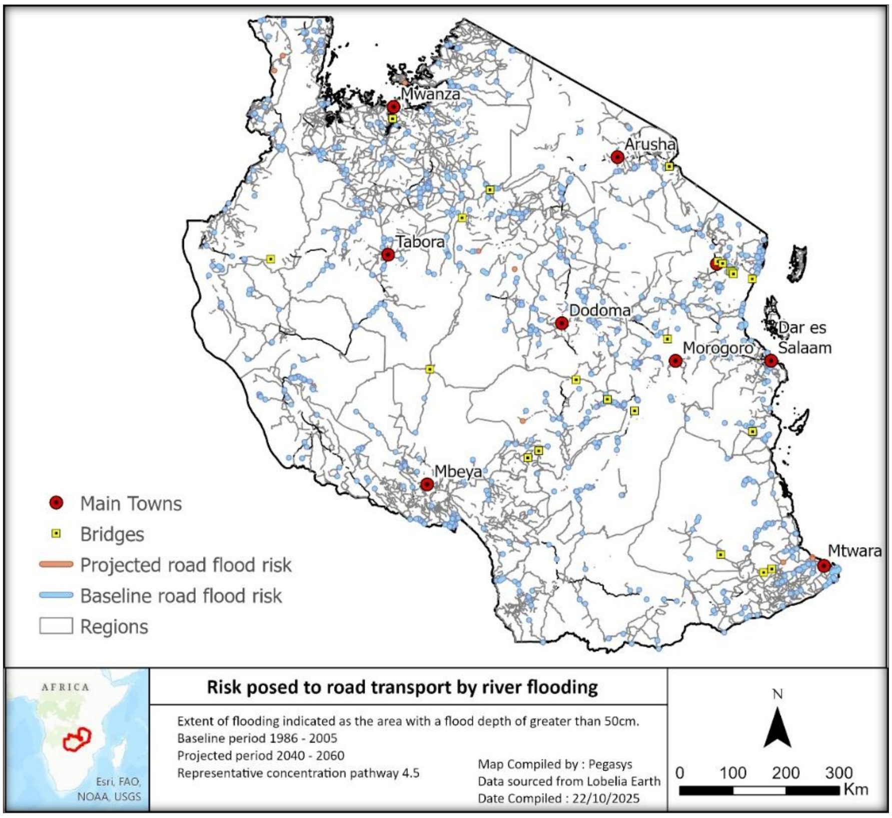


Figure 28: Distribution of road exposure to baseline and projected river flooding depths of > 0.5m in Tanzania

Table 17: Length of different road classes (km) located within the 1:50 year flood areas for the baseline and projected periods

	Asphalt (sealed)			Other surfaces		
Regions	Baseline	Projected	Change	Baseline	Projected	Change
Arusha	0.2	0.2	0.0	13.9	14.5	0.6
Dar es Salaam	0.7	0.4	-0.3	0.9	0.9	0.0
Dodoma	0.9	1.0	0.1	17.4	17.9	0.5
Geita	0.3	0.3	0.0	5.6	5.4	-0.2
Iringa	2.3	1.5	-0.8	9.4	7.0	-2.4
Kagera	0.8	0.9	0.1	7.7	9.0	1.2
Katavi	0.8	0.9	0.1	5.3	5.8	0.5
Kigoma	3.4	3.4	0.0	11.9	11.4	-0.5
Kilimanjaro			0.0	8.3	5.5	-2.8
Lindi			0.0	25.0	25.6	0.6
Manyara	4.2	6.6	2.4	29.0	32.1	3.0
Mara			0.0	12.9	13.5	0.6
Mbeya			0.0	16.6	16.1	-0.5
Morogoro	5.4	5.8	0.4	34.7	36.2	1.6
Mtwara			0.0	58.3	66.2	7.9
Mwanza	0.2	0.3	0.1	3.1	3.2	0.1
Njombe			0.0	2.8	2.9	0.1
Pwani	7.9	8.5	0.6	48.9	52.1	3.2
Rukwa	0.3	0.3	0.0	6.8	6.8	0.0
Ruvuma	0.5	0.5	0.0	9.8	9.3	-0.5
Shinyanga	0.7	0.6	0.0	33.5	31.9	-1.6
Simiyu			0.0	18.8	17.8	-0.9
Singida	0.6	0.6	0.0	22.2	21.5	-0.7
Songwe	0.2	0.2	0.0	7.8	7.7	-0.1
Tabora	3.8	3.8	0.0	34.7	34.2	-0.5
Tanga	6.1	6.0	0.0	39.2	42.7	3.4
Grand Total	39.2	41.9	2.6	484.5	497.3	12.7

Pluvial flooding (intense precipitation) risk pathways

Tanzania has one of the lowest paved-road densities in Africa, relying on few major roads (GoURT, 2013). Of all the road system nodes, pluvial flooding caused by intense precipitation will impact unsealed (gravel) roads most significantly. This will happen primarily through erosion, rutting, and subgrade weakening. When heavy rainfall falls on gravel surfaces, water infiltrates the gravel and underlying subgrade, softening the soil and reducing its load-bearing capacity. This often leads to the formation of ruts and potholes as vehicles deform the softened surface. Runoff from precipitation can wash away the gravel, causing loss of the protective gravel layer and exposing unstable subsoil.

Additionally, poor drainage exacerbates these effects by allowing water to accumulate, leading to saturation and increased erosion along the road surface and shoulders. The combined effect is a rapidly deteriorating road condition marked by rough, uneven surfaces that increase maintenance needs and reduce road usability. Engineering solutions such as adequate gravel depth, proper compaction, drainage structures such as culverts, and use of geotextile reinforcement can mitigate these impacts, however, heavy precipitation remains a primary cause of gravel road degradation.

Whilst unsealed roads are not critically strategic at the national trunk level, they are important to connect local routes. Any loss of local connectivity can negatively affect service delivery, trade and movement of people, resulting in localised socio-economic impacts. These can have knock-on effects on productivity in the broader economy.

The overlay of the road network and change in the magnitude and distribution of extreme precipitation (Figure 29) indicates that the greatest changes in risk to road transport are located in the coastal areas around Mtwara, Dar es Salaam and Tanga. The dense network of unsealed roads in the northern areas around Mwanza and Tabora are projected to be exposed at a higher degree of risk than the central plateau.

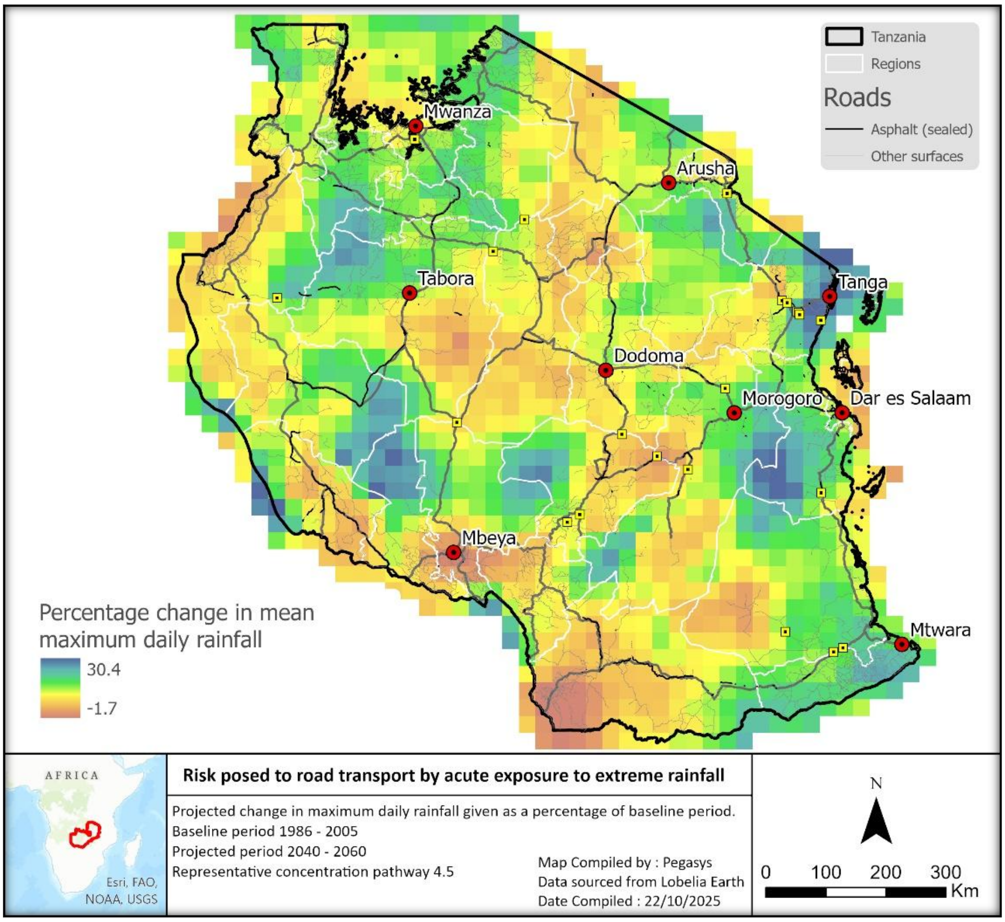


Figure 29: Overlay of sensitive road infrastructure on the distribution of projected change in exposure to extreme rainfall

Extreme temperatures

The Tanzanian trunk road network is vitally important for the transportation of people and freight across the country. Heavy goods vehicles in particular are important as they are the primary means to transport freight within the country and to export nodes such as the ports at Dar es Salaam, Tanga and Mtwara.

Currently, road is an important system for the transport of goods to markets – even though in March 2026, Tanzania Railways Corporation announced it has started container transport operations on its Standard Gauge Railway. Any impacts to the road network are thus important risks to the economy and the livelihoods of people and communities.

Extreme temperatures (>35 degrees Celsius) can have significant impacts on asphalt roads in particular. At these ambient air temperatures, research shows that the asphalt surface temperature may reach 60 to 65°C due to solar radiation absorption (Nicholls, 2001). This elevated pavement temperature has the following technical impacts:

- Softening and rutting: At surface temperatures of 60-65°C, the pavement is more susceptible to permanent deformation or rutting under traffic loads, especially in wheel paths, reducing the structural integrity over time.
- Thermal expansion and cracking: Repeated daily cycles of heating and cooling induce thermal stresses which can cause micro-cracking. These can allow water ingress and deterioration.
- Oxidative aging: Elevated surface temperatures makes the binder brittle, reducing flexibility and increasing susceptibility to cracks.
- Reduced Fatigue Resistance: Aging plus daily thermal cycling cumulatively degrade the pavement's fatigue life at these extreme temperatures.
- Surface Degradation: Solar insolation greater than ambient temperature catalyzes binder degradation and surface embrittlement.

Extreme temperatures are therefore expected to degrade road surfaces and to result in the requirement for increased maintenance with associated costs and impacts to trade and the economy. Chronic exposure to extreme ambient temperatures can also result in impacts to bridges and other supporting road infrastructure. Large bridges in particular often contain metal components which expand and contract with fluctuating temperatures. Over time with chronic exposure, this can result in metal fatigue and a risk of component failure. Increasing exposure to high maximum daily temperatures can therefore increase maintenance requirements and associated costs.

The risk posed to the trunk road infrastructure by increasing exposure to extreme temperatures is illustrated in Figure 30 on the overleaf. The highest risk increase areas fall within a triangle between Dar es Salaam, Tanga and Morogoro which includes the important T1 highway. Increased risk is however also indicated surrounding Tabora.

Cross-cutting risks

There are limited cross-cutting risks from the energy sector to road transport. The exception is the impact that any impacts to the energy sector may have on road signalling. With respect to the manufacturing sector, the vulnerability of the manufacturing processes for raw materials for roads such as cement will cascade down to increase risk associated with construction and maintenance activities.

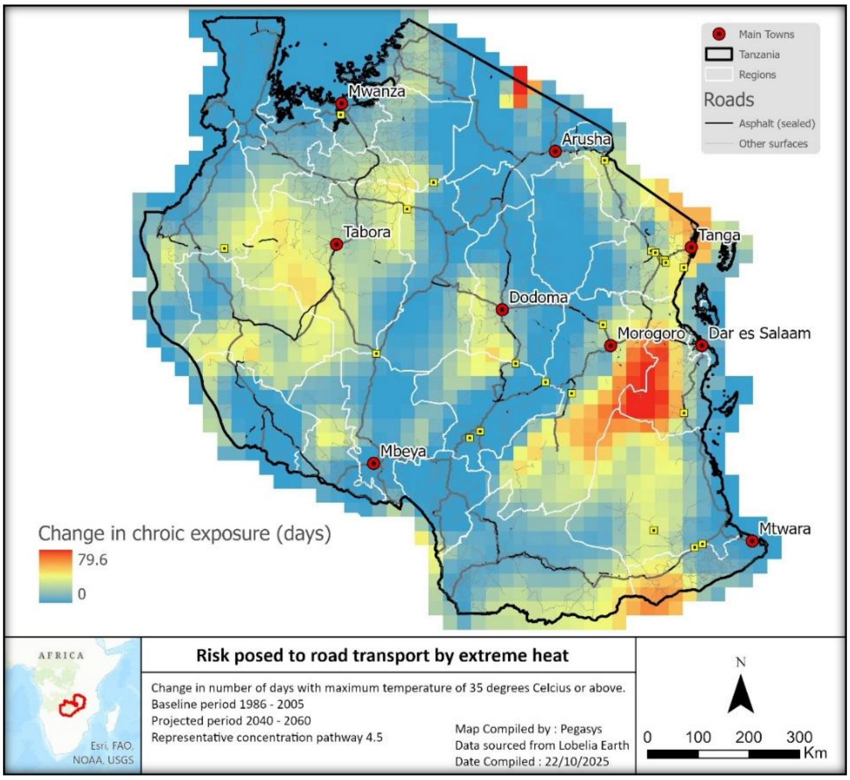


Figure 30: Overlay of sensitive road infrastructure on the distribution of exposure to extreme temperatures

Transport – Rail

As described in Section 3 of this report, key rail nodal vulnerabilities exist with respect to hazards of flooding and extreme temperatures. This is illustrated in the rail transport nodal sensitivity heat map in Table 18. These climate hazards therefore form the focus of the risk pathway analysis.

Table 18: Nodal sensitivity heat map for the Tanzanian rail transport system

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Rail	Railway lines	1	2	3	0	1	2	0	0	1	1	2	3	1	2	3	0	0	1	0	1	1	0	0	0	0
	Overhead electification	0	1	2	0	0	0	1	2	3	1	2	3				1	2	3	0	1	2	2	3	0	0
	Stations / sidings / shunting yards	1	2	2	0	0	1	1	2	2	1	2	3	1	2	3	0	0	1	0	1	2	0	2	0	0
	Bridges	0	1	2	0	0	0	0	1	1	1	2	3	1	1	2	0	1	2	0	1	1	0	0	0	0
	Signalling	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	1	1	0	1	1	0	3	0	0
Number of system level "High sensitvities"		1			0			1			4			2			1			0			0	2	0	0

Flooding

Whilst flood sensitivity of railway systems is high, analysis of the current Tanzanian railway network against baseline and projected 1:50 year flood extents (for depths greater than 0.5 m) shows that exposure of the network is very low with less than 30km exposed across the entire network (Table 19). Although overall network exposure to flooding is low, localized vulnerabilities remain significant. Historical records show that flooding along the Central Line (Meter Gauge Railway) near Kilosa (between Dar es Salaam and Dodoma and near to Morogoro), has repeatedly disrupted operations, causing prolonged service interruptions and costly repairs. In recent years, these disruptions have averaged around 120 days annually, and interruption days are expected to rise due to severe sedimentation issues along the Kinyasungwe River, which runs parallel to the MGR between Kilosa and Igandu. These challenges illustrate that even limited spatial exposure can lead to disproportionate operational impacts when key nodes are affected.

Table 19: Extent of flood exposed railway under baseline and projected conditions

Region	Flood exposed length 1986 – 2005	Flood exposed length 2040 - 2060	Change
Dar es Salaam	0.28	0.14	-0.14
Dodoma	28.19	26.82	-1.38
Iringa	1.56	1.51	-0.05
Katavi	0.24	0.22	-0.02
Kigoma	16.95	16.39	-0.56
Kilimanjaro	6.26	6.43	0.17
Mbeya	0.51	0.55	0.04
Morogoro	21.98	23.01	1.03
Njombe	0.71	0.69	-0.02
Pwani	11.86	12.73	0.87
Shinyanga	2.07	2.02	-0.05
Singida	6.72	6.84	0.12
Songwe	0.20	0.15	-0.05
Tabora	10.65	10.48	-0.18
Tanga	45.97	47.18	1.21
Grand Total	154.16	155.15	1.00

Extreme temperature

Rising temperatures and the increasing occurrence of heatwaves present a growing systemic risk to Tanzania's rail infrastructure. The impacts of thermal stress are most pronounced across track systems, bridges, sidings, and stations, where material expansion, deformation, and heat-induced wear can affect both operational safety and service reliability. Rising temperatures can also reduce the conductivity of overhead powerlines and result in sagging of the lines. This is important given Tanzania's recent investment in a high-speed electrified line between Dar es Salaam and Dodoma.

Rail steel expands as temperatures rise, creating compressive stresses that can lead to track buckling or misalignment, particularly on continuous welded rail lines where expansion joints are absent. Even small deviations in alignment can reduce service speeds or necessitate line closures. The risk is elevated where ballast conditions are poor, or maintenance backlogs have weakened lateral restraint. Sustained exposure to high temperatures also accelerates rail fatigue, sleeper degradation, and ballast deterioration. Over time, these processes shorten the service life of the permanent way and increase maintenance costs. In extreme cases, derailment risk increases if rail warping occurs undetected.

Sidings and yard area, often surfaced with compacted gravel or unreinforced concrete, are highly susceptible to thermal expansion and subgrade deformation. High ambient temperatures can cause softening of the ground and settlement under static loads, leading to track misalignment and difficulty in shunting operations. Prolonged heat exposure also affects mechanical components such as switch points, couplers, and braking systems, particularly where lubrication degrades at high temperatures. This can impair operational safety and efficiency during hot periods. Stations and passenger service buildings are exposed to both thermal stress and increased cooling demand. High roof and surface temperatures can degrade materials such as asphalt, sealants, and roofing membranes, leading to cracking, roof leaks, and insulation failure. Thermal expansion of concrete platforms can also cause surface deformation or vertical misalignment, affecting passenger safety and train accessibility. Additionally, elevated temperatures in unventilated waiting areas can pose heat stress risks for passengers and staff.

Bridges represent critical nodes within the rail system and are particularly vulnerable to thermal expansion and contraction. High temperatures cause elongation of steel members and expansion of bearings and joints, which, if not adequately accommodated, can result in binding, deck misalignment, or joint failure. Concrete bridge decks may also experience thermal cracking or spalling, especially where daily temperature fluctuations are large. Over time, these processes reduce structural integrity and increase maintenance frequency.

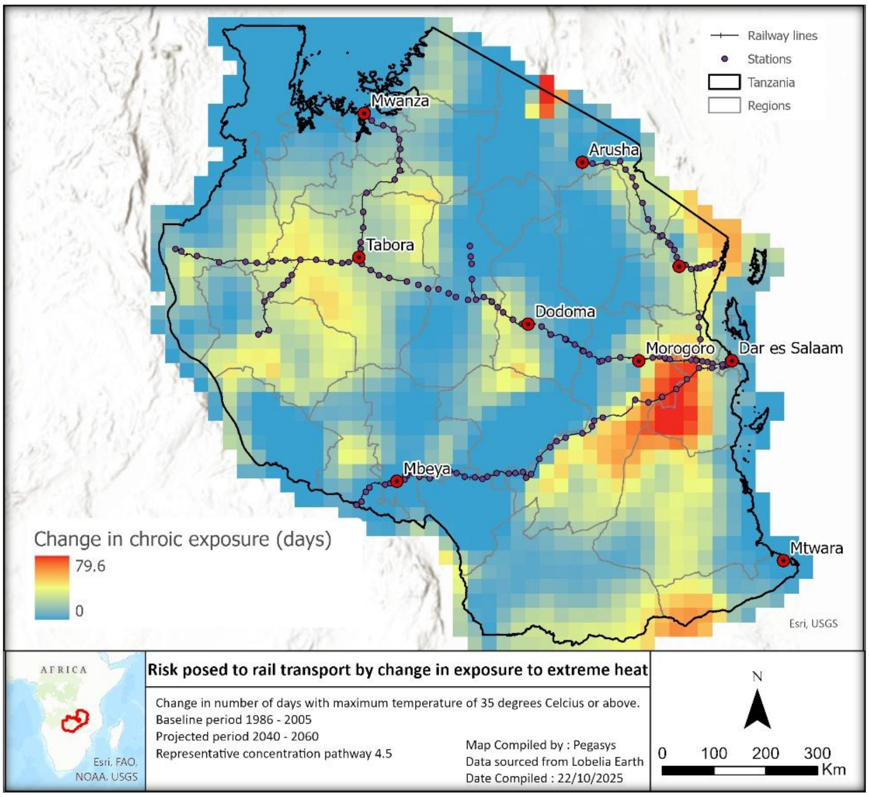


Figure 31: Overlay of rail infrastructure on the distribution of exposure to extreme temperatures

Cross-cutting impacts

As with road transport, the only cross-cutting risk that is likely to significantly impact the operation of the rail network is that of energy, whereby, interruptions in electricity supply will result in the suspension of rail services on electrified tracks but also on non-electrified lines due to the lack of signalling.

Affordable and social housing

As described in Section 3, key housing related nodal vulnerabilities exist with respect to hazards of flooding and extreme temperatures. This is illustrated in the nodal sensitivity heat map in Table 20, and are further explored in the sections that follow.

Table 20: Nodal sensitivity heat map for the Tanzanian social infrastructure – affordable housing system

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Housing	Raw materials	0	0	1	0	1	1	1	2	2	1	2	3	0	0	0	0	0	0	0	0	0	3	2	3	0
	Construction (People element)	1	2	3	0	0	1	1	2	3	1	2	3	0	1	1	0	1	1	0	0	1	3	2	0	0
	Water and sanitation (infrastructur	0	1	1	0	0	0	0	1	1	1	2	3	0	1	1	0	0	0	0	1	1	3	3	0	0
	Electricity	0	1	2	0	0	0	0	1	2	1	2	3	0	1	1	0	1	2	0	1	2	3	3	0	0
	Foundations	0	0	0	0	1	1	0	1	1	0	1	2	0	1	3	0	0	0	0	0	0	0	0	2	0
	Walls	0	0	1	0	0	1	0	1	2	1	2	3	1	2	3	0	0	2	0	0	0	0	0	2	0
	Roof	0	1	2	0	0	0	0	1	1	1	2	3	0	1	1	0	1	3	0	0	0	0	0	2	0
Number of system level "High sensitvities"		1			0			1			6			2			1			0			4	2	1	0

Flooding

Whilst sensitivity to flooding is very high in all nodes of housing developments, spatial analysis using national scale flood maps shows that the exposure of built-up areas to floods, during a 1:50 year flood event, is relatively low. Although this suggests that flood exposure, and thus risk, is relatively low, it is acknowledged that exposure to flooding is a difficult hazard to assess at a regional scale, given that fine-scale flood data is not available at a national scale and so flood areas associated with smaller watercourses are not well represented (Figure 32). Scale is important because the difference between severe flood damage and infrastructure being 'high and dry' can be a few lateral metres.

This was illustrated in April 2018 when severe flooding occurred in Dar es Salaam affecting nearly 12,000 people, collapsing dozens of houses and latrines, and severely damaging hundreds more. Given 1) the high sensitivity of all housing infrastructure and 2) the propensity of low-income housing to be positioned on flood prone areas and 3) the increase in maximum daily rainfall (see section that follows) across Tanzania, there is a high likelihood that low-income housing is potentially far more exposed than the national scale flood analysis suggests. Flooding risk to affordable and social housing is therefore still an important factor to consider in addressing climate resilience in the infrastructure sector.

Figure 32: Example of high-density housing within close proximity to watercourses in Dar es Salaam which are not reflected in national scale flood extent data (Image credit: Bing)

Heat and extreme precipitation impacts on construction.

Housing construction is an activity that is highly subject to weather conditions. Extreme heat is likely to result in construction delays due to a reduction in worker productivity whereby work is suspended or significantly slowed down by temperatures over 35^0C. Areas in the coastal regions, and particularly in the lower Rufiji Valley are likely to be particularly heavily impacted under projected climatic conditions (2040 – 2060) as areas with up to 80 additional days with temperatures exceeding this level are concentrated in these lower lying areas.

Construction activities are also likely to be constrained by heavy rainfall as building sites become inaccessible by heavy machinery for periods, and activities which require dry conditions such as foundation work and concrete pouring delayed. All coastal lowland urban centres are projected to see an increase in the maximum daily rainfall, as well as Arusha, Tabora and Mwanza (Table 21). While these values range up to approximately 14%, areas outside of major urban centres are likely to see increases of up to 30%. Higher lying areas like Mbeya (1.3%) are not likely to see a similar increase in maximum daily rainfall.

Table 21: Projected (2040 – 2060) increase in maximum daily rainfall from baseline conditions (1996 – 2005) across the major urban centres of Tanzania

Urban area	Projected increase in max daily rainfall (%)
Mwanza	9.9
Arusha	12.1
Tabora	11.9
Dodoma	9.3
Mogorogo	13.4
Dar es Salaam	7.2
Mbeya	1.3
Mtwara	13.8

Cross-cutting impacts

Housing development is subject to significant risk stemming from cross-cutting vulnerabilities associated with other sectors. These include vulnerabilities of the road and rail infrastructure on which the transportation of construction materials depends, water supply infrastructure to supply water for construction as well as for household use once completed, as well as the supply of electricity also for household use. Any impacts to these systems will cascade down to the affordable social housing system.

The manufacture of cement is a critical input into the construction and maintenance of houses. Risks associated with this manufacturing system (e.g. the loss of productivity due to extreme heat) therefore also cascade down onto the affordable and social housing system.

Water supply

As described in Section 3, key water supply nodal vulnerabilities exist with respect to hazards of flooding, drought and extreme temperatures. This is illustrated in the nodal sensitivity heat map for the water supply sub-sector in Table 22. It is only in larger built-up areas where treated water is supplied to consumers through a formal reticulation system. The vast majority of Tanzanians source their water from boreholes, springs or rivers, however in some major urban centres, treated water is supplied via a municipal system. The most important river for supplying water for domestic and industrial needs in Dar es Salaam is the Ruvu River. The abstraction is directly from the river using run-of-river pumps. Few reservoirs are used for storage and abstraction of water for domestic supply. The Ruvu River water is augmented by supply from the Kimbiji deep aquifer. Importantly though, the majority of informal settlements draw water from the shallow coastal aquifer which is highly vulnerable to pollution and saline intrusion.

Dodoma's water supply is sourced exclusively from groundwater abstracted from 24 deep boreholes located in the Makutupora Basin, about 27 to 35 km north of the city center. This basin serves as the sole reliable water source for the urban area of Dodoma. The city relies on this deep aquifer to meet its water supply needs, with boreholes producing clean underground water that is distributed through an extensive network of about 393 km of pipes. Current production averages around 37,000 to 45,000 cubic meters per day, with system capacity close to 61,500 cubic meters per day

Table 22: Nodal sensitivity heat map for the water supply sub-sector

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Raw water supply	Catchment runoff	1	2	3	1	2	3	0	0	0	0	0	0	1	2	2	0	0	0	0	1	2	0	0	0	0
	Reservoir	1	2	3	0	0	0	0	0	1	0	1	1	1	2	3	0	0	0	0	0	1	0	1	1	0
	Groundwater	1	2	3	1	2	3	0	1	2	0	0	0	1	2	3	0	0	0	0	0	0	0	3	0	0
	Run-of-river pumps	1	2	2	1	2	3	0	1	2	1	2	3	0	1	2	0	0	0	0	0	0	0	3	0	0
	Pumps and pipe infrastructure	1	2	2	0	0	0	0	0	0	1	2	3	1	2	2	0	0	0	0	0	1	0	3	1	0
Number of system level "High sensitvities"			3			3			0			2			2			0			0		0	3	0	0

Floods

Floods pose a significant threat to run-of river abstraction infrastructure given that it is located within the river channel. Whilst small floods are accommodated in the design specifications of such structures, climate change projections in the headwater areas of the Ruvu river indicate increases in mean maximum daily rainfall of the order of 20% and a 1:25 year event of over 100mm. Increases in daily maximum precipitation will significantly increase the scale and power of floods which will likely have an increased level of impact, particularly on treatment facilities if these are exposed.

Figure 33: Run-of-river abstraction point on the Ruvu River and associated water treatment plant (Image credit Google Earth).

Drought

Drought is an important risk factor for water supply in Tanzania because most water abstraction is taken from rivers and groundwater with limited storage to augment supply when flows decline. The Ruvu River system is highly vulnerable to reduced flows during prolonged dry periods, which directly affects Dar es Salaam's water security. Central regions such as Dodoma, Singida, and Shinyanga are particularly drought-prone. Dodoma relies exclusively on groundwater from the Makutupora Basin, which is relatively resilient but has low recharge rates (estimated at 1–2% of annual rainfall). Increasing demand and climate variability pose sustainability challenges for this aquifer. Projections indicate that drought frequency and severity will rise, potentially affecting rural water points and urban supply systems.

Extreme temperatures

The most significant risk to water supply linked with increased exposure to extreme temperatures is the associated increase in evaporation of surface water and reductions in river baseflow. This is critical for systems like the Ruvu River abstraction, where higher evaporation combined with reduced rainfall during dry spells will intensify water scarcity risks. Increased evapotranspiration will also affect groundwater recharge in semi-arid regions. These changes will not be offset by reduced demand, as water needs remain high during heatwaves. The ecological impact will extend to freshwater ecosystems, with implications for biodiversity and water quality.

Sea-level Rise

Sea-level rise is an important consideration in coastal areas where the higher level will result in greater saline intrusion into shallow, unconfined coastal aquifers. In the case of Dar es Salaam, many informal settlements rely on this aquifer for water and saline intrusion will significantly affect the quality of this water.

Cross-cutting impacts

The water supply system is highly dependent on the energy sector, with electrical supply being critical for the operation of pumping equipment and other operational components of the water treatment system such as filtration. Energy interruptions will have major impacts on the ability of utilities to abstract, treat, and supply water to users. At a lower level, the majority of boreholes require electricity to pump water from aquifers to the surface, so electricity supply disruptions will have an impact on local and household water supply. Households often increase storage on their premises to account for periods when they cannot pump. In rural areas, solar-powered boreholes are increasingly used to mitigate these risks, but coverage remains limited.

Waste water management

As described in Section 3, key waste water management nodal vulnerabilities exist with respect to hazards of flooding, intense precipitation and drought. This is illustrated in the nodal sensitivity heat map in Table 23.

Table 23: Nodal sensitivity heat map for the Tanzanian waste water sub-sector

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Centralised treatment	Sewerage network	0	0	0	0	2	3	1	2	3	1	2	3	0	1	2	0	0	0	0	0	0	0	3	0	0
	Settling ponds	0	0	0	0	2	3	1	2	2	1	2	3	0	1	1	0	0	0	0	0	0	0	0	0	0
	Sludge treatment	0	1	2	0	0	0	1	2	2	1	2	3	0	1	1	0	0	0	0	0	0	0	0	0	0
Number of system level "High sensitvities"		**0**			**2**			**1**			**3**			**0**			**0**			**0**			**0**	**1**	**0**	**0**
Decentralised treatment	Anaerobic Baffled Reactor	0	1	2	0	0	0	0	1	2	1	2	3				0	0	0	0	1	2	3	1	0	0
	Clarification ponds	0	0	0	0	1	2	1	2	3	1	2	3				0	0	0	0	0	1	0	0	0	0
	Artificial wetlands	0	1	2	1	2	3	1	2	3	1	2	3				0	1	2	0	1	2	0	0	0	0
Number of system level "High sensitvities"		**0**			**1**			**2**			**3**			**0**			**0**			**0**			**1**	**0**	**0**	**0**
In-situ / septic tank	Septic tanks	0	0	0	0	0	0	1	2	3	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Soakaway	0	0	0	0	0	0	1	2	3	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of system level "High sensitvities"		**0**			**0**			**2**			**2**			**0**			**0**			**0**			**0**	**0**	**0**	**0**

Floods

Wastewater treatment infrastructure in Tanzania is increasingly vulnerable to flood-related impacts, particularly in urban centres such as Dar es Salaam and Dodoma. Centralised treatment facilities are typically located in low-lying areas to facilitate gravity-fed sewer systems. However, these locations are also more prone to flooding, especially during intense rainfall events that are becoming more frequent due to climate change. In Dar es Salaam, for example, the Msimbazi River floodplain is a known hotspot for recurrent flooding, which has led to damage of sanitation infrastructure and contamination of nearby water sources.

Flooding poses two major risks to centralised wastewater systems. First, it can physically damage infrastructure such as sewer networks, pumping stations, and treatment ponds, leading to loss of functionality. Second, floodwaters can cause untreated wastewater to spill from broken pipes and overwhelmed treatment facilities into surrounding communities and natural ecosystems. These spillages often continue after floodwaters recede, posing serious public health and environmental hazards. The lack of fine-scale flood mapping data, particularly for smaller watercourses, makes it difficult to accurately assess and mitigate these risks.

In contrast, decentralised wastewater systems, such as pit latrines and septic tanks, are the predominant form of sanitation in both rural and urban Tanzania. These systems are not necessarily located in flood-prone areas, and their exposure to flooding varies widely depending on local topography and construction quality. While decentralised systems handle smaller volumes of wastewater and are easier and cheaper to repair, they are still vulnerable during heavy rains. Overflow and structural failure of latrines and septic tanks can lead to the spread of pathogens and contamination of surface and groundwater, especially in densely populated informal settlements.

Despite their lower individual risk, the widespread use of decentralised systems means that flood-related damage can have cumulative impacts on public health, particularly in areas with poor access to desludging services and safe sanitation alternatives. In Dar es Salaam, for instance, inadequate drainage and sanitation infrastructure in informal settlements has led to frequent mixing of floodwaters with human waste, increasing the risk of waterborne diseases.

Intense precipitation

Increasingly intense precipitation events in Tanzania pose significant risks to public health and the environment, particularly through the spillage of untreated wastewater. These risks emerge from several interconnected pathways: (1) localised pluvial flooding that overwhelms drainage systems, (2) the overloading of centralised wastewater treatment infrastructure such as settling ponds and sewer networks, and (3) the contamination of ground and surface water sources due to rising groundwater levels and the flooding of decentralised sanitation systems like pit latrines and septic tanks.

Centralised wastewater systems are especially vulnerable to these impacts. Facilities are often located in low-lying urban areas to facilitate gravity-fed sewage collection, but this also makes them susceptible to flooding. As presented in Table 21, projected climate trends indicate that rainfall intensity will increase across most urban centres. For example, Morogoro (+13.4%) and Mtwara (+13.8%) are expected to experience the largest percentage increases in mean daily maximum rainfall, while Arusha (+12.1%) and Tabora (+11.9%) also show notable gains.

Drought

The most significant risks to wastewater treatment systems associated with drought are primarily linked to the treatment process. During prolonged dry periods, sewage strength and pollutant concentrations increase because of reduced dilution, raising the likelihood of sub-optimally treated wastewater being discharged into the environment. Elevated temperatures that often accompany drought further exacerbate this challenge by lowering oxygen concentrations and reducing the efficiency of aerobic oxidation processes. This combination significantly increases the risk of poorly treated effluent entering rivers and coastal ecosystems.

Climate projections indicate that most regions of Tanzania will experience a decrease in the SPEI signalling an increase in drought frequency, with the most pronounced changes occurring along the western boundary of Tanzania, with particularly significant changes occurring near Mbeya and to a lesser degree Dodoma, Morogoro, and parts of Singida and Tabora. The projected change in the SPEI for 2040–2060 ranges from -0.4 to -0.98, signalling a moderate to low increase in drought frequency and intensity (see Figure 34).

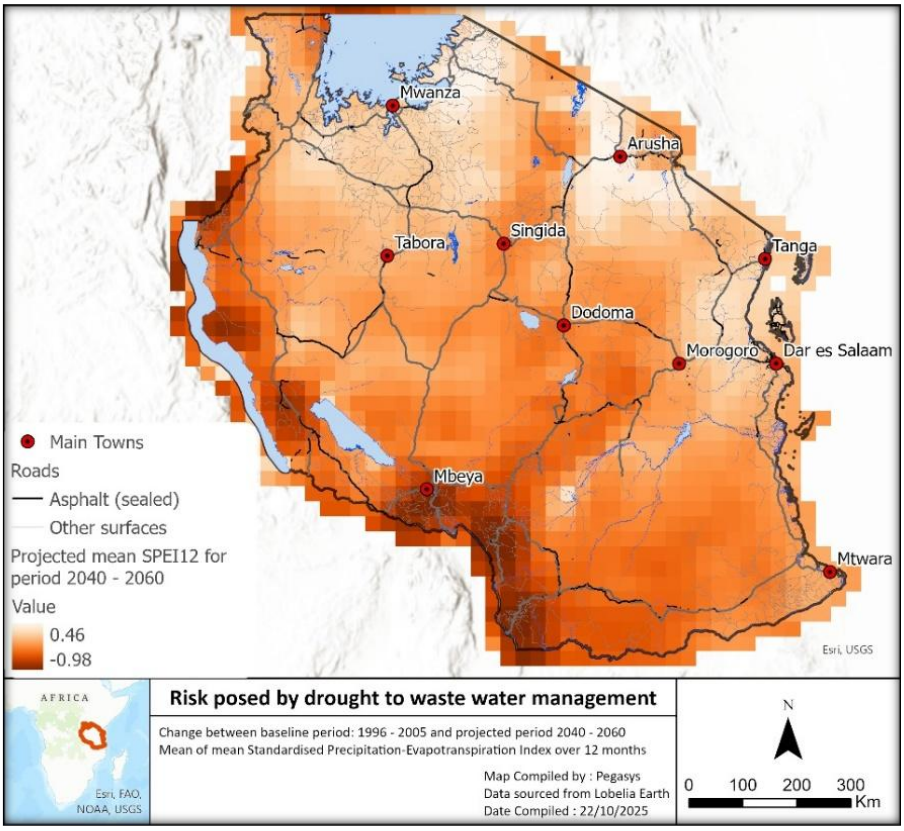


Figure 34: Distribution of change in mean 12-month SPEI values projected for the period between 2040 and 2060

Cross-cutting impacts

Risks associated with the supply of electricity will cascade down to the waste water system. Importantly, drought will have a double negative impact on waste water management, firstly through limiting electrical power availability for operations due to impacts on hydropower generation, and secondly due to the effect of increasing the concentration and strength of sewage arriving at waste water treatment plants. Drought may also have the effect of reducing flow of sewage in the water-borne sewerage network, thus resulting in blockages and increased maintenance costs.

Solid waste

Solid waste management in Tanzania faces significant vulnerabilities related to flooding, intense precipitation, and fire, while extreme wind poses minor risks primarily to collection activities rather than infrastructure damage. This is illustrated in the nodal sensitivity heat map in Table 24. Most urban areas in Tanzania lack fully engineered sanitary landfills. While some sites, such as Pugu Kinyamwezi in Dar es Salaam, were initially designed as sanitary landfills, they have largely degraded into unmanaged open dumpsites. Across the country, the majority of collected solid waste is disposed of in open dumps, and a substantial portion of waste remains uncollected, often ending up in drains, waterways, and informal dumping grounds. This situation increases environmental hazards and exacerbates flood risk during heavy rainfall events.

Table 24: System nodal sensitivity heat map for solid waste management in Tanzania

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																									
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Collection	Collection vehicles	0	1	1	0	0	0	1	2	2	1	2	2	0	0	0	0	0	1	0	0	1	3	0	0	0
	Labour / staff	1	2	3	0	0	0	0	1	2	0	0	0	0	0	0	0	0	1	1	2	3	0	0	0	0
	Depots	0	0	1	0	0	0	0	1	1	1	2	3	0	1	2	0	1	1	0	1	1	2	1	0	0
Number of system level "High sensitvities"		1			0			0			1			0			0			1			1	0	0	0
Landfill disposal	Landfil liner	0	0	0	0	1	2	0	0	0	1	2	3	1	2	3	0	0	0	1	2	3	0	0	0	0
	Landfil compactors	0	1	2	0	0	0	0	1	2	0	0	0	0	0	0	0	0	1	1	2	3	0	0	0	0
	Landfill waste	0	1	2	0	0	0	0	0	0	1	2	3	0	0	0	0	1	2	1	2	3	0	0	0	0
	Stormwater systems	0	0	0	0	0	0	0	1	2	1	2	3	1	2	3	0	0	0	0	0	0	1	0	0	0
	Leachate management	0	1	2	0	0	0	1	2	3	1	2	3	1	2	3	0	0	0	1	2	3	0	0	0	0
Number of system level "High sensitvities"		0			0			1			4			3			0			4			0	0	0	0
Open dump	Waste dump	0	0	0	0	0	0	1	2	3	1	2	3	0	0	1	0	1	2	1	2	3	1	0	0	0
Number of system level "High sensitvities"		0			0			1			1			0			0			1			0	0	0	0

Floods and intense precipitation.

Solid waste management systems are highly vulnerable to flooding, particularly in Dar es Salaam, where poor drainage infrastructure intersects with high waste generation. Pluvial flooding, caused by inadequate stormwater drainage during heavy rainfall, is a major concern. Waste dumped in drains and waterways obstructs flow, increasing flood severity. During flood events, open dumpsites can leach harmful chemicals and pathogens into groundwater and surface water, while runoff from waste piles contaminates rivers and coastal ecosystems. Climate projections indicate that coastal and southern regions may experience up to 30% increases in extreme rainfall, amplifying these risks.

Fire

A large proportion of municipal solid waste in Tanzania is combustible, including plastics, paper, and organic matter. Waste dumps are therefore sensitive to fire outbreaks, which can occur due to wildfires during dry seasons or intentional burning of waste. Fires at dumpsites release toxic fumes and particulates, posing severe health risks to nearby communities. Given the large volumes of accumulated waste, such fires can burn for extended periods, making suppression difficult and hazardous for workers. These risks are expected to increase under climate change scenarios that project hotter and drier conditions in central and northern Tanzania, which heighten wildfire frequency.

Cross-cutting impacts

Solid waste management has limited direct dependencies on other sectors, but road infrastructure is critical for waste collection and transport. Flooding that damages roads or restricts access can disrupt collection services, leading to waste accumulation in urban areas. At disposal sites, operations rely on diesel-powered equipment, and future plans for engineered landfills may introduce dependencies on the energy sector for leachate monitoring and digital systems. Additionally, poor waste management contributes to blocked drainage systems, which intensifies urban flooding, a feedback loop that worsens climate vulnerability.

ICT Telecoms

As described in Section 3, key ICT / Telecoms nodal vulnerabilities exist with respect to hazards of extreme temperatures, fire, and high winds, alongside cross-cutting risks from energy supply disruptions. This is illustrated in the nodal sensitivity heat map in Table 25.

Table 25: System nodal sensitivities to climate related hazards for the ICT Telecoms sub-sector

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Mobile	Cellular base stations	0	0	2	0	0	0	0	0	1	1	2	3	0	1	2	0	2	3	1	2	3	2	3	0	0
Network			**0**			**0**			**0**			**1**			**0**			**1**			**1**		**0**	**1**	**0**	**0**
Core Network	Data Centers	1	2	3	0	0	0	0	1	2	1	2	3	0	0	0	0	1	1	0	1	1	2	3	1	0
	Core Switches and Routers	1	2	3	0	0	0	1	2	2	0	1	2	0	0	0	0	0	0	0	1	1	1	3	1	0
Number of system level "High sensitvities"			**2**			**0**			**0**			**1**			**0**			**0**			**0**		0	2	0	0
Transmission & backhaul	Microwave towers	1	2	3	0	0	0	0	1	2	1	2	3	0	1	2	0	1	2	1	2	3	0	3	0	0
	Underground and Aerial Cables	0	1	1	0	0	0	0	0	1	0	1	2	0	1	2	0	1	2	1	2	3	2	3	0	0
Number of system level "High sensitvities"			**1**			**0**			**0**			**1**			**0**			**0**			**2**		0	2	0	0

Extreme temperature

The primary risk associated with chronic exposure to extreme temperatures for the ICT Telecoms sub-sector relates to increased cooling demand and potential overheating of servers and other digital hardware. This drives higher operational costs and raises the likelihood of service disruptions. Exposure is greatest in lowland areas near Morogoro and Mtwara. However, as presented in Figure 35, with the data centres being located near Dar es Salaam, which shows limited changes to the number of days with temperatures exceeding 35^{o}C, the risks of extreme or chronic heat to data centres is limited.

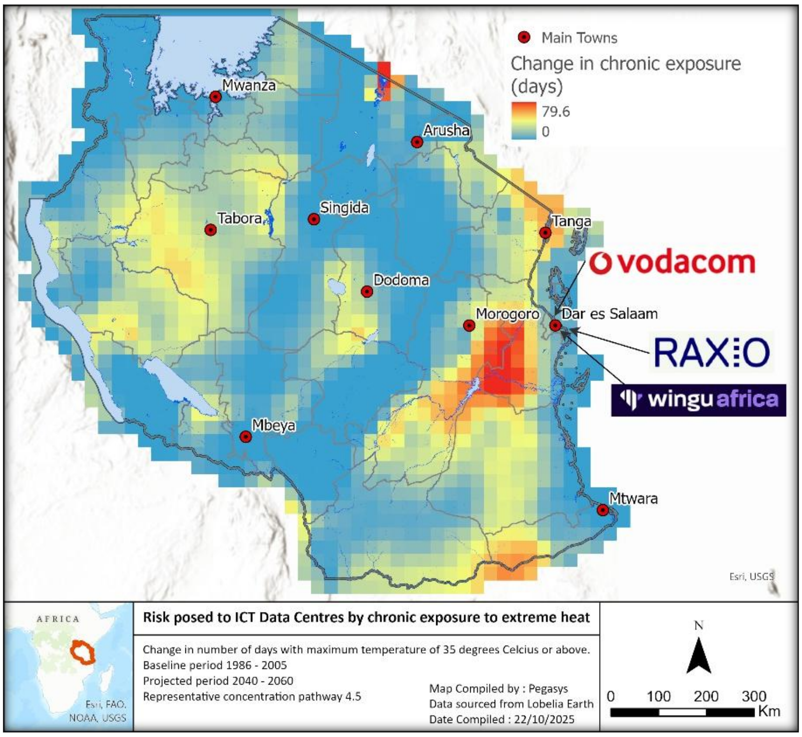


Figure 35: ICT data centre locations and the extent of chronic exposure to extreme temperature

Fire

Fire poses a significant and growing threat to ICT Telecoms infrastructure in Tanzania, particularly for assets located in bushland and open areas where wildfires can spread rapidly and remain uncontrolled. Infrastructure such as cellular base stations, microwave towers, and overhead cabling is highly exposed because these components are often situated in remote regions with limited fire suppression capacity. When fires occur, they can cause direct physical damage to towers and cabling, destroy backup power systems, and interrupt connectivity for large geographic areas.

As presented in Figure 36, projected changes in fire weather conditions indicate a substantial increase in risk across western and southwestern Tanzania, with hotspots in Mbeya, Tabora, and Singida. These areas are expected to experience a marked rise in the FWI, signalling more frequent and intense fire-prone conditions by mid-century. The combination of high vegetation fuel loads and prolonged dry spells will amplify the likelihood of wildfires, making these regions critical zones for infrastructure vulnerability.

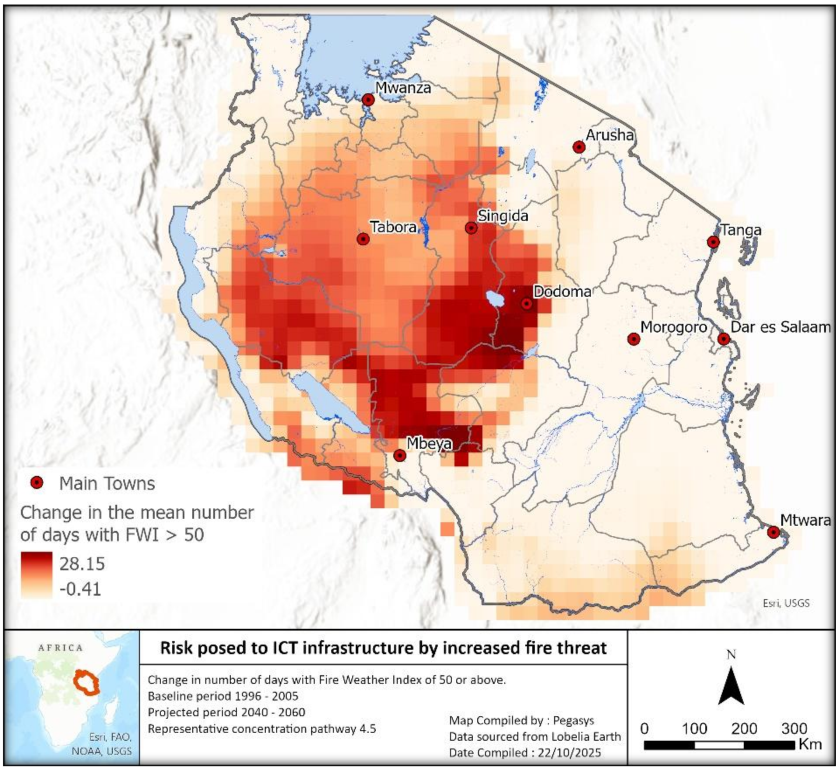


Figure 36: Distribution of increased risk associated with increased fire threat to ICT telecoms infrastructure

Wind

Wind hazards primarily affect above-ground ICT assets such as cellular towers, microwave links, and overhead cables. These structures are generally designed to withstand typical wind loads, but projected climate changes introduce new stressors that can compromise their integrity. Severe winds may bend or topple towers, dislodge antennas, and snap overhead cables, leading to service interruptions and costly repairs. Even when structural failure does not occur, strong gusts can misalign antennas, degrading signal quality and disrupting connectivity. High winds often coincide with storms, which can damage power transmission lines and cause cascading outages for ICT nodes reliant on grid electricity. Over time, increased wind speeds also accelerate wear on tower components, raising maintenance costs.

As presented in Figure 37 projections indicate that maximum wind speeds could reach up to 18 m/s in localized areas, particularly along a north-south corridor through Tabora, Singida, and Mbeya. While modest increases of around 4% may be absorbed within current engineering standards, localized spikes combined with other hazards, such as heightened fire risk in western regions, create compound vulnerabilities. High winds can exacerbate wildfire spread, threatening isolated towers in bushland areas, and power instability further amplifies ICT exposure.

These trends underscore the need for targeted resilience measures. Reinforcing tower anchoring, adopting aerodynamic antenna designs, and prioritizing underground cabling in high-risk corridors can reduce vulnerability. Integrating real-time wind monitoring into Network Operation Centers will also enable proactive responses to extreme events, minimizing cascading failures and service disruptions.

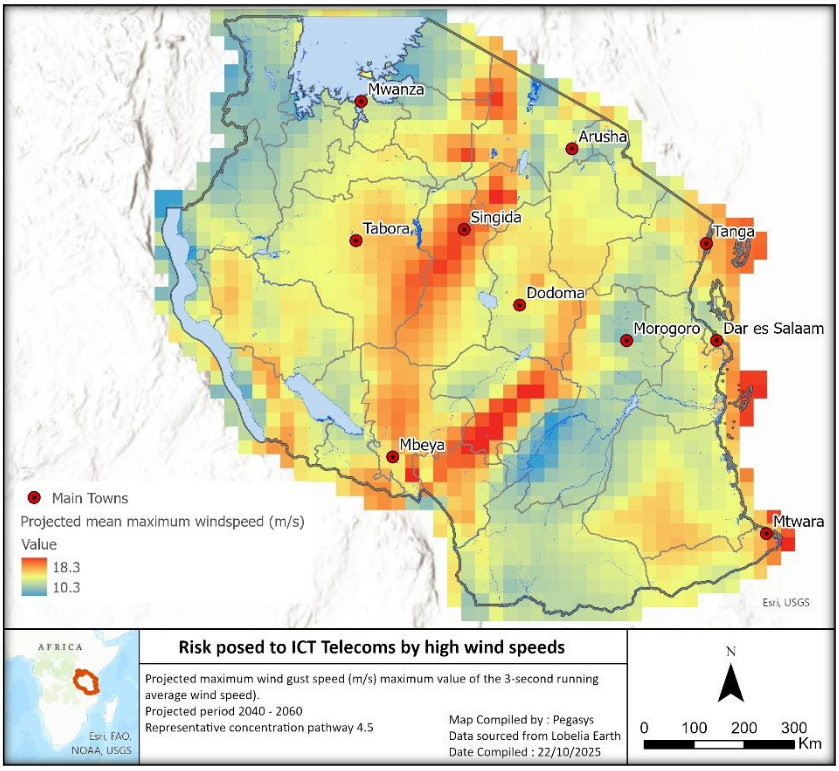


Figure 37: Risks posed to ICT Telecoms by high wind speeds

Cross-cutting impacts

The most significant risks to the ICT telecoms sub-sector that originate in other sectors are those associated with the energy sector. Limited or intermittent power supply will have major impacts on a wide range of ICT Telecoms nodes, from the functioning of cellular base stations (continued power outages cause any battery backup to eventually fail and need replacement), to data centre operation and server cooling. Given Tanzania's high dependence on climate dependent energy sources (hydropower), energy risks are the most significant climate related risks facing the ICT Telecoms sub-sector.

Energy

Generation - Hydropower

Within the Hydro-power system, three hazards are identified as being critical threats to the production of power. These are 1) extreme temperature, which results in increased evaporation and reduction of production water, 2) drought, which also reduces available water for power production, and 3) floods which threaten water quality, reduce impoundment storage through sedimentation and in extreme cases, may damage hydropower infrastructure. The sensitivity scoring for hydropower is given in Table 26.

Table 26: Node sensitivity scoring for Hydropower production

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Hydro power	Catchment	0	1	2	1	3	3	0	1	2	0	1	3	0	0	0	0	0	0	0	1	2	0	0	0	0
	Generating water quantity	1	2	3	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
	Generating water quality	0	0	0	0	0	0	1	1	2	1	3	3	0	1	2	0	0	0	0	1	2	0	0	0	0
	Reservoir (infrastructure)	0	1	2	0	0	0	0	0	1	1	2	3	1	2	3	0	0	0	0	0	1	0	1	1	0
	Power Generation Infrastructure	0	2	2	0	0	0	1	1	2	1	2	3	1	2	3	0	0	0	0	0	0	0	2	0	0
	Substation	1	2	3	0	0	0	1	2	2	1	2	3	1	2	3	0	2	2	1	2	2	0	1	0	0
Number of system level "High sensitvities"		2			4			0			6			3			0			0			0	0	0	0

Drought

Drought can impact two key nodes in the hydropower generation system. The most obvious and probably the most important is the impact drought can have on the amount of water available for generating power. Droughts have historically curtailed Tanzania's hydropower output which before the operationalisation of the Julius Nyarere plant, accounted for about 36% of the country's electricity supply, by lowering reservoir levels, causing generation drops of over 50% during major dry spells (International Energy Agency, 2025). Persistent droughts, such as those observed in recent years including 2022, have drastically reduced water inflows to major hydropower reservoirs like the Mtera-Kidatu system (ESI Africa, 2025), causing a sharp decline in generation capacity from an installed 280 MW to about 124 MW during drought periods.

The Julius Nyerere Hydropower Plant, commissioned in 2024 with a 2,115 MW capacity, mitigates this vulnerability by expanding hydropower generation far beyond previous limits. Hydropower however is still vulnerable to reductions in water availability. Climate projections for the 2040 – 2060 period suggest that the drought situation in the critical Rufiji basin is likely to get worse with drought indicators showing increased drought intensity there, with a mean SPEI value of -0.35 indicating a relatively significant drying relative to reference conditions (Table 27). Projections indicate the situation in the Pangani catchment over the 20-year period will remain largely unchanged, largely due to the micro-climate that exists around Mt Kilimanjaro. The extreme case of a 1 in 25 year drought event will see extreme dry conditions in both catchments.

Table 27: Critically important basis with respect to hydropower generation and the projected changes in drought conditions (2040 – 2060).

Basin	Minimum	Maximum	Mean	1:25 year event
Pangani	-0.27	0.45	0.01	-1.97
Rufiji	-0.91	0.14	-0.35	-2.24

Information Box: Interpreting an SPEI score:

The Standardized Precipitation Evapotranspiration Index (SPEI) measures drought by comparing how much water is available (precipitation minus potential evapotranspiration) against what is normal for a location, standardized as deviations from the average. SPEI values are expressed in terms of standard deviations: values near 0 mean normal conditions, positive values mean wetter than normal, and negative values mean drier than normal.

- SPEI near 0: Normal moisture conditions.
- Negative SPEI: Indicates dryness or drought.
- Positive SPEI: Indicates wetness or surplus moisture.
- The further away from zero, the more intense the drought or wetness.

Specifically, values below -1.0 indicate moderate drought, below -1.5 indicate severe drought, and below -2.0 indicate extreme drought.

A second, and often under-considered impact of drought is the impact on the catchment of the water resource. Drought can significantly reduce vegetative cover in a catchment which has the effect of increasing evaporation and reducing water availability. It also results in long term sedimentation of the hydropower reservoir or penstock as high volumes of sediment are carried off the denuded land during the initial rain events after drought is broken. Importantly, this can have significant water quality and associated turbine abrasion impacts. Drought also forces changes in land use in the catchment as livestock farmers look to mitigate drought risks by expanding rangeland through bush-clearing, ultimately leading to further degradation and further sedimentation and water quality problems. Projected changes in SPEI for Tanzania are presented in Figure 38 below.

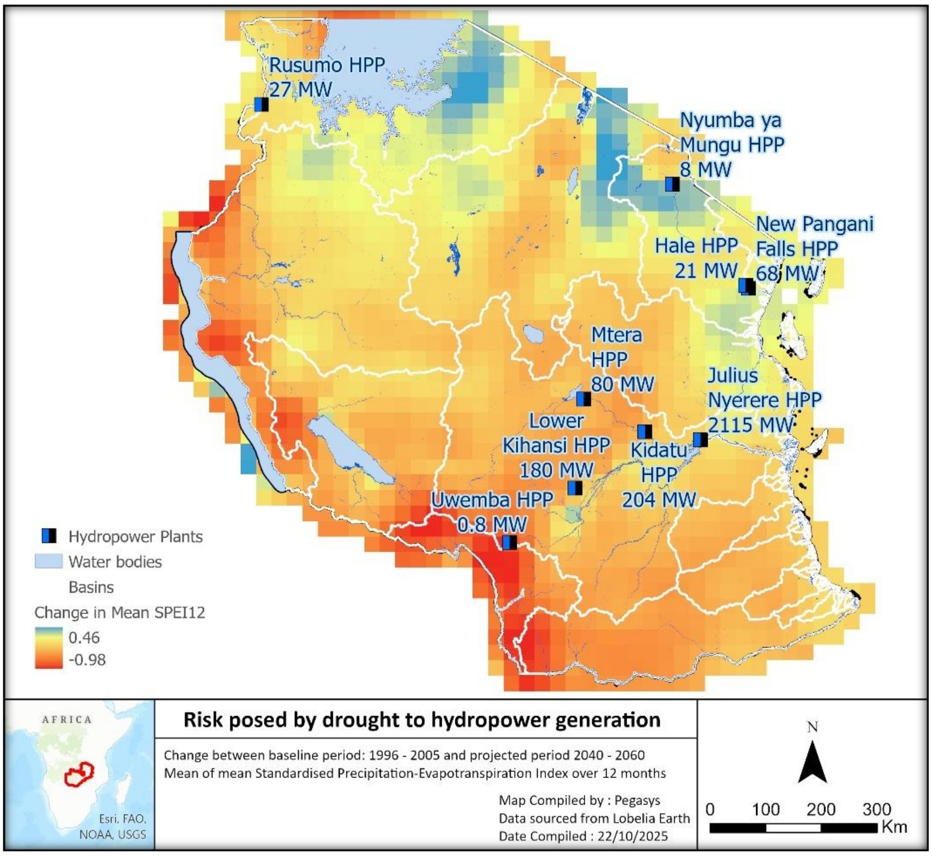


Figure 38: Distribution and magnitude of change in mean SPEI values across the major catchments of Tanzania

Key insight: Projected declines in SPEI indicate worsening drought stress in central and northern catchments, threatening hydropower output and water-dependent industries.

Floods

Floods can significantly impact hydropower infrastructure at various nodes. During flood events, rivers carry much higher sediment loads, which can rapidly accelerate sedimentation in reservoirs. This increased sedimentation not only reduces the reservoir's storage capacity but also affects the dam's ability to attenuate floods, as sediment buildup can block spillways and reduce the effectiveness of flood control mechanisms. High suspended sediments during floods can also severely impact turbines. Sediment-laden floodwaters increase the risk of abrasive damage to turbine blades and other mechanical components, leading to higher maintenance costs and more frequent outages. The sedimentation process can also clog low-level outlets and spillway tunnels, further reducing the dam's ability to safely release floodwaters and manage reservoir levels.

Extreme temperature.

Hydropower systems in Tanzania are increasingly vulnerable to extreme temperatures due to the intensification of evaporation from reservoirs and water bodies. Higher temperatures accelerate water loss, which becomes critical during prolonged dry periods when inflows are already reduced. This evaporation diminishes the volume of water available for power generation, directly impacting electricity supply reliability.

Projected changes in chronic exposure to extreme heat (Figure 39) show the most pronounced increases in southern and eastern Tanzania, particularly around major hydropower assets on the Rufiji River, including the Julius Nyerere Hydropower Plant (2,115 MW). Other facilities such as Kidatu (204 MW), Lower Kihansi (180 MW), and Mtera (80 MW) also fall within zones of elevated heat exposure. These sites are strategic for Tanzania's energy security, as they collectively supply a significant share of national electricity.

Increased evaporation in these areas could compound drought-related risks, creating cascading effects on grid stability. This has direct implications for sectors dependent on reliable power, including ICT infrastructure such as data centres and mobile networks. Without adequate adaptation measures, rising temperatures may undermine hydropower reliability and amplify systemic vulnerabilities across Tanzania's economy.

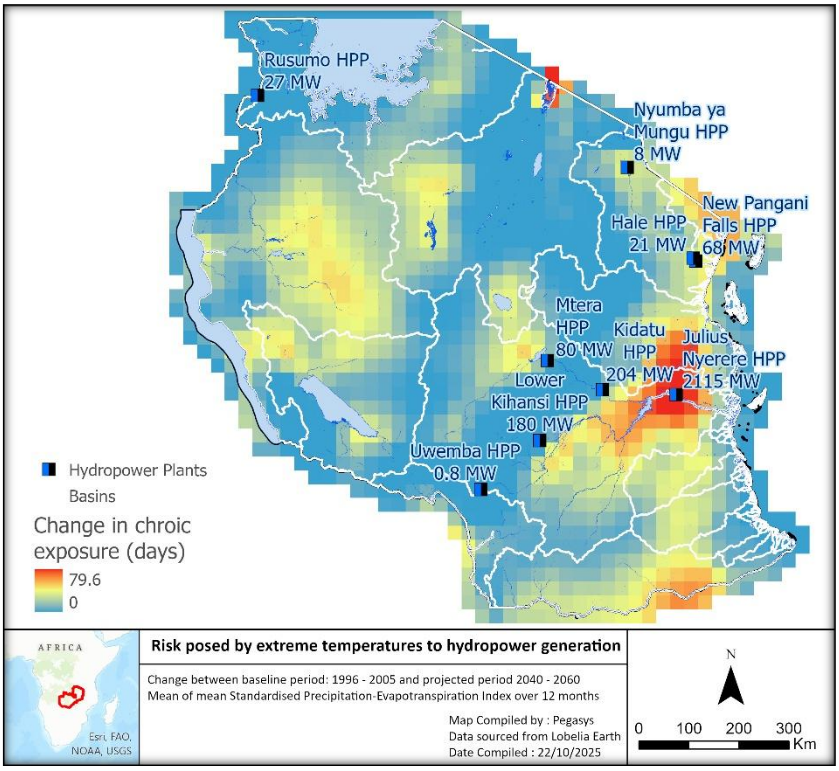


Figure 39: Distribution of change in number of days with a maximum temperature exceeding 35 ^{0}C as an indicator of evaporation risk to hydropower production

Cross-cutting impacts

The hydropower generation system is not significantly dependent on any of the other sectors considered in this report. However, the agricultural sector can have an impact on hydropower generation potential due to the impact agriculture can have on erosion potential and resultant sediment loading of rivers. This can result in the sedimentation of reservoirs and abrasion of turbines.

Generation - Solar power

Solar power constitutes a very small part of the current generation mix in Tanzania, however it is an important component of future planning. As such, it is considered here. As described in Section 3, key solar power generation nodal vulnerabilities exist with respect to hazards of extreme temperatures, flooding, and fire. This is illustrated in the nodal sensitivity heat map in Table 28.

Table 28: Nodal sensitivity heat map for solar power generation in Tanzania

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Solar	Panels	1	2	3	0	1	1	0	0	0	1	2	3	1	1	2	0	1	1	1	2	3	0	0	0	0
	Generating insolation (sunshine)	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Inverter	1	2	3	0	0	0	0	1	1	0	1	3	0	1	1	0	0	0	1	2	3	0	0	0	0
	Substation	1	2	3	0	0	0	1	2	2	1	2	3	0	1	1	0	2	2	1	2	3	0	1	0	0
Number of system level "High sensitvities"		**3**			**0**			**0**			**3**			**0**			**0**			**3**			**0**	**0**	**0**	**0**

Extreme temperature

Solar panel output power decreases approximately by 0.3% to 0.35% (or sometimes up to 0.5%) for every 1°C increase in panel temperature above 25°C. Solar power generation is thus sensitive to chronic exposure to high temperatures with output decreases of up to 5% as temperatures exceed 35°C. In addition to this, high temperatures reduce the conductivity of cables and transmission wires and thus also reduces the potential for grid power contribution.

Fire

Ground-mounted solar power plants are highly vulnerable to fire. The land on which panels are situated is often vegetated and fire can move easily through such an installation. If exposed to fire, severe damage will result to panels, cabling, connectors, inverters and substation equipment. There are currently very few solar plants of significance in Tanzania, mostly on Zanzibar, however, given the growing interest in diversification of the generation mix and a growing commitment to solar power generation, identifying and managing fire risk is an important consideration in locating, designing and managing new solar power plants.

Floods

As with almost all physical infrastructure, solar power facilities are sensitive to flooding. None of the existing solar power facilities in Tanzania are exposed to the projected 1:50 year riverine flood event (considering the regional flood models used in this study and their associated limitations), and so current risk is very low to nil. Future solar power developments should however consider flooding as an important hazard and locate all infrastructure outside of delineated flood areas.

Cross-cutting impacts

Beyond the reliance of the construction phase on infrastructure and manufacturing, solar power generation is not significantly linked to any of the other sectors.

Generation - Thermal power

Tanzania is highly reliant on natural gas fired thermal power stations which comprise approximately 30% of installed capacity. The gas used is almost exclusively sourced from the Songo Songo gas fields. As described in Section 3, key thermal power generation nodal vulnerabilities exist with respect to hazards of extreme temperatures, drought, flooding and intense precipitation. This is illustrated in the thermal power generation nodal sensitivity heat map in Table 29.

Table 29: Nodal sensitivity heat map for thermal power generation in Tanzania

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																									
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Thermal - Natural gas	Generating gas	0	1	1	0	2	2	1	2	3	1	2	3	1	2	3	0	0	0	1	2	2	3	3	0	0
	Generating water	1	2	3	1	2	3	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	3	3	0	0
	Generation facilities	0	1	2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cooling stacks	0	1	2	0	0	0	0	0	0	0	1	1	0	1	2	0	1	1	0	0	0	0	0	0	0
	Substation	1	2	3	0	0	0	1	2	2	1	2	3	0	1	1	0	2	2	1	2	3	0	1	0	0
Number of system level "High sensitvities"		2			1			1			2			1			0			1			2	2	0	0

Figure 40: The Songo Songo gas plant on Songo Songo Island (Image credit Google Earth)

Extreme wind

The vulnerability of the thermal power generation to extreme winds in Tanzania lies mostly with the gas extraction process which entails off-shore drilling and extraction. Extreme winds, particularly related to tropical storms and cyclones are a major hazard to the equipment and workers off-shore in the Songo Songo gas fields. These gas fields include several natural gas wells situated on and around Songo Songo Island, about 15 km from the mainland and 200 km south of Dar es Salaam. Offshore platforms and wellheads in this marine environment are extremely exposed to strong coastal winds, which can cause physical damage to drilling rigs, pipelines, and associated processing infrastructure. The risk of structural failure or mechanical damage from wind-induced forces is significant, potentially leading to gas leaks, operational disruption, or accidents. The offshore location also means that maintenance and emergency responses can be more challenging during high wind events.

Wind speed projection data indicates that winds of up to 80km/hr will potentially threaten the area around the Songo Songo gas plant, placing well heads and platforms at risk. Damage to this infrastructure will threaten the supply of gas to the country's thermal power stations.

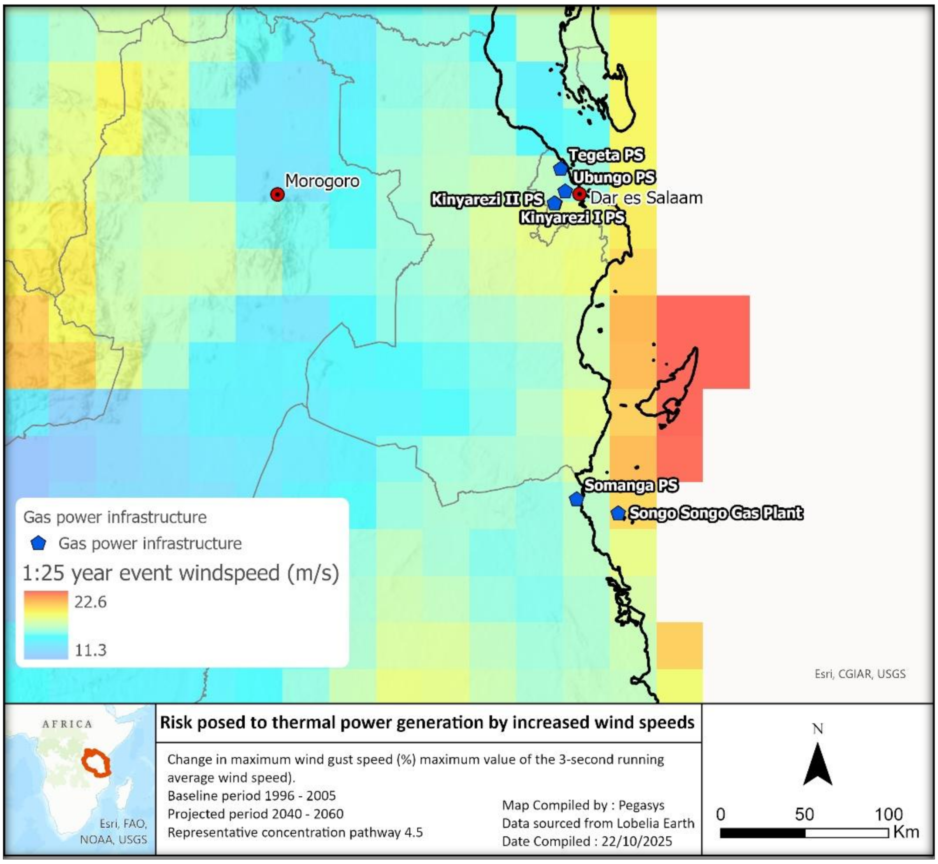


Figure 41: Risk posed to thermal power generation by 1:25 year wind events.

Extreme temperature

Extreme daily maximum temperatures impose risks on thermal power stations. This increases the likelihood of forced outages due to equipment overheating and operational stress. Higher ambient temperatures reduce cooling efficiency, raise the heat rate (fuel consumption per unit electricity), and decrease generation capacity. Equipment such as turbines, boilers, and cooling systems are stressed under high temperature conditions. These impacts increase maintenance requirements, operational costs, and risks of unplanned shutdowns.

All of the gas powered power stations are located along the coastline where the number of days with maximum daily temperatures greater than 35^0C is projected to increase by between 10 and 15 days a year.

Floods

Flooding poses a notable risk to Tanzania's thermal power generation infrastructure, particularly because most gas-fired power stations are located along the coastal belt, including Tegeta, Ubungo, Kinyerezi I & II (Dar es Salaam), Somanga, and the Songo Songo Gas Plant. These areas are highly exposed to pluvial flooding during intense rainfall events and storm surges, which are projected to become more frequent and severe under future climate scenarios.

Pluvial flooding can inundate onshore processing facilities, damage electrical systems, and disrupt access roads critical for maintenance and fuel transport. In Dar es Salaam, where multiple gas plants are clustered, poor urban drainage amplifies flood risk, increasing the likelihood of prolonged outages. For Somanga and Songo Songo, coastal flooding and storm surge events present additional hazards, threatening both infrastructure integrity and operational continuity. Offshore platforms at Songo Songo face compounded risks during cyclonic events, where heavy rainfall combines with high winds and rough seas, making emergency response and repairs extremely challenging.

These flooding hazards, when combined with other climate stressors such as extreme heat and wind, underscore the need for robust drainage systems, elevated equipment platforms, and improved coastal defenses to safeguard Tanzania's thermal power generation assets.

Cross-cutting impacts

Although thermal power generation is part of the energy sector, its vulnerabilities are closely linked to other systems and infrastructure. The most significant cross-cutting risk arises from hydropower variability. During drought periods, reduced hydropower output increases reliance on gas-fired stations such as Kinyerezi I & II, Ubungo, Tegeta, Somanga, and the Songo Songo Gas Plant. If these thermal plants experience operational disruptions due to extreme heat, flooding, or wind hazards, the combined effect can lead to severe grid instability and widespread outages.

Infrastructure dependencies further amplify these risks. Road networks connecting Dar es Salaam and coastal areas to inland regions are critical for transporting spare parts, maintenance crews, and emergency equipment. Flooding or storm damage to these routes can delay repairs and exacerbate outages. Similarly, port infrastructure plays a vital role in importing specialized components for gas plants; disruptions caused by coastal flooding or storm surges could hinder timely maintenance.

Transmission and Distribution

As described in Section 3, key energy transmission and distribution nodal vulnerabilities exist with respect to hazards of extreme temperatures, intense precipitation, flooding, extreme wind and fire. This is illustrated in the energy transmission and distribution nodal sensitivity heat map in Table 30.

Table 30: Nodal sensitivity heat map for the energy transmission and distribution system in Tanzania

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Transmisison	Overhead high voltage powerlines	1	2	3	0	0	0	0	0	0	0	1	2	1	2	3	1	2	3	0	0	1	0	0	0	0
	Substations	1	2	3	0	0	0	1	2	2	1	2	3	0	1	1	0	2	2	1	2	3	0	1	0	0
Distribution	Overhead low volatge powerlines	1	2	3	0	0	0	1	2	3	1	2	3	0	1	2	0	2	3	1	2	3	0	1	0	0
	Substations	1	2	3	0	0	0	1	2	2	1	2	3	0	1	1	0	2	2	1	2	3	0	1	0	0
Number of system level "High sensitvities"		4			0			1			3			1			2			3			0	0	0	0

Extreme temperature

High temperatures reduce the conductivity of transmission cables, affecting grid efficiency. For copper conductors, conductivity loss per degree Celsius above 25°C is approximately 0.40%, meaning that at 35°C, conductivity is about 4% lower than at the reference temperature. Prolonged exposure to temperatures above 35°C, projected to increase across central and coastal Tanzania, will reduce transmission efficiency and increase line losses. This risk is compounded during drought periods when power availability is already constrained, further limiting the ability of the grid to meet demand.

Fire

Wildfires pose a significant threat to distribution infrastructure, particularly in rural areas where transmission lines traverse bushland with high fuel loads. While steel transmission towers are relatively resilient, wooden distribution poles are highly vulnerable to fire damage. Increased fire risk is projected for western and central Tanzania (Figure 42), where prolonged dry spells and high temperatures create conditions conducive to uncontrolled fires. These fires can cause outages and increase maintenance costs.

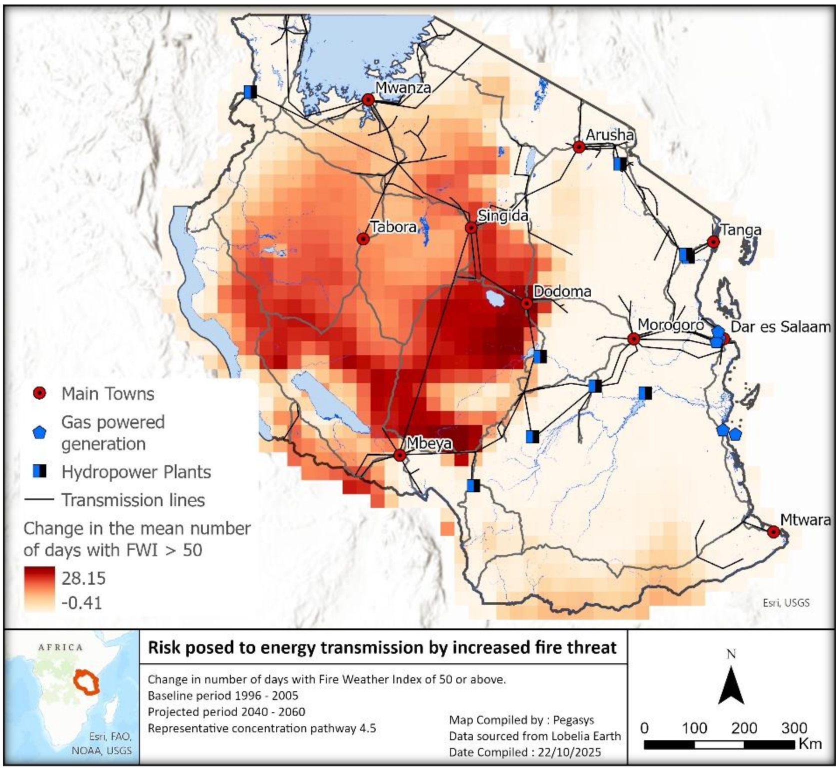


Figure 42: Distribution of the risk to energy transmission (modelled powerline routes) posed by the increased threat of fire

Floods

Flooding is a critical hazard for transmission and distribution infrastructure in Tanzania. Riverine floods can damage or destroy transmission towers, while floodwaters erode foundations, leading to structural collapse. Coastal and low-lying areas, including Dar es Salaam, Bagamoyo, and Rufiji Basin corridors, are particularly exposed to pluvial flooding and storm surge events. Inland regions such as Morogoro and Mbeya, which serve as key transmission hubs, also face risks from intense rainfall and flash floods that disrupt access roads and maintenance operations.

Wind

Strong winds pose a significant threat to electricity transmission lines in Tanzania by causing physical damage and operational disruptions. High wind speeds can lead to mechanical stress on transmission towers and conductors, increasing the risk of tower collapse or conductor breakage. Falling tree branches, often blown down by strong winds, can cause lines to short circuit or touch, leading to widespread outages. Such winds can also increase conductor oscillations and sagging, affecting line stability and clearance. Coastal and exposed regions in Tanzania, prone to cyclones and storms like Cyclone Dikeledi, are particularly vulnerable to wind-related damage to transmission infrastructure. These impacts not only cause power outages but also increase repair and maintenance costs while posing safety risks to workers and the public.

Projected wind speed data (Figure 43) indicates high risk to lines linking the hydropower installations in the Rufiji basin with Dodoma and Mbeya, and the lines converging in Sindinga sub-station to the east of Tabora. Transmission lines located close to the coast are also indicated to be at risk.

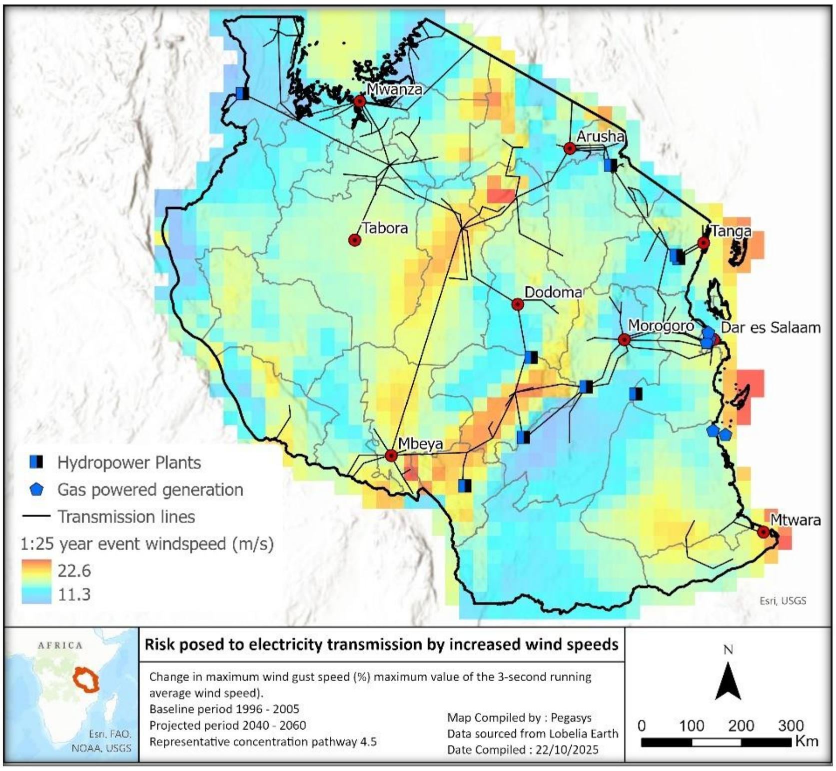


Figure 43: Risk posed by 1:25 year maximum wind speeds to electricity transmission powerlines.

Cross-cutting impacts

Cross-cutting vulnerabilities affecting Tanzania's transmission and distribution system are primarily linked to the construction and maintenance of powerline infrastructure. The manufacture of cement is a critical input for transmission towers, while steel components, though often imported, remain essential for tower construction and reinforcement. These dependencies tie the resilience of the energy sector to the performance of the manufacturing industry, particularly cement production hubs in Dar es Salaam, Tanga, and Mbeya.

For distribution networks, timber poles are widely used and sourced from the domestic forestry sector. Increased wildfire risk and unsustainable logging practices could disrupt supply chains for wooden poles, creating additional vulnerabilities. Furthermore, climate-related disruptions to transport infrastructure, such as flooding of roads and bridges, can delay delivery of these materials and impede emergency repairs, amplifying outage risks.

Manufacturing

There are many climate-driven risk pathways in the manufacturing sector given the wide variety and sources of raw materials, transportation routes and options, the myriad production processes and the many routes to market for different products. The extent of dependence on the energy and infrastructure sector is large which results in some of the most important vulnerabilities to climate hazards being external to the actual factory / production environment. Examples of these critical risks include the loss or interruption of electrical power due to drought impacting on the energy sector or risks of not getting raw materials because of climate related impacts to road and rail infrastructure such as flood damage.

Food, Beverage and Tobacco Manufacturing

As described in Section 3, key food, beverage and tobacco manufacturing nodal vulnerabilities exist with respect to hazards of extreme temperatures, drought, intense precipitation, flooding and fire. This is illustrated in the food, beverage and tobacco manufacturing nodal sensitivity heat map in Table 31.

Importantly, the sensitivities included for the nodes of agricultural production and transport of raw materials and product are essentially duplications of vulnerabilities assessed under the cross-cutting vulnerabilities of the infrastructure, energy and agricultural sectors.

Table 31: Nodal sensitivities for the food, beverage and tobacco manufacturing sub-sector

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Raw materials	Agric cultivation	1	2	3	1	2	3	1	2	2	1	2	3	0	0	1	0	0	1	1	2	3	3	2	1	3
	Transport	1	2	3	0	0	0	1	2	3	0	0	0				0	1	2	0	0	0	3	0	0	0
Production	Processing	1	2	3	1	2	3	0	1	2	1	2	3	0	0	1	0	0	1	1	2	3	3	3	2	0
	Refrigeration	1	2	3	0	0	0	0	0	0	1	2	3				0	0	0	0	0	0	0	3	0	0
Physical distribution	Packaging	0	1	2	0	0	0	0	0	0	1	2	3				0	0	0	0	0	0	0	3	0	0
	Transport	0	0	0	0	0	1	0	0	1	1	2	3	0	0	1	0	0	1	0	0	0	3	2	0	0
Number of system level "High sensitvities"		4			2			1			5			0			0			2			4	3	0	1

Chronic exposure to extreme temperature

Extreme temperature poses multiple risk pathways in food processing, impacting food safety and quality. High temperatures can cause incomplete inactivation of pathogens, leading to microbial contamination and foodborne illnesses such as listeria and salmonella. Over-processing or excessive heat can degrade nutrients and produce toxic compounds like acrylamide. Temperature fluctuations during storage and transportation promote pathogen growth, especially in high-risk foods like ready-to-eat meats and dairy. Additionally, improper temperature control in cooking can allow bacteria to survive and multiply, increasing health risks for vulnerable populations.

Drought

The key risk pathway for drought to impact the sub-sector is through restrictions in water available for critical operations like food cleaning and processing and the washing of equipment. Moreover, drought can elevate input costs like water and energy, reducing profit margins for food and beverage manufacturers.

Cross-cutting impacts

Food, beverage and tobacco manufacturing is highly dependent on other sectors and consequently many of the risks faced by this sub-sector cascade down from other sectors. In considering the value chain, critical climate-driven risks arise firstly in the agricultural sector. Agriculture is highly exposed to climate hazards where extreme temperature, drought floods and fire can all result in the damage or destruction of food crops. Transportation of crop products from farm to production facility and the transportation of products to market are critically dependent on road and rail infrastructure, and impacts from flooding or temperature driven degradation of infrastructure are important to consider.

With respect to the actual production environment, climate-driven risks to the energy sector impose risks to electrically powered processing and packaging equipment and refrigeration.

Textiles

As described in Section 3, key textile nodal vulnerabilities exist with respect to hazards of extreme temperatures, drought, intense precipitation, flooding, extreme wind and fire. This is illustrated in the thermal power generation nodal sensitivity heat map in .

Table 32: Sensitivity heat map for Textile manufacture.

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Raw materials	Agric cultivation	0	1	2	0	1	1	1	2	3	1	2	3	1	2	3	0	0	0	1	2	3	3	2	2	3
	Transport	1	2	3	0	0	0	1	2	3	0	0	0	0	0	0	0	1	2	0	0	0	3	0	0	0
Production	Production facilities	1	2	3	1	2	3	0	1	2	1	2	3	0	1	1	0	2	3	1	2	3	3	3	1	1
Physical distribution	Packaging	0	1	2	0	0	0	0	0	0	1	2	3	0	0	0	0	0	0	0	0	0	0	3	0	0
	Transport	0	0	0	0	0	0	0	1	1	1	2	3	0	0	0	0	0	1	0	0	1	3	1	1	0
Number of system level "High sensitvities"			**2**			**1**			**2**			**4**			**1**			**1**			**2**		**4**	**2**	**0**	**1**

The textile industry in Tanzania primarily revolves around cotton, which is the most important raw material and is grown mainly in the western and eastern cotton-growing zones. Key products from the industry include cotton yarn, woven and knitted fabrics, traditional garments like Kitenge and Khanga, and basic apparel items. Tanzania has a growing organic cotton sector that supports sustainable textile production. Despite existing textile mills and garment factories, much of the cotton is still exported unprocessed, pointing to opportunities for local value addition.

Almost all of the cotton grown in Tanzania is produced in the north west of the country as given in Figure 44 by the 2019/2020 Tanzanian agricultural census. Simiyu Region is the leading producer, generating approximately half of cotton produced in the 2019 / 20 season.

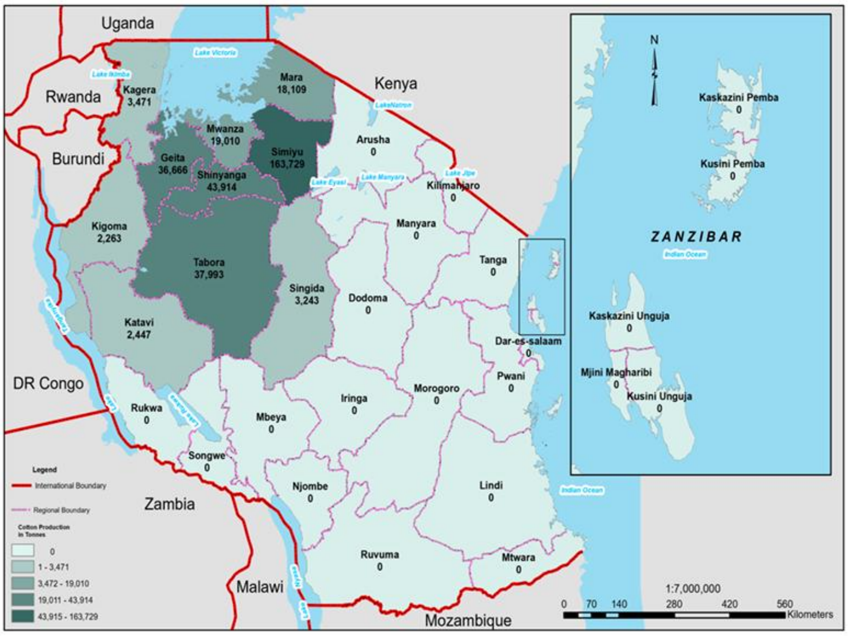


Figure 44: Cotton production in Tanzania 2019/2020 agricultural census.

Extreme temperature

Extreme temperatures are expected to have a number of important impacts on the textile industry in Tanzania. From a **raw material production perspective**, cotton production is likely to be adversely affected by increased exposure to extreme temperatures. Increasing temperatures are likely to increase evapotranspiration and increased plant stress. This will result in reduced crop productivity. Research shows that cotton thrives optimally in daytime temperatures ranging between 20-30°C, with reproductive growth and boll development adversely affected when temperatures exceed about 32-34°C (Fromme, Cothren, & Lem, 2-14).

Increasing global temperatures are also expected to exacerbate problems with pests in the cotton industry. Pests such as jassids (*Cicadidae spp*) and bacterial blight are important pests in the Tanzanian cotton industry. Studies on the cotton bollworm (Helicoverpa armigera), one of the most damaging pests to cotton globally, indicate that rising temperatures can lead to: 1) Increased pest population sizes, especially at lower latitudes where cotton is predominantly grown, 2) More generations of pests per year due to faster development cycles in a warmer climate, 3) Earlier and prolonged activity periods (phenology) of pests, increasing the duration of crop exposure to damage, and 4) Greater overwinter survival rates, leading to higher baseline populations in subsequent seasons.

Research shows that a 1°C increase in accumulated temperature correlates with a significant increase in bollworm moth numbers, with more rapid changes in pest pressure observed in warmer regions. This leads to higher pest infestation risks and challenges in pest management for cotton producers under climate change conditions (Huang, 2021).

The distribution of increased exposure to extreme temperatures (Figure 45) indicates that cotton growing regions are likely to see increased exposure to high, crop damaging temperatures and increased instances of pests and associated crop damage.

Manufacture of textiles is also likely to be impacted by increased exposure to extreme temperatures. Increasing daily maximum temperatures significantly reduce factory worker productivity. Studies show productivity drops about 3% for every 1°C rise above approximately 27°C, with heat stress causing fatigue, dehydration, and cognitive decline that impair workers' efficiency, accuracy, and speed. Heat exposure also increases absenteeism, with hotter conditions driving more workers to miss shifts due to heat-related illnesses or exhaustion. This results in fewer labour hours and lowered output quality, which cumulatively impact industrial throughput and economic performance. Climate projections show (Figure 45) that the major textile manufacturers identified in Tabora, Morogoro and Dar es Salaam and potentially also Arusha and Moshi are likely to see impacts to worker productivity related to increased exposure to extreme temperatures

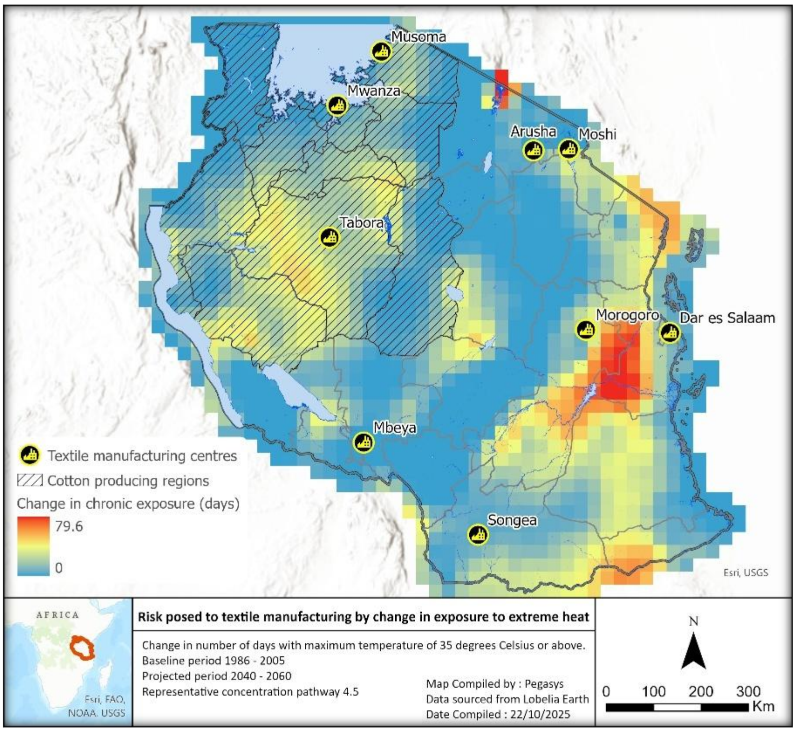


Figure 45: Projected change in the distribution of exposure to extreme temperature overlaying the cotton growing regions and locations of textile manufacturing industries.

Key insight: Manufacturing nodes in central and coastal regions face escalating heat stress, with implications for worker safety, equipment performance, and energy demand.

Drought

Drought significantly impacts Tanzania's textile industry by affecting both raw material production and manufacturing processes. Cotton, the primary raw material, is highly water-intensive, requiring substantial irrigation or rainfall; drought conditions reduce cotton yields and fibre quality, leading to supply shortages and price volatility. Additionally, textile manufacturing processes such as dyeing, washing, and finishing demand large volumes of clean water, making factories vulnerable to water scarcity during droughts. Water shortages can disrupt production schedules, increase operational costs, and force the adoption of costly water-saving technologies.

Climate projection data indicates that drought frequency / intensity is likely to increase across the country as a whole, but most markedly along the western borders (Figure 46). From a textile manufacturing perspective, the most important impacts are indicated to be felt in Mbeya and Songea, and to a lesser degree, in Tabora. Textile factories in these locations are likely to incur increasing costs and production reductions associated with water restrictions.

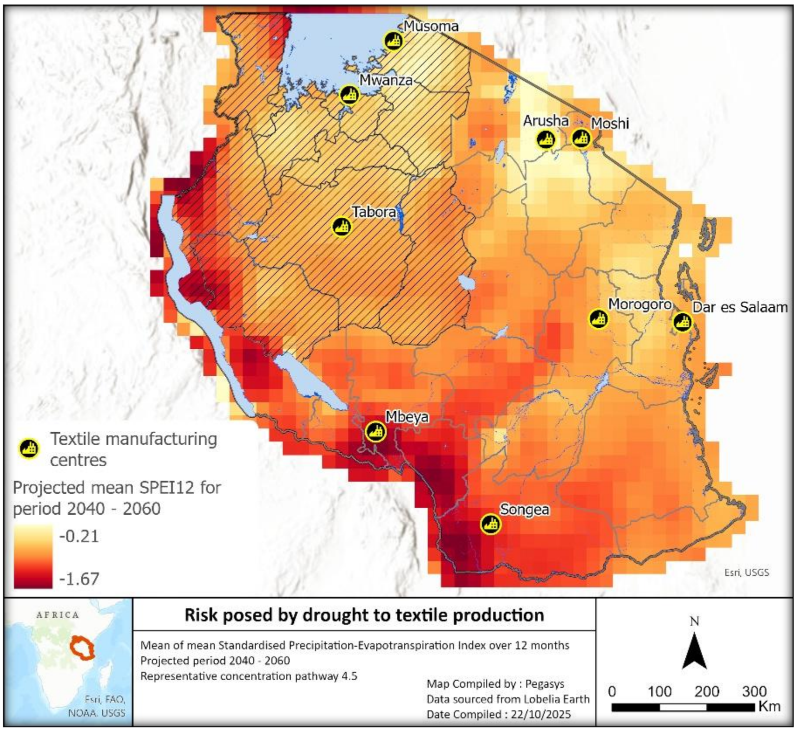


Figure 46: Distribution of projected drought risk to textile manufacturing nodes.

Wildfire

Whilst wildfire in Tanzania is more associated with the forest and woodland environments, it is worth noting that there is a projected significant increase in conditions favoring fire across all of the cotton growing regions of the country (Figure 47). Whilst this represents a low probability risk, where cotton fields are not well protected from fire in adjacent vegetation, the danger exists of wildfire spreading into the croplands and damaging or destroying the crop.

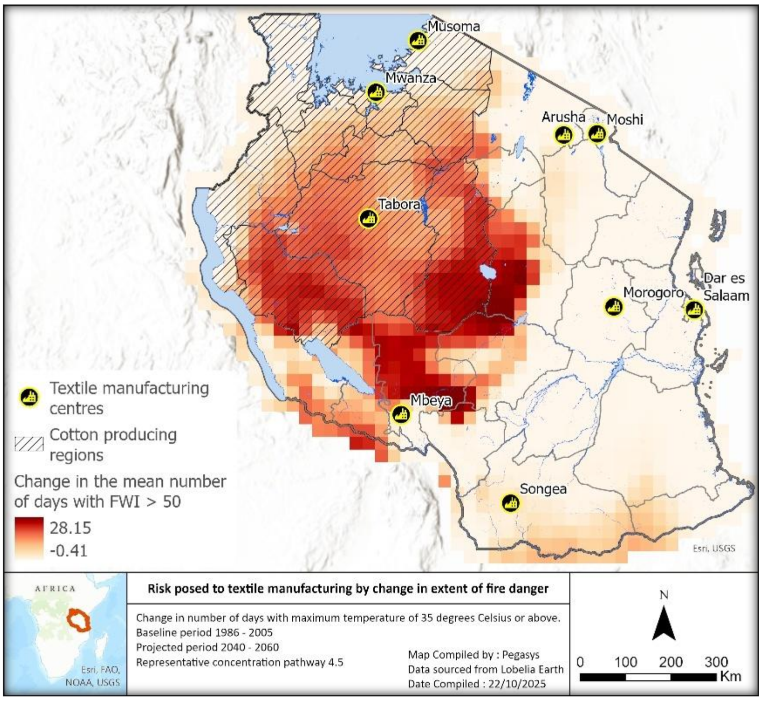


Figure 47: Projected distribution of increasing risk associated with wildfire.

Non-metallic mineral manufacture

As described in Section 3, key non-metal and mineral manufacturing nodal vulnerabilities exist with respect to hazards of extreme temperatures, drought, intense precipitation and flooding. This is illustrated in the Non-metallic mineral products' nodal sensitivity heat map in Table 33.

Table 33: Nodal sensitivity heat map for the non-metallic mineral manufacturing sub-sector in Tanzania

		Extreme temperature			Drought			Intense precipitation			Floods			Sea-level rise			Extreme wind			Fire			Cross-cutting vulnerabilities			
		Scale & Severity of the Hazard																								
System	Node	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	Mi	Mo	Se	In	En	Ma	Ag
Raw materials	Quarry / mine	1	2	3	0	1	2	1	2	3	1	2	3	0	1	3	0	1	2	0	1	2	3	2	0	0
Production	Production facilities	1	2	3	1	2	3	1	2	3	1	2	3	0	1	2	0	1	2	0	1	2	3	3	2	0
Physical distribution	Transportation roads	0	0	0	0	0	0	0	1	2	1	2	3	0	1	1	0	0	1	0	0	1	3	1	0	0
Number of system level "High sensitvities"		**2**			**1**			**2**			**3**			**1**			**0**			**0**			**3**	**1**	**0**	**0**

Chronic exposure to extreme temperature

There is international recognition of the risks to manufacturing worker health and safety imposed by extreme ambient temperatures. Germany's guideline ASR 3.5 recommends 26°C as the maximum comfortable indoor temperature for most office work, with urgent action required above 30°C and work deemed unsuitable above 35°C. China has regulations permitting suspension of outdoor work at 40°C, with limits on work hours when temperatures reach 37-40°C to protect workers. Whilst occupational health and safety legislation does not explicitly prescribe fixed maximum or minimum ambient temperature limits for safe working conditions, the Act emphasizes general duties to provide a safe work environment free from recognized hazards, which would include managing risks from extreme temperatures.

Extreme ambient temperatures can significantly diminish labour productivity by reducing available working hours, impairing workers' health, reducing effort and cognitive sharpness, and causing delays in manual tasks. These effects can lead to slower production rates, increased costs, and higher safety risks, making temperature management a critical aspect of industry resilience and efficiency.

Manufacturing non-metallic mineral products is concentrated in Ndola and in Lusaka. In these centres, the mean number of days exceeding 35^{0}C is projected to increase by between 20 and 30 days a year (Figure 48). Unless mitigated, this increase in heat-stressed days will have an impact on productivity of these facilities.

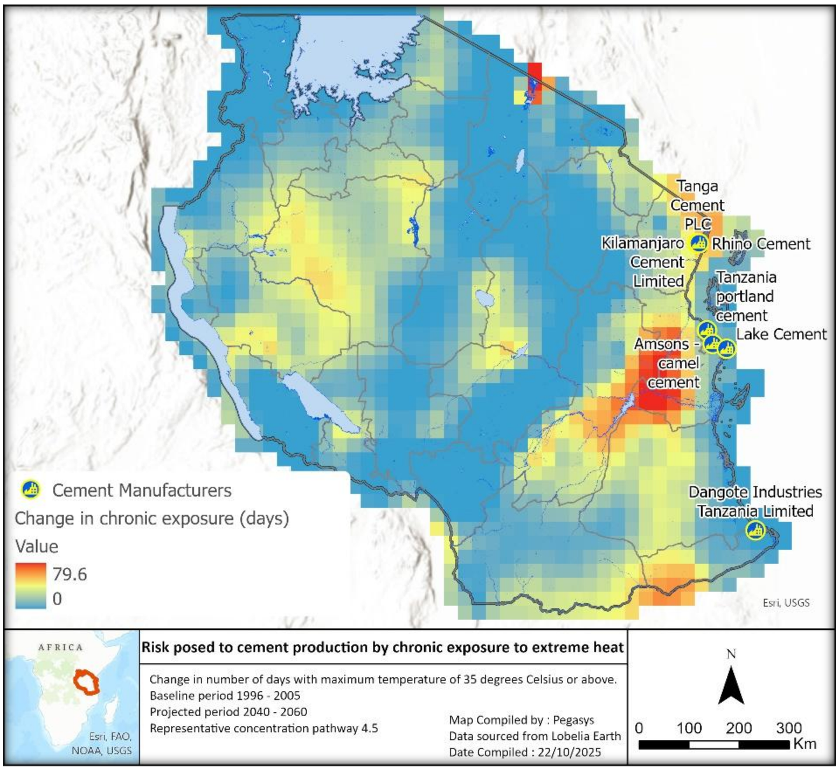


Figure 48: Distribution of risk associated with increasing exposure to extreme heat

Acute exposure to extreme precipitation

Extreme precipitation is an important hazard in this sub-sector given that it will directly impact any outdoor activities that are part of the production process. This will manifest as unsafe working conditions and roads and mine/quarry areas becoming saturated and impassable for heavy machinery. The key production areas are located in Dar es Salaam, Tanga and Mtwara, and the projected increases in mean maximum daily precipitation for these three centres are given in Table 34.

Table 34: Mean maximum daily precipitation for Dar es Salaam, Tanga and Mtwara, given as baseline (1996 - 2005), medium-future projected value (2040 - 2060) and the 1:25 year event value

Urban Centre	1996 Mean (mm)	2050 Mean (mm)	Projected increase (%)	2050 1:25 Yr Event (mm)
Dar es Salaam	51.9	55.6	7.1	95.8
Tanga	84.9	104.3	22.9	262.5
Mtwara	57.6	65.6	13.8	124.4

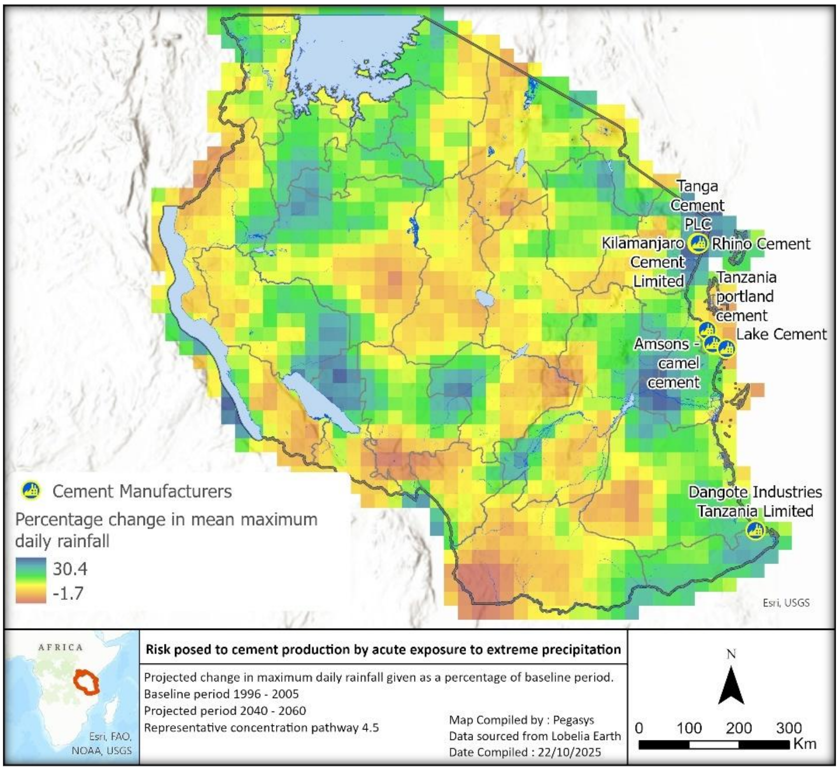


Figure 49: Distribution of risk associated with increasing exposure to extreme precipitation

Summary of Major Tanzanian Climate Risks

The analysis identifies three interconnected climate risk narratives that define Tanzania's resilience and investment priorities:

Drought and Energy Security

Tanzania's hydropower system, which provides about 65% of national electricity, is concentrated in the Rufiji River Basin and other inland catchments. This system is highly vulnerable to climate variability. By mid-century, temperatures are projected to rise by 2–3°C, increasing evaporation rates and reducing reservoir storage—especially during prolonged dry periods when inflows are already low. These dynamics threaten generation capacity at strategic sites such as the Julius Nyerere Hydropower Plant (2,115 MW) and Kidatu (204 MW). Reduced water availability could lead to significant power shortages, creating cascading effects on grid stability and sectors that depend on reliable electricity, including ICT and manufacturing. In response, diversifying generation through solar and gas investments will be essential to stabilize the grid and sustain economic growth.

Energy insecurity has far-reaching consequences for Tanzania's economy, particularly for manufacturing hubs in Dar es Salaam, Morogoro, and Mwanza. These hubs rely on uninterrupted power for production processes. Textile and apparel factories, which require continuous electricity for spinning, weaving, and garment finishing, are especially vulnerable to outages. Prolonged power rationing would raise production costs, disrupt supply chains, and undermine competitiveness in regional export markets.

Heat Stress and Productivity

Average annual temperatures are projected to rise most sharply across central and southern Tanzania, with a marked increase in extremely hot days (above 35°C) in historically cooler areas. These conditions pose serious challenges to worker productivity, occupational safety, and asset durability. Heat stress can reduce labour productivity by 5–15% in exposed sectors such as agro-processing, textiles, and logistics, which employ large numbers of women and youth. Industrial hubs in Dar es Salaam, Morogoro, and Mbeya are particularly vulnerable. Heat also accelerates road surface degradation and increases electricity demand for cooling, straining an already climate-sensitive energy system. Adaptation measures such as passive cooling, shift rescheduling, and solar-powered ventilation can deliver measurable productivity and health benefits.

Flooding, Connectivity, and Trade

Fluvial and pluvial flooding associated with extreme rainfall events is projected to increase in spatial extent, particularly in coastal and central regions and along major river systems. Dar es Salaam, already prone to urban flooding, faces heightened risk from drainage failures and sea-level rise. Inland transport corridors linking Dodoma, Morogoro, and Mbeya to regional trade routes are also exposed to intensified rainfall and slope instability. Flood events disrupt road and rail infrastructure, curtailing logistics and regional exports to Kenya, Zambia, and Malawi. Even moderate increases in rainfall intensity can render secondary and tertiary road networks impassable, impacting agriculture supply chains and industrial operations. For the financial sector, recurrent flood damage to transport and warehousing assets poses growing credit and insurance risks, underscoring the need for resilient transport design, improved drainage systems, and diversified trade routes.

OPPORTUNITY IDENTIFICATION AND PRIORITISATION

Introduction

This section identifies adaptation options that respond to the climate risks identified in the sections above as being of particular relevance in Tanzania. As a starting premise the analysis recognises that not all adaptation response options, while they may be socially and economically desirable, present viable investment opportunities for Commercial Banks in Tanzania. In addition while some solutions may have an investment case suitable for private finance, the nature of some solutions, due to their return and risk profile, will be suitable for other providers of finance, such as multi-lateral finance institutions or equity and project developers. Accordingly, analysis looked to integrate considerations of commercial relevance for banks early to focus on relevant sector and solutions.

Approach Summary

To establish investment opportunities for Commercial Banks in Tanzania, the following three steps where followed:

1) A extensive database[2] of broadly applicable adaptation investment opportunities was built for seven sectors of infrastructure, energy and manufacturing. This was developed based on reviewing and compiling options identified in international taxonomies such as those produced by the organisation Tailwind and the Climate Bonds Initiative, as well as sector specific adaptation databases such as that produced by the EDHEC Climate Institute[3]. Where necessary this was supplemented by industry research by the assignment team, which provided a foundation for identifying response opportunities in each sector and to select options that responded to specific climate risks in Tanzania.

2) To allow the team to focus on the sectors within Infrastructure, Energy and Manufacturing most relevant for Commercial Banks, a basic materiality assessment was conducted. Figure 50 provides the framework against which the seven sectors were scored and weighted, ultimately resulting in a ranking of the sectors, and the selection of the 2 highest-ranked ones. This explored a) The level of current Commercial Bank lending to key sectors, based on aggregate Central Bank data, with a 30% weight b) An assessment of the extent to which explicit Policy or Regulatory pressures can be expected to increase commercial bank lending to those sectors in the future, with a 30% weight and c) Impact, which provided an assessment of each sectors potential to deliver benefits to women, youth, low-income or marginalized groups based on a contextualized understanding of factors such as women's employment in the workforce, with a 40% weight. This materiality assessment provided a basis to focus analysis on key sectors and ensure relevance for Commercial Banks

   Details of the analytical framework used, the comparative weightings given to each measure as well as the criteria for segmentation scoring can be found in the appendix.

[2] The database contains approximately 400 specific measures that can be taken to build adaptation. The Tailwind classification was utilised to assign these measures into groups: Physical Asset, Intelligence, Products and Services and Finance and Insurance.

[3] A list of key taxonomies and databases can be found in the appendix to this document.

Segmentation Criteria

Ranking Criteria			
Criteria Category	**Sub-Measure / Description**	**Sub Indicators and Sources** *These will be assessed to inform scoring*	**Weighting**
1. Current commercial bank lending	**% of commercial bank loan book** allocated to sub-sector, per country | *Lagging Indicator*	▪ Central Bank Data on Aggregate Commercial Bank lending using standardised categories ▪ Corroborating data and informed estimates[1]	*30%*
2. Future commercial bank lending	**Clear Policy or Regulatory Pressures** that would drive increased commercial bank lending to sub-sector, per country | *Leading Indicator*	▪ National 5-year plans, sector investment plans ▪ National Adaptation Plans ▪ Capital & regulatory-treatment policies ▪ Government tax and subsidy plans ▪ ESG and sustainability policies	*30%*

3. Inclusive Socio-economic development and impact potential	Assessment of sub-sectors potential to deliver benefits to women, youth, low-income or marginalized groups. [2]	▪ Informed by contextual country GESI analysis of sub-sector participation rates, and impacts on women, youth and marginalised groups
		▪ Specific considerations informing scoring include:
		  ▪ Female employment share in sector %
		  ▪ Reduction in time burden for women and youth from greater access - % of time spent per day
		  ▪ Micro, Small or Medium Sizes Enterprises (MSME's) in the sector – participation rate as %
			40%

1: See data limitations slide below for more detail

2 Will incorporate an assessment of the scale of that potential and the degree to which benefits accrue direct or indirectly. For example transport may deliver a primary benefit via enhanced access to markets while contributing to economic growth as a secondary benefit)

Figure 50: Segmentation criteria used for sector selection

As presented in Figure 51, our analysis identified Housing and Manufacturing as the two key sectors of highest relevance for further analysis, clearly outperforming other sectors on combined lending exposure, policy relevance, and inclusive impact potential.

In these cases Commercial Banks already allocate a material portion of their loan books to the sectors, with approximately 40% of commercial bank lending going to the Personal and Household sector (the largest lending category), assuming a large share is allocated to home and building purchase or retrofit[4], and approximately 10% to manufacturing (Tanzania Ministry of Finance and Planning, 2021).

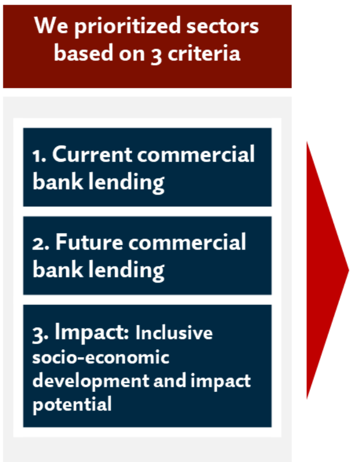
There is a strong basis to believe that Tanzanian domestic policy and regulatory commitments will drive increasing commercial bank lending into manufacturing and housing. On the manufacturing side, the Tanzanian government has set a target of a 23% share of GDP from the manufacturing sector by 2025 which, although yet to be achieved, shows great commitment to growing the sector (Ministry of Industry and Trade of the United Republic of Tanzania, 2025). In housing, the government has prioritised expanding affordable housing supply, acknowledging a nationwide deficit of around 3 million units with an annual increase of 200,000 units (Habitat for Humanity, 2025), and is strengthening the enabling environment through measures such as the creation of the Real Estate Regulatory Authority and continued support to mortgage market development via the Tanzania Mortgage Refinance Company (TMRC).

The benefits of scaling adaptation solutions in both housing and manufacturing are clear. In housing, climate risk is intensified by the prevalence of informal settlements, which accommodate 70–80% of urban residents (ICLEI – Local Governments for Sustainability, 2025) and are often located in flood-prone, underserved areas, making inhabitants disproportionately vulnerable. In manufacturing, particularly small-scale and food-processing subsectors, women represent a significant share of the workforce and operate many SMEs that face thin margins and limited capital buffers. Strengthening

[4] Central bank data does not clearly disaggregate spending on housing purchase, construction or retrofit. We must therefore make assumptions about what proportion of the Household and Personal Category are plausibly spent on housing. Solid data-points here are hard to establish, despite significant effort. So, in absence of this we make the crude assumption that given the comparably large size of housing in the average household spending basket - In the range of 25-35% we take the mid-point of 30% and apply it here (30% of 40% = 12%). Given the separate categories of mortgages for Tanzania at 1.6% of the total loan book we can assume a low end estimate of 13.6% of the full commercial bank loan book.

climate-resilient infrastructure and services in these sectors can therefore directly reduce climate-related production disruptions and support more stable livelihoods for vulnerable groups.

To help us focus on investment opportunities of acute interest to commercial banks, we prioritized sectors based on 3 criteria



Housing & Manufacturing are the most relevant sectors in Tanzania based on our analysis

Sub-sector	Total Weighted Score	Rank
Housing	**3.4**	**1**
Manufacturing	**2.6**	**2**
Energy	2.2	3
Waste	2.0	4
Telcoms/ICT	1.8	5
Water	1.6	6
Transport	1.4	7

Figure 51: Summary of scoring results for sector prioritisation

3) Evaluation of adaptation opportunities responding to climate risks in the Tanzanian housing and manufacturing sectors.

Having determined Housing and Manufacturing as sectors for focus, detailed analysis was then conducted to examine the climate risks facing these sectors and identify promising adaptation investment opportunities. The detailed analysis can be found in the Appendix.

For the manufacturing sector seven value chains where examined, to establish the degree of solution relevance for the foods, beverages, tobacco, metals (aluminium, iron and steel), non-metallic minerals and cement, chemicals and pharmaceuticals, and textiles – given that these represent the main manufacturing value chains (Ministry of Finance and Planning, 2016), on top of their differing contexts and production processes.

The relevance of different solutions was then scored *(0= low relevance, 1= moderate relevance, 2= significant relevance),* with those having benefits for multiple value chains prioritised. In the housing sector, solutions where screened according to those with most relevance to the private sector as well as the climate adaptation impact potential.

For both sectors, solutions that had different value chains with a significant degree of relevance were then scored for the degree of technology readiness and supply-chain maturity, and, wherever possible, supported by data-backed evidence on the feasibility of each solution for private-sector investment (*Low, Moderate and High scores).* This included indications of existing implementation or track record in Kenya or comparable markets - alongside the potential for positive impact on Women, Youth and Social Inclusion - which will become an area of more detailed focus in the subsequent development of investment briefs.

Solutions that had a high score in technology readiness and supply-chain maturity were then identified as being relevant the priorities for Commercial Banks in the Tanzania manufacturing and housing sector. Figure 52 provides a summary of the entire selection and scoring process, while the detailed scoring results are found in the Appendix.

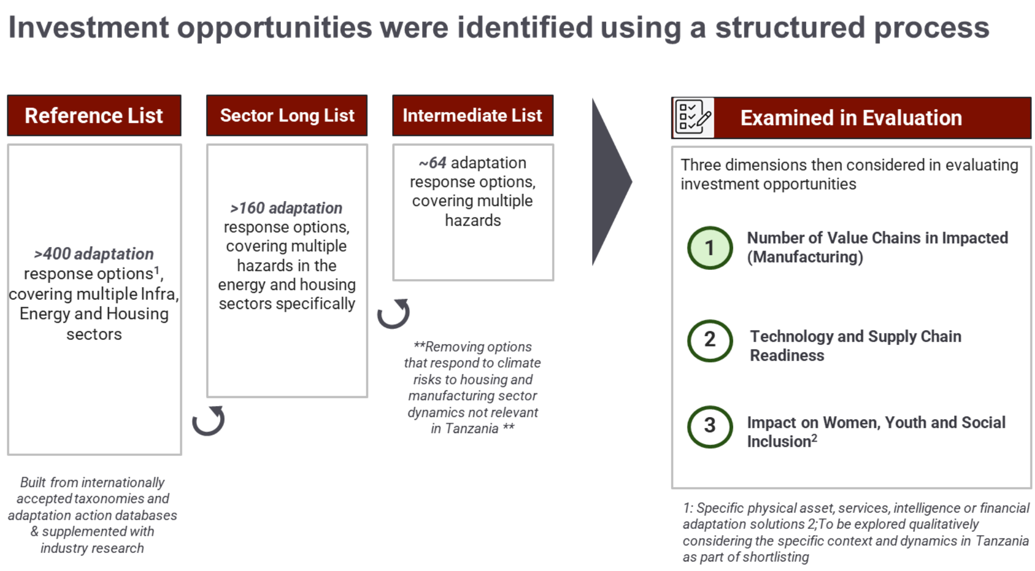


Figure 52: Summary of sector specific investment opportunity analysis

Manufacturing Sector Opportunities

This section summarizes the adaptation opportunities identified as being most relevant for Commercial Banks in the Tanzanian manufacturing sector. These respond to prominent climate risks including drought, floods, fires in particularly exposed regions (often forested or woodland areas such as Tabora, Mbeya and near lake Victoria) and temperature increases in particular.

We provide further detail in the appendix of how the analysis was developed based on the varying relevance of different investment solutions to mitigating climate risks in significant manufacturing value chains. We also look at the technology and supply chain maturity of solutions and their potential to support social impacts for marginalized groups.

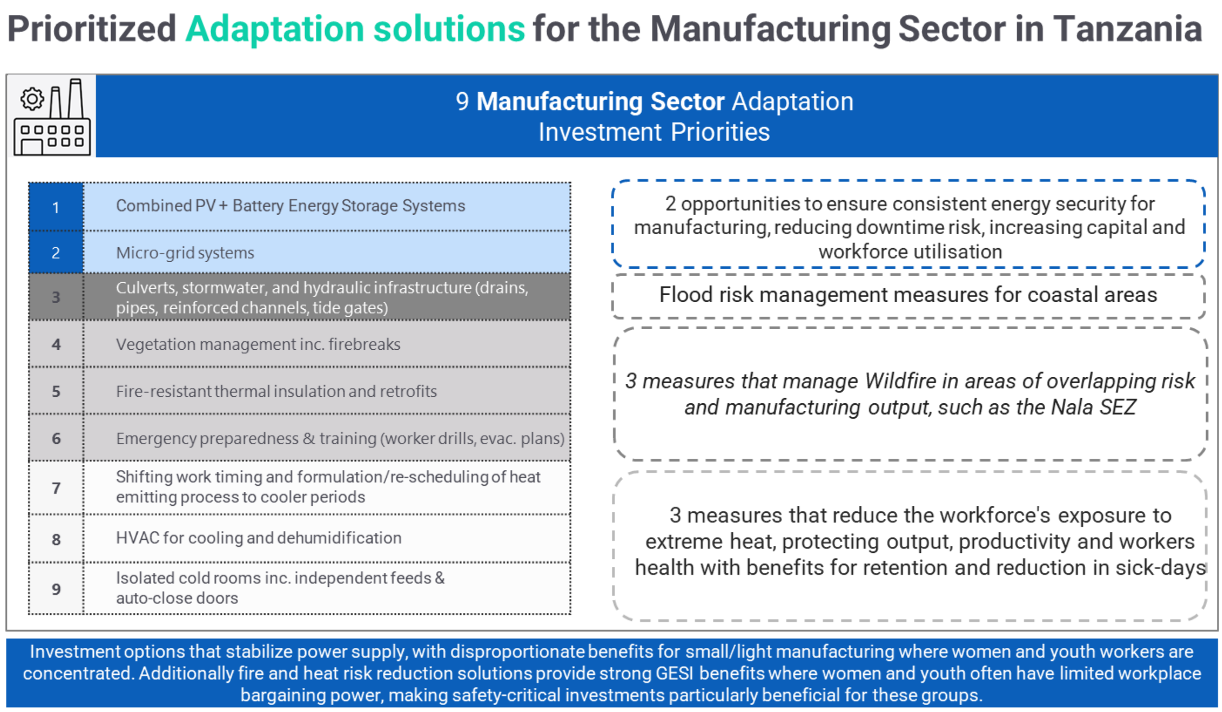


Figure 53: Prioritized solutions for the Tanzania Manufacturing sector

In summary, the analysis suggests nine specific investment opportunities are relevant in Tanzanian manufacturing, and these can be grouped into four categories:

1. Opportunities to mitigate drought risk and its impact on energy production by accelerating deployment of energy alternatives such as micro-grids and solar PV with battery storage

Tanzania has made substantial progress in building the resilience of its energy system and enhancing energy access over recent years. Reliance on hydropower has been reduced significantly, from above 60% to below 35% as natural gas has become the dominant source of installed capacity. In addition, according to the World Bank, electricity access increased from 14% of the population in 2011 to over 40% by 2022.

However drought and its impact on hydro-power is still a pronounced systemic climate risk in Tanzania's energy system in which grid reliability also remains a serious issue. Power outages continue to impose real costs on Tanzanian businesses. The World Bank Enterprise Survey revealed that power outages in Tanzania cost businesses an estimated 15% of annual sales. Industry representatives have noted that manufacturers face serious consequences from power cuts, including being forced to use generators and incurring additional costs, with some suspending production[5].

While solar has significant potential in Tanzania its remains a negligible portion of installed and grid-connected power (<1%). While plans for greater participation of Independent Power Producers (IPP's) exist, there are significant regulatory and institutional constraints. So, unlike regional peers like Zambia, analysis suggests less direct opportunity for Commercial Banks in either defensive measures for existing renewable energy (through mitigating physical climate risks to renewable energy generation sites) or lending to new IPP's.

However, distributed power generation, particularly through solar PV, battery storage, and micro-grid solutions, is expanding across Tanzania. These systems include both standalone solar-plus-battery installations for residential and industrial users, as well as projects integrated into local distribution networks under the country's well-established Small Power Projects framework.

This growth has been driven by strong policy support for mini-grid development, led by government institutions such as Tanzania's Rural Energy Agency alongside dedicated development financing programs, including the Sustainable Energy Fund for Africa.

The cost competitiveness of utilising distributed power for manufacturing when these sites are connected to the grid maybe a barrier, given low tariffs. However, independent assessments (like those done by NREL & Energy 4 Impact) show that connecting Maize mill's in Tanzania to solar-PV-plus-battery mini-grid reduced the mini-grid's levelised cost of energy by approximately 14%, demonstrating the commercial viability of energy-intensive productive use. However it is likely that the business case for this solution in Tanzania is likely to be most compelling when displacing diesel generators, when factoring grid outages and failures or for those not connected to the grid, rather than a direct $ cost per KwH comparison.

Alternative energy solutions | Descriptions

#		Solution	Description
1		Combined PV + Battery Energy Storage Systems (BESS)	PV+BESS projects pair solar power generation with batteries so some solar output can be stored and discharged later (evenings/peaks), improving reliability on a hydro-leaning grid.
2		Microgrid Systems, powered by RE	Often highly coupled, i.e microgrids based on PV + BESS Microgrid or mini-grid systems are localized electricity generation, storage, and distribution networks operating independent of, or loosely connected to, the main grid.

Figure 54: Alternative energy solutions

2. Measures that help protect manufacturing assets from floods and sea-level rise

Analysis suggests that a second set of investment priorities relates to reducing the physical exposure of manufacturing assets to flooding, coastal inundation, and sea-level rise. These priorities focus on strengthening hydraulic and stormwater infrastructure, including culverts, drainage systems, reinforced channels, and tide-gates, to safeguard industrial zones and ensure continuity of production.

Tanzania's manufacturing sector is disproportionately clustered in low-lying coastal and riverine areas, most notably Dar es Salaam, Tanga, and parts of Morogoro and Mwanza. These locations are already experiencing more frequent flash floods, tidal surges, and prolonged waterlogging as climate impacts intensify. The World Bank estimates that Dar es Salaam alone incurs flood-related economic losses exceeding USD 100 million annually, much of which results from disrupted transport, damaged industrial facilities, and lost production time. This implies that flood and sea-water inundation will be issues at sites including the following; Benjamin Mkapa SEZ at Mabibo, Kwala SEZ in Kibaha, Bagamoyo Eco Maritime City as well as the Lower Msimbazi Basin in the central-west of Dar es Sallam, already identified by the World Bank and Government as one of the city's most flood-prone areas.

Existing drainage and hydraulic systems are insufficient to cope with rapidly growing urban populations or more intense rainfall. Ageing culverts, undersized stormwater channels, and poorly maintained drainage pipes contribute to significant surface flooding, particularly around industrial estates and logistics corridors. In coastal zones, the absence of adequately engineered tide-gates and backflow prevention systems means high tides and storm surges routinely push seawater into drainage networks, compounding flood severity and accelerating the degradation of transport infrastructure and industrial assets.

These challenges present clear opportunities for climate-smart upgrades. Investment in modern culverts, expanded stormwater drainage grids, reinforced concrete channels, and engineered hydraulic structures can significantly reduce flood frequency and duration in industrial areas. International experience shows that relatively modest investments in tide-gates and one-way valves dramatically improve the effectiveness of existing drainage systems by preventing seawater intrusion. For example, in Mombasa, Kenya coastal industrial district, installation of reinforced culverts and tidal backflow systems reduced flood-related disruptions to manufacturing operations by more than 30% within two years.

In Tanzania, such interventions align closely with national climate resilience priorities under the National Adaptation Plan and urban development strategies that emphasise resilient infrastructure. While public-sector financing has historically dominated this space, there is scope for private finance models—particularly where hydraulic upgrades directly protect industrial parks, logistics hubs, or high-value manufacturing clusters.

Flood risk mgmt. for manufacturing | Descriptions

#		Solution	Description
2	 	Manufacturing sites can deploy a range of hydraulic infrastructure solutions to manage flood risk including: 2.A Permanent hard & green NBS engineering solutions 2.B Emergency & Rapid-Deployment Flood solutions	**Permanent hard engineering solutions** ▪ Install culverts to safely convey water under roads, access routes etc ▪ Implement stormwater management systems such as catch basins, sumps, and detention/retention structures to control runoff ▪ Use engineered drains and pipeline networks or green infra. to direct surface and subsurface water away from production areas ▪ Construct reinforced drainage channels to handle high-volume flows, prevent erosion, and ensure long-term durability under industrial loading. ▪ Integrate tide gates in coastal or tidal regions to stop seawater intrusion **Emergency & Rapid-Deployment Flood solutions** ▪ **Use modular, rapid-placement flood barriers** (e.g., water-filled, interlocking, or weighted systems) to create instant protection around key assets, access roads, or vulnerable buildings. ▪ **Deploy temporary flood walls or barriers** that can be quickly installed ahead of severe weather to prevent flow entering production areas. ▪ **Install high-capacity mobile pumps** to rapidly remove standing or rising water from critical operational zones, loading areas, and basements.

Figure 55: Flood Risk Management Solutions for Manufacturing Sites

3. Measures that manage wildfire in areas of overlapping risk and manufacturing output

Wildfire risk is rising in several Tanzanian regions where manufacturing facilities border savannah or peri-urban vegetation such as the industrial zones in Nala SEZ in Dodoma as well as Arusha, Kilimanjaro, and Mbeya. Fire events disrupt production, damage equipment, and pose safety risks for workers.

Practical adaptation measures include improved vegetation management. This can include regular clearing, controlled burns, and the establishment of firebreaks to reduce ignition and slow fire spread. Such approaches have been effective in comparable industrial settings across East and Southern Africa. In addition site retrofits, such as fire-resistant thermal insulation, ember-proof vents, and heat-resistant roofing, can significantly reduce structural vulnerability, especially for facilities handling combustible materials.

Finally, strengthened emergency preparedness—worker drills, evacuation plans, and coordination with local fire services—helps minimise injury and downtime when fires do occur. Together, these interventions offer a cost-effective pathway to protecting manufacturing assets and maintaining operational continuity under growing wildfire risk.

Measures that manage Wildfire in manufacturing areas | Descriptions

#		Solution	Description
4		Vegetation management inc. firebreaks	Reduce wildfire and grassfire risk by clearing brush, trimming vegetation, and maintaining defensible spaces around factory sites. Firebreaks prevent external fires from reaching buildings, lowering the likelihood of major asset damage and production downtime.
5		Fire-resistant thermal insulation and retrofits	Upgrade roofs, walls, and equipment areas with non-combustible insulation (e.g., mineral wool, fire-rated panels) to slow fire spread and protect critical machinery. These materials also boost energy efficiency, reducing operating costs while improving fire resilience.
6		Emergency preparedness & training (worker drills, evac. plans)	Implement regular evacuation drills, clear emergency procedures, shutdown protocols, and worker training. Strengthens response to fires and extreme weather, reduces injury risk, and improves business continuity by ensuring rapid, coordinated action.

Figure 56: Flood Risk Management Solutions for Manufacturing Sites

4. Measures that reduce the workforce's exposure to extreme heat, protecting output, productivity and workers health with benefits for retention and reduction in sick-days

Rising temperatures and more frequent heatwaves identified in the CRVA are already affecting productivity in Tanzania manufacturing sector, where many production lines involve manual or heat-intensive processes. Excessive heat reduces worker concentration, increases fatigue, and raises accident and absenteeism rates, all of which translate into lower output and higher costs. These impacts are especially acute in sectors with high internal heat loads, such as food and beverage processing, where boilers, ovens, and dryers compound ambient heat. This is also likely to be an issue in Tanzania's textiles sector - identified by the CRVA as being at risk in the Dar es Sallam and Morogoro regions.

One practical response is shifting work schedules and sequencing heat-emitting processes to cooler periods of the day. Early shifts, night operations, and re-scheduling of thermal processes have been shown to materially reduce heat stress without affecting throughput. Several large processors in East Africa already apply staggered shifts and thermal-process timing to sustain productivity during hot seasons.

Mechanical cooling solutions also play an important role. Targeted use of systems focusing on active cooling, ventilation, and dehumidification can stabilise indoor temperatures, protect sensitive equipment, and significantly reduce the risk of heat-related illness. While capex can be a constraint, energy-efficient units and zoned cooling strategies help keep costs manageable.

In facilities where temperature control is mission-critical, such as beverage bottling, dairy, or meat processing, **isolated cold rooms with independent power feeds and auto-close doors are essential to ensure both worker safety and product integrity**. These systems reduce cold-chain losses, prevent heat contamination, and allow staff to rotate into cooled zones during high-heat periods.

Practical adaptation measures include **shifting work timing and rescheduling heat-emitting processes to cooler morning or evening periods**, to maintain safe indoor temperatures, and using heat barriers or baffles to separate hot machinery from work areas.

These investments deliver commercial benefits through improved efficiency and reduced downtime. By creating safer, cooler workplaces, manufacturers can sustain production levels, protect worker wellbeing, and enhance operational resilience.

Manufacturing solutions that manage extreme heat risks | Descriptions

#		Solution	Description
7		Shifting work timing and formulation/re-scheduling of heat emitting process to cooler periods	Change high heat tasks and the peak-heat steps (e.g., sugar crystallization, high-temp curing) into **early mornings, evenings, or nights** to avoid the day's highest Wet Bulb Globe Temperature (WBGT). Pair with brief, scheduled cool-down breaks. **Higher output per labor hour** (less heat-related slowdown/absenteeism); **fewer safety incidents**.
8		HVAC for cooling and dehumidification	Targeted **mechanical cooling + humidity control** (HVAC or spot cooling, plus industrial dehumidifiers) to keep process rooms, packing lines, and electronics/instrumentation within spec. Especially useful for **food processing & beverages and pharma**.
9		Isolated cold rooms inc. independent feeds & auto-close doors	Design cold rooms as **thermally isolated spaces** with their own electrical feeds, sealed partitions, and **auto-close/rapid-close doors** to prevent temperature loss. Reduces heat ingress during peak-temperature periods, stabilises product quality, and cuts refrigeration energy loads. Particularly valuable for **food processing, beverages, pharmaceuticals, and any heat-sensitive inventory**.

Figure 57: Extreme Heat Management Solutions for Manufacturing Sites

Table 35 below provides a recap of adaptation benefits each solution contributes to, as well as the GESI impact it can offer.

Table 35: Adaptation Benefits and GESI Impacts of Manufacturing Solutions

Solution	Adaptation Benefit	GESI Impact
Combined PV + Battery Energy Storage Systems	Improves reliability of power on a hydro-dominated grid; reduces outages and production losses; stabilises voltage for sensitive equipment.	Supports women- and youth-led SMEs that cannot afford frequent downtime; reduces reliance on diesel, lowering operating costs for low-margin enterprises.
Micro-grid systems	Provides decentralised, climate-resilient electricity for industrial zones and underserved areas; reduces dependence on central grid and hydropower variability.	Expands energy access for women-owned micro-manufacturing and services; creates local jobs for youth in installation, operation, and maintenance.
Culverts, stormwater, and hydraulic infrastructure (drains, pipes, reinforced channels, tide gates)	Reduces flood frequency and depth at factory sites; protects machinery, stock, and access roads; lowers clean-up and repair costs; improves business continuity.	Protects employment in labour-intensive sectors where women and youth are concentrated; reduces income shocks for workers with limited savings.
Vegetation management and firebreaks	Reduces wildfire and grassfire spread to industrial sites; lowers ignition risk; protects buildings and outdoor storage.	Safeguards peri-urban workers, including women and youth in low-wage roles; reduces evacuation risks for persons with disabilities and caregivers.
Fire-resistant thermal insulation and retrofits	Slows fire spread; protects critical machinery and structures; reduces damage and downtime after fire events.	Protects workplaces where women and youth are concentrated in packing, processing, and assembly; reduces asset loss for smaller, locally owned firms.

Solution	Adaptation Benefit	GESI Impact
Emergency preparedness and training (drills, evacuation plans)	Improves response to fires and extreme weather; reduces injuries and fatalities; shortens recovery time and disruption.	Enhances safety for all workers, especially women, youth, and PWDs who may face greater barriers during emergencies; builds skills and confidence among staff.
Shifting work timing and rescheduling heat-emitting processes	Reduces worker exposure to peak heat; lowers heat-related absenteeism and accidents; maintains productivity during hot periods.	Protects women and youth in labour-intensive roles; benefits workers with health vulnerabilities who are more affected by extreme heat.
HVAC for cooling and dehumidification	Keeps process rooms, packing lines, and electronics within acceptable temperature and humidity ranges; protects product quality and equipment.	Improves working conditions for women and youth; reduces heat stress in enclosed spaces where lower-paid workers are often concentrated.
Isolated cold rooms with independent feeds and auto-close doors	Reduces heat ingress; stabilises product quality; cuts refrigeration energy loads; protects temperature-sensitive goods during heatwaves and outages.	Supports food and beverage value chains where many women work in processing and handling; reduces spoilage-related income losses for smaller firms.

The manufacturing-focused adaptation solutions identified in this report align closely with Tanzania's NDC and NAPA priorities. The Updated NDC (The United Republic of Tanzania, 2021) emphasises renewable energy expansion, including decentralised solar systems and mini-grids, directly supporting the deployment of PV-BESS and renewable microgrids for industrial zones – driven by the target of reducing greenhouse gas emissions economy-wide between 30-35% by 2030. The NDC also calls for energy-efficient technologies and improved resilience of productive sectors to heat stress, aligning with HVAC upgrades, heat-resilient building design, and shift rescheduling. The NAPA (The United Republic of Tanzania, 2007) prioritises strengthening resilience to floods and coastal hazards, which corresponds to riverbank protection, improved drainage, and rapid-deployment flood management measures for manufacturing sites. Measures to reduce wildfire risk - such as vegetation management and fire-resistant retrofits - also align with NAPA's emphasis on protecting economic assets from climate-induced disasters. Together, these policies confirm that the proposed manufacturing solutions directly advance Tanzania's national adaptation agenda.

Housing Sector Opportunities

This section summarizes the adaptation opportunities identified as being most relevant for Commercial Banks in the Tanzanian housing sector. These respond to prominent climate risks including floods and sea-level rise (with coastal areas like Dar es Salaam being particularly exposed), extreme heat, and wildfires, exacerbated by extreme winds.

We provide further detail in the appendix of how the analysis was developed based on the varying relevance of different investment solutions to mitigating key climate risks. We also look at the technology and supply chain maturity of solutions and their potential to support social impacts for marginalized groups.

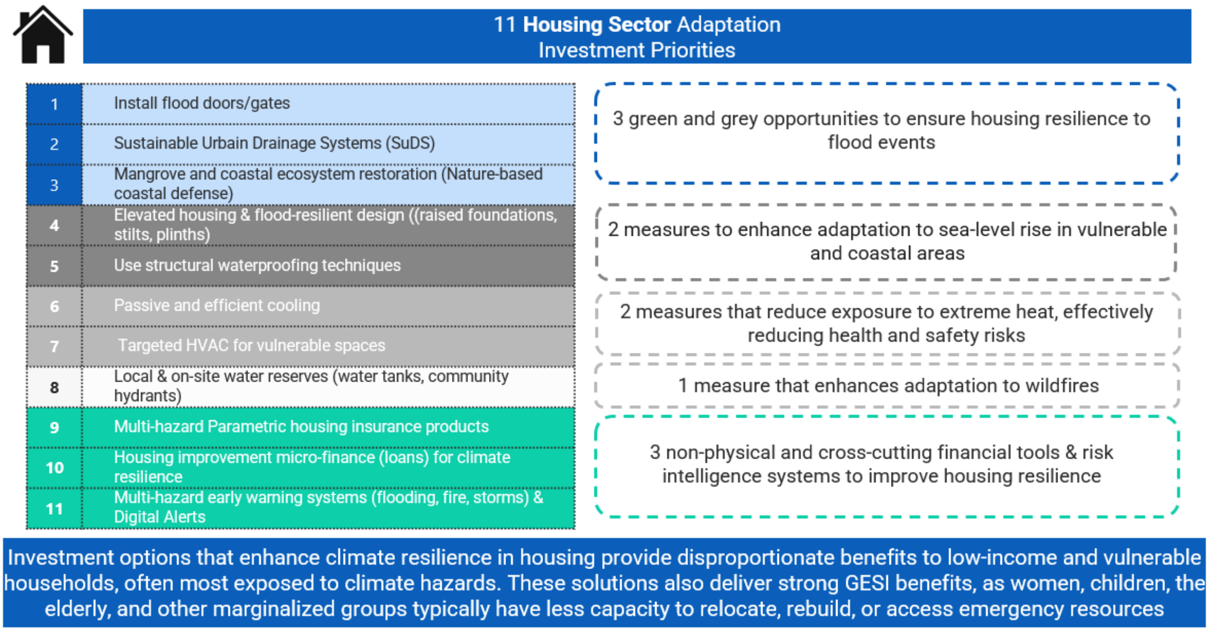


Figure 58: Prioritized solutions for the housing sector

In summary, analysis suggests investment priorities within housing come in five broad categories:

1. Three measures that reduce the housing sector's exposure to flood risk

Flooding remains one of the most disruptive hazards for Tanzania's housing sector, especially in low-lying and unplanned settlements where affordable housing is concentrated. Housing systems are highly sensitive across all nodes (foundations, walls, roofs, water and sanitation, and electricity), which can fail rapidly during pluvial or fluvial floods. The 2018 Dar es Salaam floods illustrate this: nearly **12,000 people** were affected, and dozens of houses collapsed or were severely damaged. With climate change driving higher maximum daily rainfall, the number of flood-prone homes is expected to rise, particularly in low-income neighbourhoods built on marginal, poorly drained land - causing property damage, sanitation disruption, and displacement.

These 3 measures can mitigate flood risk by relying on either **green** (natural and semi-natural areas and features designed to deliver a wide range of environmental, economic, and social benefits) or **grey** (conventional, human-made systems that use hard building materials like concrete and steel to provide essential services, often for a single purpose) infrastructure solutions.

The first solution is the **installation of flood doors/gates**, which are secure installations at street level to reduce flow of flood water into properties, protecting from flood damage. There is evidence of commercial/institutional buildings using them (Floodbreak, 2025) and product sold in marketplaces, available for general public to purchase.

Sustainable Urban Drainage Systems (SuDS) are green infrastructure solutions (such as swales, permeable pavements, retention ponds, and constructed wetlands) to help manage stormwater by slowing and infiltrating runoff. These systems reduce peak flows and mitigate flooding pressure on drainage networks, making them highly relevant for dense residential areas.

Another efficient green solution is **Mangrove and coastal ecosystem restoration** (Nature-based coastal defence). Nature-based defences are already being scaled up in Tanzania. For instance, UNEP-backed projects in Dar es Salaam restored mangrove belts, rehabilitated storm drains, and stabilized shoreline vegetation to buffer tidal surges and protect coastal communities (UNEP, 2017). There is growing momentum backed by national and international organizations, with the high carbon capture potential of mangrove restoration playing a key role in that growth (IPP Media, 2025).

Green and Grey Flooding Solutions | Descriptions

#		Solution	Description
1		Install flood doors/gates	Secure installations at street level to reduce flow of flood water into properties, protecting from flood damage.
2		Sustainable Urban Drainage Systems (SuDS)	Green infrastructure solutions (such as swales, permeable pavements, retention ponds, and constructed wetlands) to help manage stormwater by slowing and infiltrating runoff.
3		Mangrove and coastal ecosystem restoration (Nature-based coastal defense)	Mangrove and coastal ecosystem restoration rebuilds mangrove belts and shoreline vegetation whose dense root systems absorb wave energy, reduce tidal surge impacts, and naturally protect coastal areas from flooding and erosion

Figure 59: Measures to address flood risk in housing

2. Two opportunities to address sea-level rise, a key climate risk in coastal areas especially for informal settlements.

Tanzania's coastal settlements (especially informal areas in Dar es Salaam and Zanzibar) are highly exposed to sea-level rise, which is driving chronic inundation, shoreline erosion, and increasing saltwater intrusion into groundwater. Affordable and social housing frequently sits on **cheaper, low-elevation land** where recurrent tidal flooding weakens foundations, damages walls, and compromises sanitation networks. Saltwater intrusion also threatens domestic water systems and accelerates material degradation. As sea levels continue rising, some areas face progressive loss of habitable land, particularly where drainage is already poor. Informal settlements, with limited structural resilience, face the most acute impacts.

The first solution identified is **elevated housing design and flood-resilient design**. Many households in flood-prone areas already respond with adaptive measures: surveys show that nearly 46% of Tanzanian households already raise foundations (stilts/plinths), build protective embankments, or elevate thresholds to reduce flood risk (Urban Resilience and Sustainability, 2024). Flood-resilient housing design also entails backflow prevention devices, which can play a significant role in stopping contaminated water or sewage from reversing flow and entering the clean potable water during high flows; and upgraded roof drainage systems, which can handle high-intensity rainfall, prevent water accumulation, and reduce maintenance compared to traditional gravity systems. Institutionalizing these practices, through raised plinths, stilts, elevated utilities, and flood-resilient site grading, can significantly reduce repeated water damage and loss.

Secondly, **structural waterproofing measures**, which involve using water-resistant materials and construction techniques such as cement-stabilised masonry, sealed renders, damp-proof courses, gasketed doors/windows and hydrostatic flood vents, can create a barrier against tidal inundation and surge-driven water ingress. In a storm surge or high tide, these measures prevent salt or flood water from penetrating walls, protect electrical and plumbing systems, and allow trapped water to drain or evaporate without compromising the building's integrity – effectively reducing structural loss and shortening recovery time. UNEP-backed coastal adaptation programmes already promote such resilient designs (UNEP, 2017).

Measures for sea level rise adaptation | Descriptions

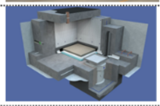
#		Solution	Description
1		Elevated housing & flood-resilient design (raised foundations, stilts, plinths)	Raising foundations (stilts/plinths), build protective embankments, elevate utilities, and use flood-resilient site gradingto reduce flood risk.
2		Use structural waterproofing techniques	Using water-resistant materials and construction techniques such as cement-stabilised masonry, sealed renders, damp-proof courses and gasketed doors/windows to create a barrier against tidal inundation and surge-driven water ingress

Figure 60: Measures for sea-level rise adaptation

3. Opportunities to address extreme heat, which creates significant safety risks in housing

Rising temperatures and more frequent heatwaves are a growing threat to Tanzania's housing sector, particularly in informal settlements where poor ventilation, metal roofing, limited vegetation, and inadequate insulation create extreme indoor heat. These areas can reach temperatures far exceeding outdoor conditions, increasing health risks and mortality for vulnerable groups. Health facilities in Dar es Salaam have already been identified as heat-vulnerable, indicating system-wide exposure. For low-income households, limited access to cooling infrastructure compounds the risk. With climate change intensifying heatwaves, extreme heat is becoming a major resilience concern for both households and community services.

Passive and efficient cooling, which are design-based solutions like cross-ventilation, ceiling fans, shading devices, thermal mass, reflective roofing, and insulation to help moderate indoor temperatures without heavy energy use. They are increasingly incorporated into urban housing projects in Dar es Salaam and Dodoma, creating clear entry points for private developers and lenders to scale climate-responsive design (Ikingura, Grabiec, & Radomski, 2025).

Targeted HVAC in critical or communal buildings (e.g., health facilities, daycare centers) offer an effective way to reduce heat stress, protect health, and maintain comfort during extreme heat. Because these systems are installed only where they add the most value, they remain commercially viable for developers and financiers while significantly improving resilience in high-risk housing assets. Over time, as Tanzania scales up renewable energy generation, these HVAC systems could be progressively powered by clean energy, further reducing operating costs and emissions.

Measures for adaptation to extreme heat | Descriptions

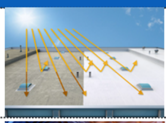
#		Solution	Description
1		Passive and efficient cooling	Design-based solutions like cross-ventilation, shading devices, thermal mass, reflective roofing, and insulation to help moderate indoor temperatures without heavy energy use.
2		Targeted HVAC for vulnerable spaces	Targeted Heating, Ventilation, and Air Conditioning (HVAC) in critical or communal buildings (such health facilities & daycare centers) offer an effective way to reduce heat stress, protect health, and maintain comfort during extreme heat

Figure 61: Measures for adaptation to extreme heat

4. One opportunity to address wildfires based on localized firefighting resources

Wildfire risk is rising in Tanzania's peri-urban and vegetated zones, where settlements are expanding into savannah and bushland. Many homes, especially informal units built with flammable materials such as timber and thatch, are highly susceptible to ignition, leading to rapid structural loss and severe safety risks. Informal housing is particularly vulnerable due to weaker construction and limited fire-resistant materials. Hotter and drier conditions linked to climate change increase fire frequency and intensity, raising the likelihood of repeat incidents.

Local & on-site water reserves (such as water tanks and community hydrants) can provide immediate firefighting resources before municipal services arrive. These solutions coincide with existing rainwater-harvesting practices widely promoted by government and NGOs across Tanzania, making them easier to integrate into both formal and informal housing. This approach builds fire resilience into housing design, leveraging locally available resources and community infrastructure.

Measures for adaptation to wildfires | Descriptions

#		Solution	Description
1		Local & on-site water reserves	Local & on-site water reserves (such as water tanks and community hydrants) can provide immediate firefighting resources before municipal services arrive.

Figure 62: Measure for wildfire adaptation

5. Three cross-cutting financial tools & risk intelligence systems to improve housing resilience

Beyond hard infrastructure, several solutions could also help the housing sector better adapt to key climate risks

Parametric housing insurance products are the first solution, covering loss and damage from flooding, heat, storms and wildfires (main climate hazards). Smart insurance products with climate triggers can help households recover quickly from disasters. In Tanzania, providers such as Stanbic Bank and ICEA Lion already offer property-insurance products that could be scaled or adapted into parametric formats.

Additionally, **Housing improvement micro-finance (loans)** for climate resilience upgrades can support renovation works such as support roof fixing, floor improvements, structural reinforcement, water-resistant retrofits, and sanitation upgrades. These could also serve to formalise land titles, associated administrative costs being a key hurdle to formalization, deepening climate hazard exposure. There is growing momentum: Habitat for Humanity has documented demand, DCB Bank offers such micro-loans, and Tanzania Mortgage Refinance Company (TMRC) is looking to expand the low-income housing finance sector in Tanzania.

Multi-hazard early warning systems (MHEWS) and digital alerts: Tanzania is rolling out climate early-warning services covering floods, storms, fires, and heat via the Tanzania Meteorological Agency's Multi-hazard early warning service (MHEWS) and the National "Early Warnings for All" initiative. These initiatives create untapped opportunities for the private sector for subscription-based or service-oriented digital alert platforms tailored for homeowners, residential communities, and housing associations, providing real-time warnings for floods, storms, fires, and heat. Platforms could integrate with smart-home systems, deliver risk analytics for insurers or lenders, and offer value-added services such as preparedness guidance or automated building responses. Big Tech and Artificial Intelligence can support Early Warnings for All (World Meteorological Organization, 2023); companies such as Google and Meta have signalled interest and even commitment to this growing market.

Cross-cutting financial tools & risk intelligence measures | Descriptions

#		Solution	Description
1		Multi-hazard Parametric housing insurance products	Parametric insurance products covering loss and damage from flooding, heat, storms and wildfires can help households recover quickly from disasters.
2		Housing improvement micro-finance (loans) for climate resilience	Housing improvement micro-finance for climate resilience upgrades can support renovation works such as support roof fixing, floor improvements, structural reinforcement, water-resistant retrofits, and sanitation upgrades; and serve to formalize land titles, associated administrative costs being a key hurdle to formalization, deepening climate hazard exposure.
3		Multi-hazard early warning systems (flooding, fire, storms) & Digital Alerts	Subscription-based or service-oriented digital alert platforms tailored for homeowners, residential communities, and housing associations, providing real-time warnings for floods, storms, fires, and heat.

Figure 63: Cross-cutting financial tools & risk intelligence measures

Table 36 below provides a recap of adaptation benefits each solution contributes to, as well as the GESI impact it can offer.

Table 36: Adaptation Benefits and GESI Impacts of Housing Solutions

Solution	Adaptation Benefit	GESI Impact
Flood doors/gates	Reduces inflow of floodwater into homes; limits structural damage and loss of household assets.	Protects low-income and women-headed households in flood-prone areas who have limited capacity to repair or relocate.

Solution	Adaptation Benefit	GESI Impact
Sustainable Urban Drainage Systems (SuDS)	Slows and infiltrates runoff; reduces pluvial flooding in dense neighbourhoods; improves local drainage.	Benefits informal settlements where women and youth are over-represented; reduces health risks from standing water for children and elderly people.
Mangrove and coastal ecosystem restoration	Reduces tidal surge impacts and coastal erosion; protects shoreline housing and local infrastructure.	Safeguards coastal communities where women engage in small-scale trade and fisheries; protects informal housing clusters with limited formal protection.
Elevated housing and flood-resilient design	Reduces exposure to floodwaters; protects structures and contents; lowers frequency of disruptive inundation.	Supports vulnerable households with few assets; reduces displacement and school/work disruption for women, youth, and children.
Structural waterproofing	Limits tidal and surge-driven water ingress; reduces mould, damp, and long-term structural degradation.	Improves health conditions for children, elderly people, and PWDs; reduces repeated repair costs for low-income households.
Passive and efficient cooling	Lowers indoor temperatures; improves comfort and habitability; reduces need for energy-intensive cooling.	Protects infants, pregnant women, and elderly residents from heat stress; benefits households that cannot afford mechanical cooling.
Targeted HVAC in critical/communal buildings	Maintains safe temperatures in health facilities, daycare centres, and community buildings; ensures continuity of essential services during heatwaves.	Supports women as primary caregivers and users of health and childcare services; protects young children and vulnerable patients.
Local and on-site water reserves (tanks, community hydrants)	Provides immediate firefighting resources and backup water during supply disruptions; enhances wildfire response capacity.	Reduces time and physical burden on women and girls who collect water; improves safety for dense, low-income settlements at wildfire risk.
Multi-hazard parametric insurance products	Provides rapid payouts after floods, heatwaves, storms, or wildfires; supports faster recovery and rebuilding.	Offers a financial buffer for low-income and women-headed households with limited savings; reduces long-term poverty traps after disasters.
Housing improvement micro-finance for climate-resilient upgrades	Enables incremental improvements (roof fixing, structural reinforcement, water-resistant retrofits, sanitation upgrades); strengthens housing resilience.	Expands access to finance for women and informal-settlement residents who lack collateral; can support formalisation of land titles over time.
Multi-hazard early warning systems and digital alerts	Provides real-time warnings for floods, storms, fires, and heat; enables timely evacuation and asset protection.	Improves safety for women, youth, and PWDs who may have limited access to traditional warning channels; supports community-level preparedness.

Housing-related adaptation measures are also strongly supported by Tanzania's national climate frameworks. The NDC (The United Republic of Tanzania, 2021) prioritises climate-resilient settlements, directly aligning with elevated housing, structural waterproofing, reflective roofing, insulation, and natural ventilation. The NAPA (The United Republic of Tanzania, 2007) identifies coastal protection, urban drainage, and flood-risk reduction as urgent priorities, supporting the inclusion of SuDS, flood doors, and mangrove restoration. The NDC further emphasises strengthening early-warning systems and expanding access to climate-risk information, aligning with digital alerts and multi-hazard early-warning systems. Measures to address wildfire risk, such as defensible space and fire-resistant retrofits, also reflect NAPA's focus on reducing climate-related disaster impacts on vulnerable households. These housing solutions therefore directly operationalise national commitments to protect communities, reduce climate-related displacement, and strengthen resilience in rapidly growing urban and coastal areas.

CONCLUSION

Tanzania's IEM systems are at a pivotal moment: economic ambitions for industrialisation and urban development intersect with intensifying climate hazards that threaten assets, services and livelihoods. The risk-pathway analysis in this report demonstrates that climate impacts have tangible credit and operational implications for commercial bank clients while also defining adaptation solutions across housing and manufacturing sectors. These findings form a foundation for deeper work to follow: assessing demand for climate-resilient housing and manufacturing solutions, quantifying the scale of market opportunities, and identifying the barriers and enablers that shape how Commercial Banks can most effectively support adaptation investment in Tanzania.

Risk Pathways: understanding exposure

The energy system is a principal conduit for systemic climate risk: variable hydrology, heat-related performance degradation and network resilience constraints can produce frequent outages that raise operating costs and increase default risk among energy-dependent firms and households. For Tanzania, where grid expansion coexists with areas of weak reliability, stabilising power supply through decentralised generation and storage is a primary adaptation pathway that can also meets mitigation objectives.

Housing and urban systems represent a second major risk pathway. Flooding and coastal inundation directly damage housing stocks, disrupt water and sanitation services, and precipitate displacement and recovery costs that fall heavily on low-income groups and borrowers. These physical shocks translate into concentrated credit stress for lenders exposed to formal mortgage portfolios, housing-loans and small business lending in affected neighbourhoods.

Manufacturing faces compound exposure from energy instability, water scarcity and heat stress: production interruptions, quality losses and labour productivity declines all undermine cash-flows and repayment capacity. These risks are amplified in labour-intensive subsectors for women and youth who are disproportionately fragile, with limited workplace bargaining power. Transport and logistics disruptions from flooding further propagate supply-chain fragility, creating systemic consequences for trade-oriented enterprises.

Opportunities for Commercial Banks: financing climate adaptation

Housing and Manufacturing emerged as the two most relevant sectors for adaptation finance for Tanzania's Commercial Banks, together accounting for nearly 25% of current lending, based on three criteria: (i) the scale of existing bank exposure, (ii) the strong policy and regulatory momentum driving private investment in both sectors, and (iii) their impact potential, with respect to their ability to deliver gender-responsive and inclusive resilience outcomes. This focus reflects where climate risk and financial opportunity most clearly intersect and where targeted investment can deliver both economic and social returns.

In the manufacturing sector, adaptation opportunities fall into four complementary categories aligned with Tanzania's industrial growth and decentralised energy ambitions. The first focuses on energy alternatives that diversify and stabilise supply, including combined PV + battery energy storage systems (BESS) that store solar power for peak periods and renewable-powered microgrids that improve reliability in industrial parks and underserved production zones. The second category comprises flood and coastal protection measures, such as expanded culverts, stormwater drains, reinforced channels and tide gates that safeguard factory sites in flood-prone urban and coastal regions. A third set of opportunities addresses wildfire risk in peri-urban manufacturing clusters (particularly areas such as the Nala SEZ) through vegetation management, firebreaks, fire-resistant insulation upgrades and strengthened emergency preparedness systems. Finally, solutions to extreme heat risk include rescheduling heat-emitting processes to cooler hours, deploying HVAC and dehumidification systems in production and packing lines, and expanding isolated cold rooms with independent power feeds to protect product quality. Together, these measures reinforce operational continuity, stabilise productivity and offer scalable adaptation lending opportunities for Commercial Banks serving SMEs and larger industrial borrowers.

In the housing sector, adaptation opportunities centre on improving climate resilience and reducing health and safety risks through five complementary pathways. The first includes green and grey flood-resilience

measures: flood doors and gates that block water entry, targeted SuDS that slow and infiltrate stormwater, and mangrove and coastal ecosystem restoration that buffers tidal surges and reduces erosion. The **second set of opportunities addresses sea-level rise**, combining elevated housing designs (stilts, raised foundations, plinths) with structural waterproofing solutions such as cement-stabilised masonry, sealed renders, damp-proof layers and gasketed openings to limit saltwater ingress. **A third set of solutions responds to extreme heat**, using passive cooling measures (cross-ventilation, ceiling fans, shading, reflective roofing and insulation) alongside targeted HVAC systems in health facilities and community buildings to protect vulnerable residents. A **fourth opportunity strengthens wildfire preparedness** through local and on-site water reserves, including household tanks and community hydrants that provide immediate suppression capability. Finally**, three cross-cutting financial and risk-intelligence tools** - parametric climate insurance, housing-improvement microfinance for climate-resilient retrofits, and subscription-based early-warning and digital alert platforms - offer rapid recovery mechanisms, support incremental upgrading of low-income housing, and provide timely hazard information to reduce losses. Together, these pathways position the housing sector as a high-impact arena for scalable, resilience-focused lending.

Looking ahead

While this report does not undertake a full enabling-conditions analysis for Tanzania, creating the right environment for adaptation investment will nonetheless be essential for scaling private-sector participation. Tanzania's climate policy framework is evolving, but investors still face uncertainty around the implementation of land-use plans, building standards, and climate-risk requirements across national and local authorities. Strengthening the predictability and enforcement of these regulatory processes would help reduce investment risk and improve long-term confidence. Expanding access to reliable climate and hazard data (particularly for urban flooding, coastal inundation, and drought-prone regions) would support banks and businesses in assessing exposure and structuring viable adaptation products. Improved coordination between national ministries, local governments, utilities, and financial regulators would also help align incentives and reduce fragmentation in adaptation planning. At the same time, Tanzania's growing experience with blended finance and public–private partnerships provides a foundation for scaling risk-sharing mechanisms that can lower early-stage barriers for commercial lenders. Together, these shifts would help create a more stable and investable environment—one that enables Commercial Banks, investors, and enterprises to play a central role in financing Tanzania's transition toward a more resilient and inclusive economy.

This phase of the assignment identified a set of clearly defined adaptation investment opportunities in energy and manufacturing which respond to major climate risks in Tanzania. Initial stakeholder confirmation and interest particularly in housing related investments, has also been confirmed through engagements with CRDB Bank in November 2025. These opportunities will be more closely analysed in the subsequent phase of the analysis, which will look at sizing the investment market for these opportunities before developing investment briefs for Commercial Banks.

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ANNEX 1: KEY TAXONOMIES AND ADAPTATION OPTION DATABASES

This Appendix provides a breakdown of the various taxonomies and adaptation options databases reviewed as part of the climate adaptation opportunity identification. These sources formed the basis for the creation of a set of broadly applicable adaptation investment opportunities.

Key Taxonomies	Year	Link
EU Taxonomy	2020	Link
Tailwind	2024	Link
UN CTCN Taxonomy	2017	Link
Climate Bonds Resilience Taxonomy Methodology	2024	Link
UNDRR – Guide for Adaptation and Resilience Finance	2024	Link
Oxford ECI – Adaptation & Resilience Taxonomies Database	2024	Link
Adaptation Lists (not exhaustive, additional resources identified per solution)	Year	Link
World Bank Group: Transport Climate and Disaster Risk Screening Reference Guide	2019	Link
World Bank Group - Environmental, Health, and Safety Guidelines - Airports	2025	Link
GCF: Adaptation: Accelerating action towards a climate resilient future	2019	Link
World Bank: Disaster and Climate-Resilient Transport Guidance Note	2025	Link
US Env. Protection Agency (EPA): Solid Waste Management and Climate Change	2023	Link
World Bank: Sustainable Solid Waste Management Project	2023	Link
EDHEC DataBase of Tech Response Options	2025	Link
EU Climate Adapt Database	2025	Link
EU Climate Adapt Database AI Agent	2025	Link
UIC Rail Adapt	2017	Link
EDHEC Climate Institute: Reducing Infrastructure Climate Risk Through Technology Measures: Transport (IC60)	2025	Link
EU Guidance on Adapting Buildings	2023	Link
UN HABITAT Green Building Interventions for Social Housing	2015	Link
Kenya Affordable Housing Green Building Guidelines	2024	Link
AAK's Healthy Homes: Guidelines and Checklist	2022	Link

ANNEX 2: SECTOR SEGMENTATION

To enable the team to focus on identifying specific adaptation opportunities it was agreed that the seven sectors considered as part of the IEM analysis should be segmented and priorities selected. An evidence base on which to focus on selected IEM sectors that are most relevant for Commercial Banks, while avoiding simply perpetuating the status quo. A set of three segmentation criteria where discussed and agreed with GCA sector teams, these where:

Current commercial bank lending to different sectors. This data was collated from central bank sources and while subject to some assumptions provided a clear directional indication of the % of existing commercial bank loan books allocated to different sectors.

Summary of National Level Commercial Bank Lending

	DRC	Kenya	Tanzania	Zambia
Sector	Share of total commercial bank lending (%)			
Commerce & Trade	37.2%	19.6%	12.3%	10.9%
Mines & Quarrying	25.7%	1.4%	1.5%	7.7%
Personal and Household	13.1%	23.2%	40%	17.4%
Manufacturing Industries	9.1%	15.7%	9.7%	21.2%
Building, Construction & Public Works	4.4%	4.1%	4.9%	1.5%
Transport & Communications	3.7%	8.3%	4.5%	9.8%
Agriculture, Forestry & Fishing	1.6%	4.4%	13.2%	9.6%
Energy, Water & Gas	1.1%	3%	2.7%	9.2%
Real Estate	-	11.7%	2.2%	-
Financial Services	-	5.8%	2.1% + 1.6% for mortgages	2.2%
Tourism and hotels	-	2.7%	2.9%	0.5%
Other	1.1%	-	2%	10%
TOTAL	100%	100%	100%	

Simple first order observations include:

→ Direct lending to manufacturing is consistently HIGH (9.1-21.2%)

→ Direct lending to the major infra classes of energy, water and gas are LOW (<3%), except for Zambia, which is a relative outlier with high lending possibly associated with lending to the solar IPP sector (>9%)

Note: plausibly lending to elements of energy, water and gas could also sit in Commerce and Trade Categories and Construction, which is the largest sector for 2/3 countries, this could be distorting the picture

Main sources: Multiple sources integrated/aligned and duplication remorve by the Pegasys team, but drawing on the following primary resources

Kenya- Central Bank 2024 Report, DRC - Banque Centrale du Congo (BCC) – Rapport Annuel, 2023, Tanzania – Bank of Tanzania, Quarterly Statistical Bulletin 2024, Zambia - Bank of Zambia, Annual Report 2023

Clear Policy or Regulatory Pressures that would drive increased commercial bank lending to a given sector. This provided a *Leading Indicator of where future bank lending might be directed.* This was established by reviewing a range of national policy statements and plans, supportive regulation but also looking at direct incentives for increased investment such as through tax treatments such as accelerated depreciation for certain sectors or specific financial incentives such as reduced capital gains on pro-adaptation instruments such as green bonds or credit guarantees for manufacturing[5].

Impact | as defined by the potential of the sector to contribute towards delivering inclusive socio-economic development and impact. Particularly with respect to the ability to deliver benefits to women, youth, low-income or marginalized groups. A qualitative assessment of this potential was made, with a score allocated as part of an assessment framework. This was informed by contextual country GESI analysis but included reviewing data points such as: female employments share in the sector, expressed as a %, the reduction in the time burden for women and youth from greater access in relevant sectors-expressed as a % of time spent per day and Micro, Small or Medium Sizes Enterprises (MSME's) in the sector, with the participation rate expressed as a %.

Weightings where attached to each of the three criteria and total aggregated scores generated for each sector to enable the team to prioritise efforts to identify specific adaptation solutions that can be sized at

[5] The following categories where considered: National 5-year plans, sector investment plans, National Adaptation Plans, Capital & regulatory-treatment policies, Government tax and subsidy plans ,ESG and sustainability policies including international frameworks such as the EU's CBAM and CSRD.

a national scale. Each segmentation criterion was given a score of 0, 2 or 4, according to the criteria presented below.

Segmentation Criteria

Criteria Category	Sub-Measure / Description	Sub Indicators and Sources *These will be assessed to inform scoring*	Weighting
1. Current commercial bank lending	**% of commercial bank loan book** allocated to sub-sector, per country | *Lagging Indicator*	▪ Central Bank Data on Aggregate Commercial Bank lending using standardised categories ▪ Corroborating data and informed estimates[1]	*30%*
2. Future commercial bank lending	**Clear Policy or Regulatory Pressures** that would drive increased commercial bank lending to sub-sector, per country | *Leading Indicator*	▪ National 5-year plans, sector investment plans ▪ National Adaptation Plans ▪ Capital & regulatory-treatment policies ▪ Government tax and subsidy plans ▪ ESG and sustainability policies	*30%*
3. Inclusive Socio-economic development and impact potential	Assessment of sub-sectors potential to deliver benefits to women, youth, low-income or marginalized groups. [2]	▪ Informed by contextual country GESI analysis of sub-sector participation rates, and impacts on women, youth and marginalised groups ▪ Specific considerations informing scoring include: ▪ Female employment share in sector % ▪ Reduction in time burden for women and youth from greater access - % of time spent per day ▪ Micro, Small or Medium Sizes Enterprises (MSME's) in the sector – participation rate as %	*40%*

Ranking Criteria

1: See data limitations slide below for more detail

2 Will incorporate an assessment of the scale of that potential and the degree to which benefits accrue direct or indirectly. For example transport may deliver a primary benefit via enhanced access to markets while contributing to economic growth as a secondary benefit)

	% of commercial bank loan book allocated to sub-sector, per country | Lagging Indicator	Clear Policy or Regulatory Pressures that would drive increased commercial bank lending to sub-sector, per country | Leading Indicator	3. Inclusive Socio-economic development and impact potential
Weighting	**30%**	**30%**	**40%**
	0 = Low to no exposure as % of loan book, <3%	0 = No or low policy pressure driving commerical bank interest	0=Limited inclusive impact: Sector provides minimal direct benefits to women, youth, low-income or marginalised groups; limited relevance to resilience or social equity outcomes.
	2 = 3>% of aggregate commercial bank lending in country	2 = Some evidence that regulation or policy pressure is already positively shaping the enabling environment for commercial banks to lend directly to the sector	2= Moderate inclusive impact: Sector demonstrates some potential to enhance equitable access, participation or livelihoods (e.g. through service access, employment or MSME engagement), but benefits are indirect or small in scale.
	4= 6>% of aggregate commercial bank lending in country	4= Clear evidence of substantial policy and regulatory pressure to increase lending to the sector	4= High inclusive impact: Sector offers clear and significant opportunities for gender-responsive and inclusive outcomes - such as women's employment, local enterprise participation, improved access to essential services, or reduced social vulnerability.

Priorities emerging from the ranking

The top-line outputs of the sector segmentation for Tanzania suggests that Housing and Manufacturing are most relevant, ranking 1st and 2nd in terms of the aggregated scoring. Energy scores 3rd reflecting a secondary area of relevance for GCA to explore in the future.

We prioritized sectors based on 3 criteria

1. **Current commercial bank lending**
2. **Future commercial bank lending**
3. **Impact: Inclusive socio-economic development and impact potential**

Housing & Manufacturing are the most relevant sectors in Tanzania based on our analysis

Sub-sector	Total Weighted Score	Rank
Housing	**3.4**	**1**
Manufacturing	**2.6**	**2**
Energy	2.2	3
Waste	2.0	4
Telcoms/ICT	1.8	5
Water	1.6	6
Transport	1.4	7

Data limitations and assumptions made

Given data quality, granularity and time there inevitably will be limitations in analysis across such a broad set of contrasting sectors. Given the data limitations and limited time available this analysis will need to be accepted as at best directional and a starting point on which future deeper research could be conducted. While the intent is to generate directionally correct insights the following challenges should be noted for future analysis.

Limited sector disaggregation of commercial bank aggregate lending data| Central Bank data uses broad categories and does not specify underlying investments in significant detail. For example, lending to 'Housing is combined into 'Personal and Household" as a category. This is a recognized economic sector classification aligned with ISIC and has some standard sub-areas but does not provide a % split in lending between two arguably very different sectors.

To be usable the team needed to make assumptions and corroborate them with external sources such as national statistical data or World Bank data to calculate realistic ratios and % splits, using for example known GDP shares or average personal household expenditures.

Where data allowed us to provide a granular view – i.e. not just look at transport but look at 'ports, roads etc. this could be done, but primarily due to lack of granular data we needed to look at the wider sector category of 'Transport' in aggregate.

There is 'Masking' of important areas of lending. For example, it can reasonably be assumed that 'Personal and Household' lending categories includes a significant share of borrowing for low, medium and even high-income housing purchases retrofits and upgrades. This is significant given that formal mortgage borrowing is typically a limited feature of these markets.

In the absence of disaggregated data, proxies and corroborating evidence will need to be collected to support evaluation – this could include top-down estimates to calculate an approximate range / lending envelope.

ANNEX 3: CLIMATE ADAPTATION SOLUTION SCORING

For both sectors, solutions that had different value chains with a significant degree of relevance were then scored for the degree of technology readiness and supply-chain maturity, and, wherever possible, supported by data-backed evidence on the feasibility of each solution for private-sector investment (*Low, Moderate and High scores)*. This included indications of existing implementation or track record in Tanzania or comparable markets - alongside the potential for positive impact on Women, Youth and Social Inclusion - which will become an area of more detailed focus in the subsequent development of investment briefs.

Below is the list of climate adaptation solutions that were selected and scored for the housing sector in Tanzania.

In the housing sector, solutions where screened according to those with most relevance to the private sector as well as the climate adaptation impact potential. The relevance of different solutions to the climate hazard was then scored (*0= low relevance, 1= moderate relevance, 2= significant relevance)*.

Solutions that had the highest impact were then scored for the degree of technology readiness and supply-chain maturity, and, wherever possible, supported by data-backed evidence on the feasibility of each solution for private-sector investment (*Low, Moderate and High scores)*. This included indications of existing implementation or track record in Tanzania or comparable markets - alongside the potential for positive impact on Women, Youth and Social Inclusion.

A total of 23 solutions were scored, distributed as follows:

- 5 solutions that responded to Flooding
- 2 solutions that responded to Sea-level rise
- 4 solutions that responded to Extreme Heat
- 3 solutions that responded to Storms and high winds
- 5 solutions that responded to Wildfires
- 4 solutions that responded to multiple hazards. These can be characterized as “soft” measures, corresponding to insurance products, loans and early warning systems.

As presented in the “Opportunity Identification and Prioritization” section, 11 of these solutions were identified as being most relevant for Commercial Banks in the Tanzania housing sector as a result of the scoring process.

Climate Hazard the response supports adaptation to	Specific adaptation response	Housing (both formal & informal; includes homeowners and tenants)	Substantial housing impact (defined as high relevance = 2)	Technology Readiness and Supply Chain Maturity - helper column (Low =low or no evidence of deployment,Moderate = some evidence of tech being used in country and having scale potential High= significant application and significant scale potential)	Technology Readiness and Supply Chain Maturity (ticks) (Low =low or no evidence of
Flooding	Install flood doors/gates	2	✓	High	✓✓
	Fit backflow valves	2	✓	Low	
	Targeted Drainage Green Infastructure: Sustainable Urbain Drainage Systems (SuDS): swales, permeable pavement, retention ponds	2	✓	High	✓✓
	Add rainwater retention systems	1			
	Mangrove and coastal ecosystem restoration (Nature-based coastal defence)	2	✓	High	✓✓
Sea-level rise	Elevated housing & flood-resilient design	2	✓	High	✓✓
	Use structural waterproofing techniques	2	✓	High	✓✓
Extreme Heat	Green infrastructure & cool/reflective roofs (green roofs, reflective/insulated roofing, urban tree canopy)	2	✓	Moderate	✓
	Passive and efficient cooling	2	✓	High	✓✓
	Targeted HVAC for vulnerable spaces	2	✓	High	✓✓
	Urban Heat Intelligence Platforms (UHI Mapping + Heat Index Alerts)	2	✓	Low	
Storms and high winds	Landscape for defensible space, windbreak, and ground cover	2	✓	Moderate	✓
	Compact settlement and building layouts	1			
	Wind-resistant building details & improved roof fixings (clips, straps, improved anchorage)	2	✓	Moderate	
Wildflires	Adopt ember-resistant ventilation systems	2	✓	Low	
	Vegetation management and defensible space around housing (fuel breaks, cleared perimeters)	1		Moderate	✓
	Fire-resistant building materials & retrofits (non-combustible cladding, ember-resistant vents)	2	✓	Moderate	✓
	Local & on-site water reserves (water tanks, community hydrants)	2	✓	High	✓✓
	Homeowner & Builder Training Programs on Fire-Resilient Practices	2	✓	Low	
Multiple (could be disaggregated by climate hazard, if need be)	Climate-risk-adjusted parametric Housing Insurance Products (covering loss and damage from flooding, heat, storms and wildfires)	2	✓	High	✓✓
	Housing improvement micro-finance (loans) for climate resilience (renovation, incremental self-construction, land title formalization)	2	✓	High	✓✓
	Multi-hazard early warning systems (flooding, fire, storms) & Digital Alerts	2	✓	High	✓✓
	Strengthened local building codes + enforcement (storm-resilient standards for roofs, walls, foundations)	1			

Below is the list of climate adaptation solutions that were selected and scored for the manufacturing sector in Tanzania.

For the manufacturing sector seven value chains where examined, to establish the degree of solution relevance for the foods, beverages, tobacco, metals (aluminium, iron and steel), non-metallic minerals and cement, chemicals and pharmaceuticals, and textiles – given that these represent the main manufacturing value chains, on top of their differing contexts and production processes.

The relevance of different solutions was then scored (*0= low relevance, 1= moderate relevance, 2= significant relevance)*, with those having benefits for multiple value chains prioritised.

Solutions that had the highest impact were then scored for the degree of technology readiness and supply-chain maturity, and, wherever possible, supported by data-backed evidence on the feasibility of each solution for private-sector investment (*Low, Moderate and High scores).* This included indications of existing implementation or track record in Tanzania or comparable markets - alongside the potential for positive impact on Women, Youth and Social Inclusion.

A total of 32 solutions were scored, distributed as follows:

- 10 solutions that responded to Drought
- 6 solutions that responded to Floods and sea-level rise
- 8 solutions that responded to Extreme Heat
- 5 solutions that responded to Wildfires
- 3 solutions that responded to multiple hazards.

As presented in the “Opportunity Identification and Prioritisation” section, 9 of these solutions were identified as being most relevant for Commercial Banks in the Tanzania manufacturing sector as a result of the scoring process.

Climate Hazard the response supports adaptation to	Specific adaptation response	Processed Foods and Food Products	Beverages	Tobacco Products	Metals (aluminium, iron and steel)	Non-metallic minerals & cement (cement, bricks, ceramics)	Chemicals and pharmaceuticals	Textiles	Substantial cross-value chain impact *(defined as 3 or more value chains impacted)*	Technology Readiness and Supply Chain Maturity - helper column (Low =low or no evidence of deployment,Moderate = some evidence of tech being used in country and having scale potential High= significant application and significant scale potential)
Drought	Expanded on-site water storage (≥48h)	2	2	1	1	1	1	2	✓	Low
	Groundwater development	1	1	1	1	1	1	1		
	Rainwater harvesting	2	2	1	1	1	1	2	✓	Moderate
	Water efficiency and circularity approaches: advanced membrane treatment for reuse, condensate recovery, leak detection	2	2	1	1	1	1	2	✓	Moderate
	Micro-grid | For backup or primary power	1	1	1	2	2	2	2	✓	High
	PV + BESS	2	1	1	2	2	2	2	✓	High
	Pooled grid-scale renewable energy purchase: Pooling manufacturing power demand to construct dedicated renewable power supply as an alternative to grid power. Likely in high density SEZ's	1	1	1	2	2	2	2	✓	Moderate
	Waste to energy - Use whey, sludge, manure, organic by-products to generate energy (methane), biogas, or	2	0	0	0	0	0	0		
	Emergency and backup energy storage systems (diesel gensets, hybrid solar+battery genset systems)	1	1	1	2	2	2	2	✓	High
	Ground source heat pumps - supplementing boilers and chillers	0	0	0	1	1	0	0		
Floods and sea-level rise	Culverts, stormwater, and hydraulic infrastructure (drains, pipes, reinforced channels, tide gates)	2	2	1	1	1	1	2	✓	High
	Catchment mgmt - assessment, policy, planning & monitoring	1	1	1	0	0	0	1		
	Targeted Drainage Green Infastructure: Sustainable Urbain Drainage Systems (SuDS): swales, permeable pavement, retention ponds	2	2	2	1	1	1	2	✓	Low
	Cathment-wide Green Infrastructure (Natural Resource Mgmt): NbS approaches to flood reduction (buffer zones, wetlands, floodplain restoration)	2	2	2	1	1	1	2	✓	Low
	Elevate equipment above flood levels	1	1	1	2	2	1	1		
	Flood doors and backflow preventers	1	1	1	2	2	2	1	✓	Moderate
Heat	Shifting work timing and formulation/re-scheduling of heat emitting process to cooler periods	2	2	1	2	2	1	2	✓	High
	Green roofs	1	1	1	0	0	1	1		
	HVAC for cooling and dehumidification	2	2	1	1	1	2	2	✓	High
	Absorption chillers using waste heat	1	1	0	2	2	1	1		
	Chilled beam technology	1	1	0	0	0	1	1		
	Heat barriers and baffles	1	1	1	2	2	1	1		Moderate
	Isolated cold rooms with independent feeds and auto-close doors	2	2	1	0	0	2	1	✓	High
	High-heat-tolerant refrigeration upgrades	1	1	2	2	1	1	0		Moderate
Wildfire	Vegetation management and firebreaks around key sourcing sites	2	2	2	1	1	1	2	✓	High
	On-site firefighting systems (hydrants, foam, water tanks, sprinklers)	2	2	2	2	2	2	2	✓	Moderate
	Early-warning systems (satellite/meteorological alerts, smoke sensors)	1	1	2	1	1	1	1		
	Fire-resistant thermal insulation and retrofits	1	1	2	2	2	2	1	✓	High
	Emergency preparedness & training (worker drills, evacuation plans)	2	2	2	2	2	2	2	✓	High
Multiple	**Supply chain risk visibility** – IoT/Blockchain tech to identify emerging risks in input supply chain	1	1	1	1	1	1	1		
	Increase inventory buffers – increase reserves or identify / build swing capacity in input use	1	1	1	1	1	1	1		
	Supplier diversity and climate risk assessment requirements	1	1	1	1	1	1	1		

The detailed scoring spreadsheet can be found here.

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