

PROJECT EXEMPLAR

Climate-Resilient Rail Development and Catchment-Level Risk Reduction: Tanzania's Central Rail Corridor



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KEY PROJECT INFORMATION



Country / Region

Tanzania, East Africa



Sector

Transport (Rail infrastructure)



Investment Value

\$200 million



Implementation Period

2024-2027



Key Partners

World Bank Group (WBG),
Tanzania Railway Corporation (TRC)



Beneficiaries

90 million people



THE ADAPTATION STORY

Context and adaptation challenge

Tanzania's central meter gauge rail corridor (Dar es Salaam - Isaka) is a vital **logistics backbone for national and regional trade**, providing critical connectivity for landlocked neighbouring countries and supporting agricultural livelihoods along its route. The World Bank Group (WBG) developed an investment project for rehabilitation efforts, prioritizing the highly exposed Kilosa-Gulwe-Igandu section, which has experienced a sharp deterioration in performance in the past two decades. Seasonal flood-related closures now last three to four months per year, up from around one week annually in the late 2000s, resulting in significant economic losses and reduced connectivity for local communities.

Climate risks along the corridor are increasing due to greater exposure to flooding, sedimentation, landslides, and rising temperatures. Flooding has worsened from a variety of reasons such as increased extreme rainfalls or upstream attenuation dams that were damaged or lost during major storms, while erosion and sediment build-up have raised riverbeds and reduced drainage capacity. Changes in land use have increased runoff and erosion, and climate change is bringing more intense short-duration rainfall. Together with ageing infrastructure, these factors are making the railway more vulnerable to disruption.

Without targeted adaptation, service reliability will continue to deteriorate, pushing freight onto the already congested Dodoma - Dar Es Salaam road corridor, increasing transport costs, and weakening economic inclusion, especially for communities that rely on the railway to access markets and essential services. This highlights the need for an integrated approach that combines railway upgrades with upstream catchment management to tackle the root causes of climate risk and restore long-term reliability.



What was GCA's role?

GCA, through the African Acceleration Adaptation Program (AAP), provided technical assistance to the WBG and the Tanzania Railway Corporation (TRC) delivering climate risk and vulnerability assessment across the 970 km Dar es Salaam-Isaka corridor, with high-resolution diagnostics for the 120 km Kilosa-Gulwe-Igandu hotspot. The analysis combined **climate modelling and geospatial hazard mapping to identify exposure to extreme rainfall, flooding, sedimentation, landslides, and extreme heat**. This was complemented by detailed hydrological and hydraulic modelling of the Kinyasungwe River system to quantify flood depths, flow velocities, and overtopping points, and to estimate how flood frequency and severity could change under future climate scenarios. The modelling confirmed that disruption days could rise beyond 200 per year (up from around 120 days in 2024) in the absence of adaptation, reinforcing the urgency of resilience investments.

To translate risk data into actionable design decisions, GCA supported **stress testing of critical railway assets and operations against extreme climate events**. In parallel, a **socioeconomic assessment quantified broader consequences of rail failure, including trade and supply chain disruption and increased transport costs**. This allowed identification and **prioritization of adaptation measures** at the most vulnerable segments and hotspots. The technical evidence was then integrated into impact-based economic analysis, including cost-benefit analysis of various combinations of adaptation solutions, to assess avoided damages, reduced disruption losses, and long-term asset performance. This evidence-based process also informed the development of technical guidelines for climate-resilient rail infrastructure, alongside capacity building through the AAP masterclass for local stakeholders on climate-resilient infrastructure PPPs.

Results and impact

GCA delivered the impact-based prioritisation of adaptation measures to strengthen railway resilience, improve operational reliability, and maximise co-benefits for surrounding communities. The analysis provided stakeholders with a clear **set of recommended measures, beginning with infrastructure design enhancements** to reduce vulnerability to flooding and service interruptions.

Importantly, the analysis included the impact evaluation of the rehabilitation of six upstream flood control reservoirs, which the study found could reduce peak flood flows by up to 50%, while also helping manage sedimentation. These reservoirs offer important community co-benefits, including opportunities for irrigation and fisheries, strengthening both livelihoods and local resilience. The modelling showed that **integrating reservoir rehabilitation with engineering measures** - rail elevation, culvert expansion, bridge strengthening - could deliver overall flood risk reduction of up to 76%.

In addition, the assessment identified **large-scale nature-based solutions as essential to reduce runoff, control erosion, and eventually mitigate sedimentation in the dams and in the river bed**, especially through conservation farming practices, riparian buffers, and targeted erosion control. While the most effective NbS options fall partly outside the project's direct investment scope, strong synergies were identified with other World Bank investment programmes, including **promotion of sustainable agricultural practices, use of reservoirs for irrigation, and catchment-wide erosion reduction**. When NbS are integrated with engineering measures, total risk reduction could reach 89%, with positive economic returns and substantial ecosystem and livelihood benefits.



Tanzania (credit: GCA)

INDICATOR	RESULT / TARGET
Direct and indirect losses	Direct damage costs for a 1-in-50-year flood event in the Kilosa-Igandu section can reach USD 78.6 million. These climate shocks generate major socio-economic impacts: a single day of disruption is estimated to cause approximately USD 170,500 in socio-economic losses and around USD 49,000 in lost revenue for the Tanzania Railway Corporation.
Benefit-cost ratios (BCR) of adaptation investments	The integrated adaptation package (combining flood measures, landslide protection, and green track heat mitigation) delivers an overall BCR of 4.9.

Climate hazards, impacts, and prioritised adaptation measures:

KEY CLIMATE HAZARDS	IMPACTS ON INFRASTRUCTURE, SERVICES AND USERS	PRIORITIZED ADAPTATION MEASURES
 Flooding	Infrastructure: Track and ballast washouts, scouring of subgrade, blocked culverts from sedimentation, bridge damage. Services: Up to 120 disruption days/year (projected 200), major freight delays and reliability losses. Communities: Damage to homes and farmland, displacement, disrupted access to markets and services, higher food and transport costs due to rail-to-road diversion.	Rehabilitation of six upstream attenuation dams to reduce flood peaks and service disruptions; Vertical railway realignment (+1 m) along flood-prone sections; Increased culvert capacity to improve drainage; Conservation agriculture to reduce erosion and sediment inflow; Riparian buffers and vetiver contours to stabilise riverbanks and limit erosion
 Landslides	Infrastructure: Damage to track and ballast. Services: Disruptions of 1-2 days for minor landslides and ≥ 5 days for major events, forcing freight to roads. Communities: Higher transport costs, crop spoilage, urban supply shortages, disrupted exports, and income losses for farmers and traders.	Targeted slope stabilisation using gabions; Nature-based slope protection (vegetation) on critical sections; Drainage improvements on unstable slopes to reduce landslide probability
 Extreme heat	Infrastructure: Increased rail, turnout and earthwork faults from thermal stress. Services: Reduced reliability and higher maintenance needs; faults projected to more than double by 2040. Communities: Indirect impacts through less reliable passenger and freight services and higher transport costs	Green track interventions using drought-resistant vegetation along track verges and shoulders to reduce heat absorption

KEY LESSONS

LESSON

1

Building climate-resilient railways highly benefits from an integrated approach that combines asset upgrades with upstream catchment management

WHAT WE HAVE LEARNT

The Kilosa-Igandu corridor demonstrates that asset-level engineering alone cannot deliver durable climate resilience when risks originate upstream. While measures such as raising embankments and enlarging culverts significantly reduce short-term flood disruptions, their effectiveness erodes over time due to accelerating sedimentation driven by land-use change and climate-intensified rainfall. Integrating railway upgrades with catchment-scale interventions, particularly attenuation dams and conservation agriculture, addresses these root causes by reducing flood peaks and sediment loads simultaneously. This combined approach restores railway reliability, limits recurrent damage, and avoids costly cycles of rehabilitation. Crucially, it also delivers wider benefits for communities, including reduced displacement, improved water availability, and strengthened agricultural livelihoods, reinforcing resilience across the broader system rather than only along the rail alignment.

REPLICABILITY

This system-wide approach is transferable to other linear infrastructure exposed to flooding and erosion, where climate risks originate beyond the right-of-way. Replication requires early integration of hydrological modelling, land-use analysis, and stakeholder engagement to identify upstream drivers of risk. Similar frameworks can be applied to roads, ports, and energy corridors in flood-prone catchments, provided projects are designed to enable cross-sector coordination between transport, water, and agriculture institutions.



Tanzania's central rail corridor (credit: GCA)

LESSON

2

Nature-based solutions are critical infrastructure that reduces climate risk, enhances resilience and strengthens the economic case for adaptation by delivering livelihoods, water security, and productivity co-benefits.

WHAT WE HAVE LEARNT

NbS proved central to reducing climate risk along the corridor. Conservation agriculture lowers runoff and sediment inflows, and riparian restoration reduces flood velocity and bank erosion, both have the ability to amplify the effectiveness of flood-control dams and protect rail assets from recurrent damage. Beyond infrastructure protection, NbS can generate substantial co-benefits, including improved crop productivity, enhanced water availability, carbon sequestration, and reduced displacement risk. These socio-economic gains can significantly strengthen the investment case for adaptation, demonstrating that NbS can outperform purely grey solutions when co-benefits are fully valued.

REPLICABILITY

NbS, such as changing agricultural practices or reforesting riparian margins, can be replicated across infrastructure projects where land degradation and hydrological change drive climate hazards. Success depends on early community engagement, development of incentives for farmer adoption, and coordination with agricultural and environmental agencies. While NbS require longer implementation horizons than engineering works, they offer scalable solutions with lasting impacts when embedded in local land management systems.



Tanzania's central rail corridor (credit: GCA)

Actionable insights for MDBs

THEME	INSIGHT
Integrated, system-wide resilience Theme	MDBs should move beyond asset-only resilience and support integrated investments. Climate stress testing and economic appraisal can help justify upstream measures that fall outside traditional transport mandates. Investing in system-wide resilience reduces future retrofit costs while strengthening economic inclusion and climate adaptation outcomes.
Cross-sector financing and coordination	Projects should be structured to enable blended financing across sectors and support coordinated delivery across institutions, enabling grey and green interventions to be planned strategically at system level. Innovative financing mechanisms, such as carbon credits, could be used to support the implementation of NbS for adaptation.
Nature-based solutions as core resilience investments	MDBs should treat NbS as core resilience investments and systematically account for their economic, social, and environmental co-benefits. Projects must allow time and resources for behaviour change and stakeholder alignment, while financing frameworks should support cross-sector delivery. Standardising methods to value NbS co-benefits can unlock larger adaptation portfolios and strengthen the case for integrated, people-centred climate resilience.



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