4th ASECAP SUSTAINABILITY FORUM

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Assessment of climate hazards on the Moroccan highway network

Towards a Resilient and Climate-adapted National Highway Infrastructures

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Outline :

- Introduction and context
- Climate hazards exposure analysis for ADM's network
- Results of hazards exposure analysis
- How to make Highway resilient and climate-adapted

Introduction and context :

- 2024: hottest year on record (+1.5°C vs 1991–2020)

- 70% of days with above-normal temperatures

- 6th consecutive year of drought (–25% rainfall)

- Increasing pressure on water resources, ecosystems, and land stability

Introduction and context :

1,800 km Moroccan highway network: a vital part of mobility, essential for trade, tourism, and territorial cohesion.

Highway Network Exposure Rising vulnerability to:

- Extreme heat
- Prolonged drought
- Windstorms
- Wildfires
- Localized flooding

Impacts on Highway Infrastructure:

- Pavement performance degradation
- Slope and soil instability
- Increased operational challenges
- Higher risks to user safety

Climate Hazards Exposure analysis for ADM's Network :

Assessment Objectives : Identify key climate hazards affecting ADM, Support long-term adaptation planning and Strengthen system resilience for future decades.

176 exposure points sampled every 10 km along 1 800 Km ADM network

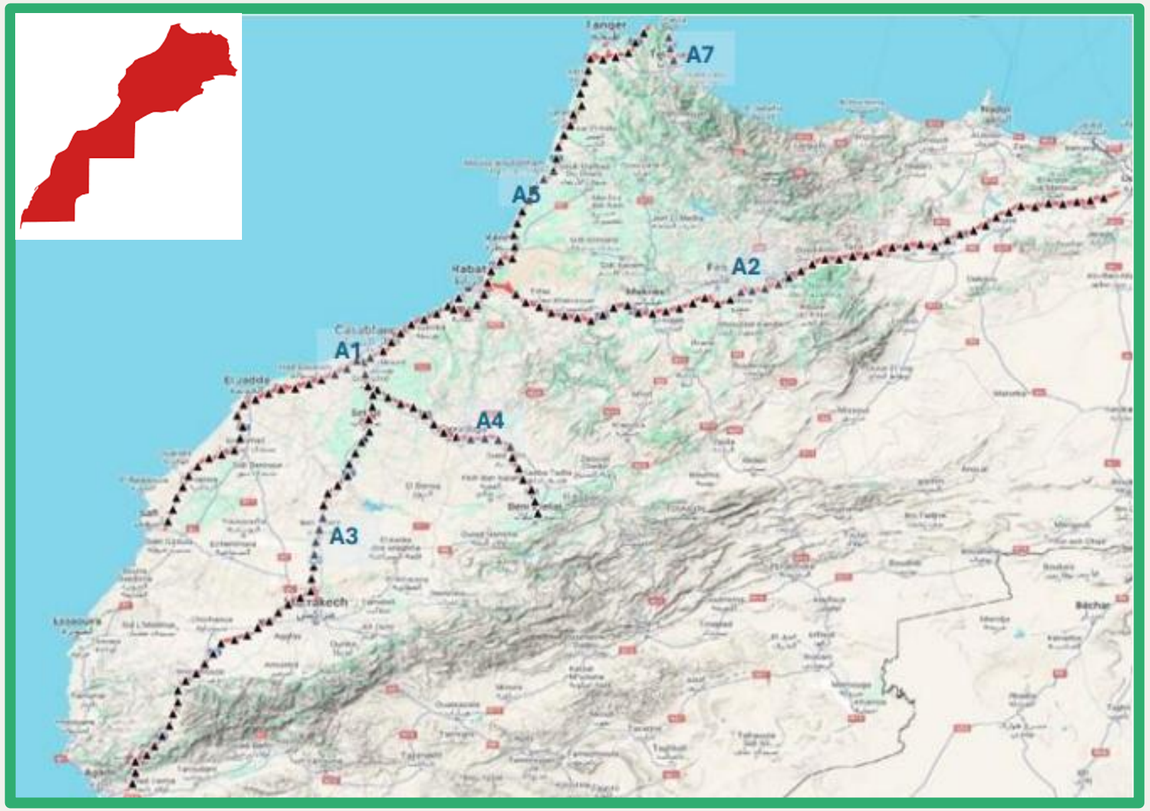
9 Key Climate Hazards Assessed

- Water stress/Drought
- Extreme changes in temperature
- Pluvial flooding
- Extreme Weather (windstorms)
- Heat Stress

- High risk of forest fires
- Potential Soil Erosion
- Landslides
- Sea Level Rise

Climate Hazards Exposure analysis for ADM's Network :

Locations of the 176 network points covered by the analysis



Highway	Number of network points included in the analysis
A1	32
A2	46
A3	46
A4	18
A5	31
A7	3
TOTAL	176

Results of hazards exposure analysis:

The percentage of network points with high or very high exposure levels is computed to identify the key climate risks for the ADM network,

Points exposed to Water stress

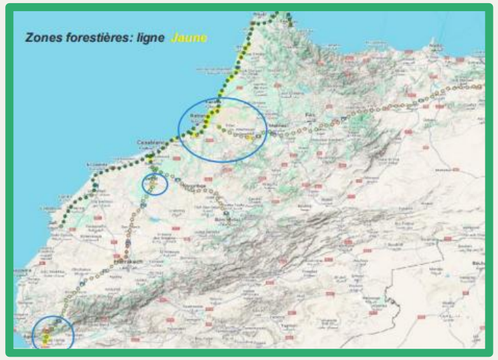
Points exposed to Extreme changes in temperature

Points exposed to Pluvial flooding

Points exposed to Extreme weather conditions

Points exposed to Heat stress

Points exposed to a High risk of forest fires



Points exposed to Potential soil erosion

Points exposed to Landslides (<3%)

Points exposed to Sea level rise

The analysis showed that none of the network points are expected to experience high exposure to sea level rise.

Results of hazards exposure analysis:

Two criteria were applied to select critical hazards:

1. More than 10% of network points show high or very high exposure.
2. More than 10% of network points show increasing exposure compared to the historical baseline.

This 10% threshold ensures that both major current risks and emerging future risks are captured, particularly those projected to intensify by 2030 and 2050.

Cross-referencing these criteria led to the identification of 8 critical hazards:

1- Extreme temperature changes,
2- Drought,
3- Wildfires,
4- Flooding,
5- Extreme weather events,
6- Heat stress,
7- Soil erosion,
8- Landslides

How to make Highway resilient and climate-adapted

Exposure analysis

Identification of major risks for the highway network

→ 7 major risks
+
Physical values and severity for a set of indicators
(for the 176 km markers)

GIS mapping

Obtaining a quick visualization of these major risks on QGIS for ADM

→ Visualization tool for the highest-risk areas of the network, compatible with ADM's management system

Vulnerability analysis

Modeling the impact of major risks on different types of assets
Assessment of:
•the direct effects of climate hazards on Infrastructure
•local indirect impacts

→ **Association with these physical parameters of:**
•potential damages to assets
•operational costs
•local indirect impacts

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Direct and indirect Impacts of major risks

Impacts on Infrastructure

- Damage to bridges and culverts
- Shortened pavement life
- More repairs
- Road closures and disruption
- Higher maintenance costs

Broader Socio-Economic Impacts

- Safety risks for road users
- Trade and logistics delays
- Isolation of communities
- Reduced accessibility
- Budgetary strain from repairs
- Slower emergency response

How to make Highway resilient and climate-adapted

Adaptation Solutions & Prioritization Tool

General

- Establish a monitoring system for climate-related events
- Strengthen monitoring of hydraulic structures, earthworks, bridges

Heatwaves

•Use materials resistant to extreme temperatures (high-modulus asphalt mixes)
•Adapt vegetation to most frequent climate hazards

Wildfires

•Regular vegetation clearing along Highway
•Create tree-free corridors along Highway

Drought

•Protect road berms in sensitive zones
•Use drought-resistant vegetation
•Maintain tree-free corridors

Extreme Rainfall

•Protect hydraulic structures
•Increase hydraulic capacity
•Adapt plantations to exposure
•Create stormwater basins
•Restore watercourses and wetlands

Landslides

•Adapt plantations to erosion risk
•Protect berms from erosion
•Vegetate slopes
•Restore native vegetation

How to make Highway resilient and climate-adapted

Decision-Aid Tool: Overview

Multicriteria Analysis

- Scores represent a weighted evaluation based on several criteria.
- The user assigns a **weight** to each criterion.
- Criteria examples include cost, effectiveness, technical feasibility, innovation, and environmental benefit.

Criteria	Weight
Cost / Additional Cost	**40%**
Solution Effectiveness	**10%**
Technical Feasibility	**10%**
Solution Maturity / Innovation	**5%**
Environmental Benefit	**35%**
Total	**100%**

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