

PROJECT EXEMPLAR

Enhancing Rural Connectivity and Security of Food Systems through Resilient Road Infrastructure in Southern Niger and Chad



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ADAPTATION

KEY PROJECT INFORMATION



Country / Region

Niger, West Africa and Chad, Central Africa



Sector

Transport (Road)



Investment Value

\$407M



Implementation Period

2023-31



Key Partners

World Bank Group (WBG), Ministry of Transport and Ministry of Public Works of Niger



Beneficiaries

16 million inhabitants in the direct area of influence. Enhancing road resilience could bolster food security for approximately 245,000 people in Niger and Chad.



THE ADAPTATION STORY

Context and adaptation challenge

Situated along the southern edge of the Sahara Desert within the Sahelian zone, **Southern Niger and Chad are exposed to significant climate hazards related to extreme temperatures, fluvial and pluvial flooding, sandstorms, and worsening drought conditions.** These hazards are increasing in frequency and intensity and, combined with historically limited operations and maintenance, are accelerating the deterioration of an already fragile and aging road network. Flooding and extreme heat contribute to structural failures, while sand and debris further degrade surface conditions, leading to recurrent transport disruptions.

The Niamey-N'Djamena corridor along the Trans-Saharan Road, linking two capitals, is essential for logistics, cross-border integration, and food security in secondary urban centers and rural areas. Its vulnerability creates major challenges for agropastoral logistics, access to markets, and agricultural value chains. Large rural populations depend on reliable connectivity to move goods and access services, yet climate-related disruptions increasingly isolate production areas and constrain regional trade. Extreme heat and recurrent droughts are placing growing pressure on agricultural yields, increasing reliance on transport connectivity to maintain food supply and balance spatial disparities between surplus and deficit regions. Climate change consequences on water availability and evolving drought patterns further intensify these pressures, particularly in southern Niger.

Without adaptation, future climate risks are expected to further marginalize vulnerable populations and limit rural transformation. This context underscores the **need for climate-adapted rehabilitation, improved maintenance planning, and measures to address flooding, extreme heat, wind, and sand movement, in order to safeguard rural connectivity, food systems, and socioeconomic stability along this critical corridor.**



What was GCA's role?

GCA partnered with the World Bank Group (WBG) to support rural logistics and food security connectivity and integration initiatives in Southern Niger and Chad under the African Adaptation Acceleration Program (AAP), providing upstream technical assistance to strengthen the climate resilience of the Niamey-N'Djamena corridor along the Trans-Saharan Road. **GCA conducted a climate risk and vulnerability assessment, including climate hazard modeling and vulnerability stress tests, mapping the impacts of climate change on assets and populations along the corridor.** This informed the development of **adaptation and resilience investment options**, including a toolbox of adaptation measures that can be implemented to climate-proof road rehabilitation in high-risk locations.

Technical assistance also included **cost-benefit evaluations of design, operations, and maintenance adaptation options**, including nature-based solutions where applicable. GCA also conducted studies to assess climate change consequences on water availability and how these affect adaptation option appraisal for corridor resilience. In parallel, GCA led **analyses on rural logistics performance and food security outcomes, and developed specific network criticality analysis** to support the WBG in identifying key sections where infrastructure enhanced resilience provides the highest impacts. **This work helped quantify where road resilience can contribute to improved food security and informed prioritization of sections to refurbish** within the planned investment project. Stakeholder consultation with representatives from relevant ministries in Niger complemented the technical work and supported data collection during project preparation. GCA also provided capacity enhancement for resilient transport sector planning in Niger and Chad through the AAP masterclass on climate resilient infrastructure PPPs.



Results and impact

GCA’s combined climate hazard assessment, vulnerability stress test, food security analysis, and economic appraisal provide a coherent evidence base for action. Together, these assessments show that **climate impacts on the corridor extend well beyond physical damage, affecting service continuity, travel reliability, and the ability of households and producers to access markets, inputs, and essential services.** The food security research identifies three distinct vulnerability clusters, smallholder farmers, pastoral households, and urban consumers, demonstrating that climate disruptions affect supply chains differently across production and consumption zones.

The prioritisation framework integrates climate hazard severity with network criticality indicators such as betweenness centrality and shortest-path accessibility between production and consumption centres, alongside food security relevance, enabling resources to be directed to locations where resilience investments generate the highest combined economic and social returns. Simulations of road disruptions show that certain road intersections disproportionately increase transport distances and costs when affected, underlining the strategic importance of selected segments. Economic appraisal confirms that resilience investments deliver benefits early in the project lifecycle and strengthen long-term performance under current future climate scenarios (RCP4.5 and RCP8.5).

The proposed adaptation strategy combines grey infrastructure upgrades, nature-based and mixed solutions, and strengthened maintenance and management practices, applied selectively across the corridor in line with the segment-specific context. The study focuses on seven priority segments of the corridor. For each segment, an economically viable package of adaptation measures has been identified, complemented by an overarching package of measures applied across the full corridor. For all segments, this includes monitoring of climate-related impacts, regular cleaning of drainage structures, and planting of dunes and areas at risk of sandstorms.

Improved resilience of the corridor translates directly into better food access and economic outcomes for vulnerable communities. According to the climate risk and vulnerability assessment, **approximately 155,000 people in Niger and 90,000 people in Chad would become more food secure with improved resilience of the road serving populations in the main districts of the corridor.** Food-security modelling indicates that disruptions disproportionately affect smallholder-dominated regions with limited market access and high dependence on the RN1 corridor for agri-food trade. The overall annual economic benefit of enhanced food security was estimated at at least USD 5 million in Niger and USD 7.5 million in Chad, with potential for even greater gains.

INDICATOR	RESULT / TARGET
Direct and indirect losses	Total climate risk at baseline is approximately USD 85 million per year in direct and indirect damages, affecting road assets, logistics, and associated economic activity. Under future climate scenarios, these losses are projected to increase to around USD 235 million annually by 2050 if no adaptation measures are implemented, representing a 276% increase in damages.
Benefit-cost ratios (BCR) of adaptation investments	All prioritised adaptation packages deliver strong positive economic returns, with BCRs well above 1 (in the range of 1.5 to above 4.0). Corridor-wide adaptation packages generate the highest net benefits, with an early payback period and high economic internal rates of return.

Climate hazards, impacts, and prioritised adaptation measures:

KEY CLIMATE HAZARDS	IMPACTS ON INFRASTRUCTURE, SERVICES AND USERS	PRIORITIZED ADAPTATION MEASURES
 Extreme heat	Infrastructure: Pavement softening, rutting and cracking; deterioration of shoulders; thermal stress and damage to bridge decks and joints, reducing asset lifespan. Services: Reduced travel speeds, frequent maintenance needs, road closures during repairs, higher transport costs. Communities: Disrupted access to markets, health and education services; increased food transport delays and higher prices.	Heat-resistant asphalt or concrete pavement on highly exposed sections; Bridge design with adequate thermal expansion joints; Enhanced monitoring and maintenance for heat-related damage; Roadside tree planting and green shading where water availability allows
 Fluvial flooding	Infrastructure: Erosion and undermining of pavement, foundations and shoulders; damage to bridges and river crossings; washouts in flood-prone basins. Services: Temporary or prolonged road closures during floods; major detours and delays for freight and passengers. Communities: Isolation during flood events; reduced access to food markets and emergency services, especially in rural areas.	Resizing culverts and bridges to accommodate higher discharges; Raising road levels on elevated earthworks in flood-prone sections; Erosion protection of road reserves and bridge approaches; Regular inspection, maintenance and post-flood repairs
 Pluvial flooding	Infrastructure: Blocked or undersized culverts; localized washouts of pavement and shoulders due to intense rainfall and debris flows. Services: Short-term but frequent traffic disruptions; repeated maintenance interventions. Communities: Flash-flood-related access disruptions, particularly affecting nearby villages and local trade.	Improved drainage design and increased culvert capacity; Routine clearing of culverts, bridges and dry fords; Installation of debris fences and sediment traps upstream; Slope stabilization and hydroseeding around drainage structures
 Sandstorms	Infrastructure: Sand accumulation on road surface; blockage and siltation of culverts and drainage structures; accelerated wear of pavement markings. Services: Reduced visibility and safety; temporary road closures; increased maintenance requirements. Communities: Transport interruptions, safety risks for road users, reduced reliability of supply chains.	Regular mechanical clearing of sand from roads and culverts; Planting of barrier vegetation to reduce wind speed and trap sand; Dune stabilization and sand fixation in high-risk sections; Enhanced maintenance and monitoring during sandstorm seasons

KEY LESSONS

LESSON

1

Incorporating food security impacts into the investment appraisal can strengthen the case for resilient transport



Image credit: g rard bontoux, Flickr.com

WHAT WE HAVE LEARNT

This project demonstrates that climate-resilient road investments can deliver substantial food security and human development benefits that are not captured through conventional transport metrics alone. By explicitly linking road resilience to food access, market connectivity, and livelihood, the assessment shows that improved corridor performance directly benefits food-insecure populations living near those priority road segments. The analysis further distinguishes between three spatially differentiated agri-food systems, smallholder farming areas, pastoral and agropastoral zones, and urban-centered food processing and consumption hubs, highlighting how resilience investments support production, mobility, and market access differently across these contexts. Quantifying these impacts, as well as gains in health, productivity, and access to education, strengthens the economic and development case for resilience investments and helps justify higher upfront adaptation costs. The analysis also highlights that food security benefits are spatially concentrated, reinforcing the value of targeting road segments that serve vulnerable rural populations and agropastoral supply chains. Integrating food security considerations alongside climate risk and economic appraisal therefore provides a more complete picture of the true development value of resilient road infrastructure.

REPLICABILITY

Food security analysis can be systematically integrated into corridor or network-level assessments using available national data and spatial analysis of populations living near road alignments. Applying this lens helps align climate-resilient road investments with poverty reduction, nutrition, and rural development objectives, while strengthening project justification. The approach is particularly relevant for rural corridors that support agricultural and agropastoral value chains, where transport disruptions have direct impacts on food access and livelihoods. The methodology can be adapted to different country contexts and project scales.

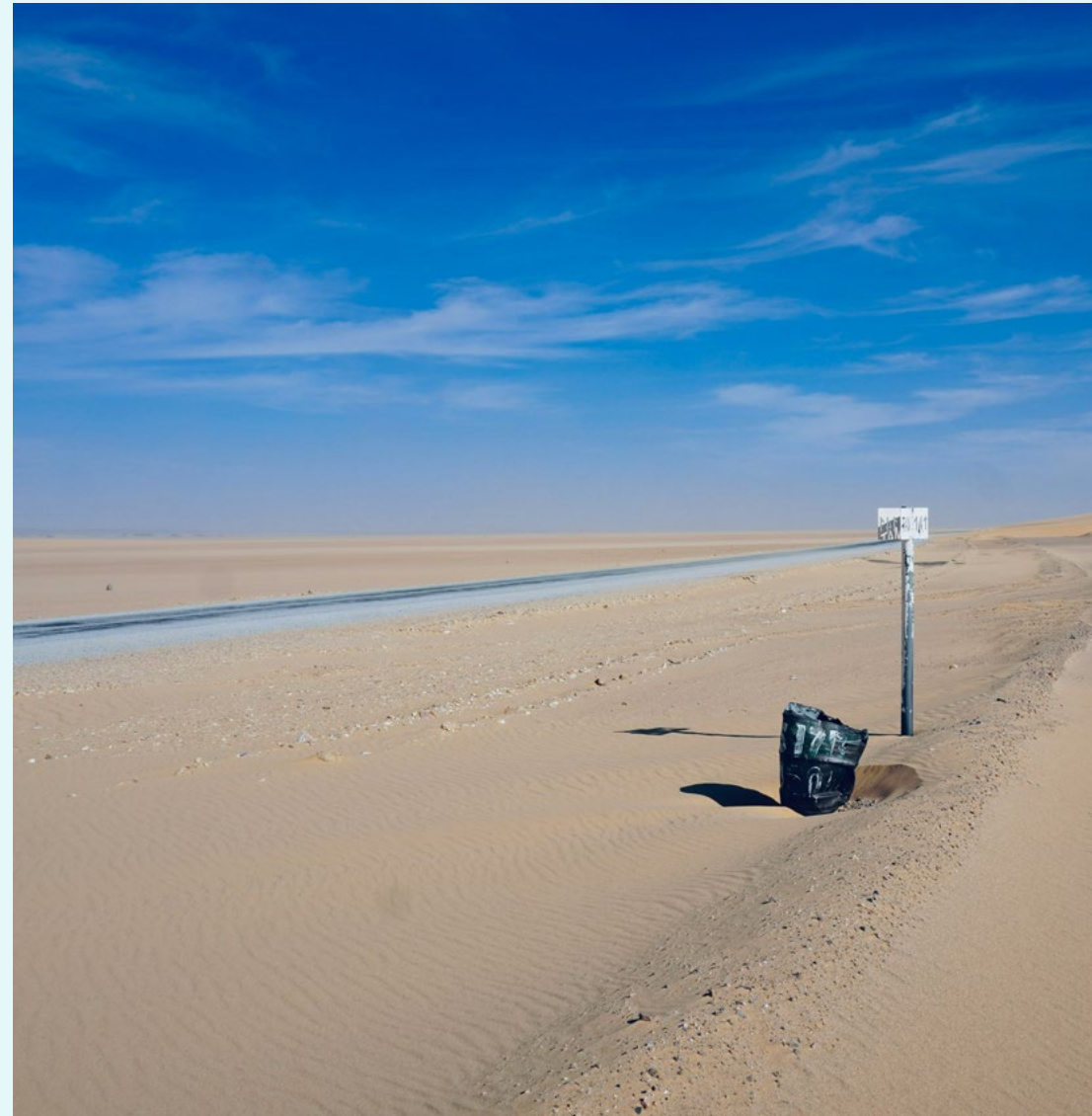
Disaggregating climate risk improves adaptation prioritisation for long linear infrastructure

WHAT WE HAVE LEARNT

This project shows that climate risks, asset vulnerability, and development functions vary significantly along long road corridors. Applying a segment-level climate hazard assessment and vulnerability stress testing made it possible to identify where climate impacts are most severe and where road disruptions would generate the highest economic and social costs. Rather than applying uniformly standard solutions, the analysis demonstrated the value of tailoring adaptation responses to segment-specific exposure, traffic patterns, and socioeconomic importance. This approach improved the cost-effectiveness of proposed interventions and ensured that adaptation investments were aligned with both climate risk reduction and development outcomes. Segment-level prioritisation also enabled clearer packaging of measures, supporting more efficient investment planning and sequencing.

REPLICABILITY

Segment-level prioritisation can be applied to other long linear infrastructure by combining spatial climate hazard data, asset exposure and usage information, and network criticality analysis. The approach helps ensure that limited adaptation resources are focused where they deliver the greatest overall benefit. It is particularly relevant for long rural corridors crossing multiple climate zones, and can be adapted to different data availability contexts.



Actionable insights for MDBs

THEME	INSIGHTS
Resilience and development outcomes	Incorporating food security and livelihood impacts into road resilience appraisals helps capture a broader set of development benefits, strengthening the justification for adaptation investments beyond transport performance alone.
Planning long linear infrastructure	Applying segment-level climate risk and criticality analysis allows adaptation resources to be targeted where disruptions would generate the highest economic and social costs, improving efficiency and value for money in long linear infrastructure investments.
Investment structuring	Packaging corridor-wide measures with segment-specific interventions supports scalable financing approaches and enables phased implementation aligned with risk severity, funding availability, and implementation capacity.
Maintenance and lifecycle costs	Climate resilience depends as much on operations and maintenance as on design upgrades. Allocating adequate OPEX for routine activities can deliver high resilience benefits at relatively low cost and protect capital investments over time.



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