Ministério das Infra-Estruturas,
do Ordenamento do Território e Habitação

Ministry of Infrastructure, Land Management and Housing

THE ROAD INSTITUTE

Consultant Services:

Climate Change and Natural Hazard Vulnerability

and Risk Assessment

and

Climate Resilience and Adaptation Strategy

for the Cabo Verde Road Network

TERMS OF REFERENCE

1. Background

As a small island developing state (SIDS) located in the mid-Atlantic, Cabo Verde is exposed and highly vulnerable to a variety of climate-related events.[1] In recent years, Cabo Verde has experienced a drastic reduction of annual precipitation and an ever-shorter rainy season causing recurrent water shortages and major harvest loss, severely impacting rural livelihoods. The rainfall is concentrated in summer—with 56 percent of the precipitation between July and September—and is very erratic, generally associated with tropical storm activity. Extreme rainfall events caused by strong storms and tropical cyclones—such as the extraordinary passing of Hurricane Fred through Cabo Verde in August 2015—has led to several damaging floods across the country, such as those in São Nicolau (2009), Boavista (2012), São Miguel (2013), and Santo Antão (2016).

With 80% of total population settled on the 1000km of coastline, Cabo Verde is particularly sensitive to sea level rise and coastal hazards.[2] Shoreline erosion exacerbated by sea level rise is already a significant environmental problem for the coastal ports and key ecosystems that play a part in the development of the tourism industry. The Intergovernmental Panel on Climate Change (IPCC) projects a sea level rise of 0.26m to 0.98m for the period 2081-2100[4], which would increase coastal submergence, erosion, flooded lands, and salinity of small estuaries, streams, and coastal waters. For an island country that is making efforts to develop tourism as its main income, reduction of coastlines and the impacts of extreme events could likely be huge constraints to development. Climate change has the potential to significantly derail both growth and equity objectives in Cabo Verde.

Climate change is increasingly posing a threat to critical infrastructure, including Cabo Verde's transport infrastructure. The country's road network consists of 1,650km spread among nine of the ten inhabited islands.[3] The comparatively dense road network is characterized by (a) major roads (often a "ring road" around the island) which extend from each island's principal port and airport to municipalities and serve small towns and rural communities; (b) secondary roads which serve smaller ports and fishing and agricultural communities farther off the main axes; and (c) municipal town roads and tracks.

The Cabo Verde road network is exposed to a range of adverse natural events including heavy rainfall, flash floods and landslides, which cause significant recurrent road damage across the archipelago. Heavy rains in 2015 and 2016 damaged road infrastructure in Santiago, Boavista and Santo Antão. The road network is expensive to maintain because of the geography (steep slopes), geology (unstable and loose terrain conducive to landslides, subsidence and rock falls), and

[1] National Adaptation Programme of Action on Climate Change (2008-2012).
[2] Global Environmental Facility, Cabo Verde Programme Strategy (2015-2018).
[3] The 10 islands comprise of Santo Antão, São Vicente, São Nicolau, Santa Luzia (uninhabited), Sal, Boa Vista, Maio, Santiago, Fogo and Brava.

climate-related events (heavy rains) which because of climate change are likely to become more frequent.

This terms of reference (TOR) relates to the preparation of a vulnerability and risk assessment and climate resilience and adaptation strategy for the Cabo Verde road network, as explained further below. This TOR utilizes commonly-used terminology among practitioners primarily as defined by the IPCC[4]: **Hazard** is understood as the potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources. **Exposure** is defined as the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected by the types of climate-related events considered. **Vulnerability** is defined as the propensity or predisposition of the population or assets to be adversely affected by a physical event. **Risk** is understood as a combination of the probability of an event occurring and the impact or consequences associated with the event.[5]

2. Objective

The objective of this assignment is to prepare a Climate Change and Natural Hazard Vulnerability and Risk Assessment; and to develop, in close consultation with local stakeholders, a Climate Resilience and Adaptation Strategy for Cabo Verde's entire road network (approximately about 1,650km over nine inhabited islands, of which 1,113km is under the responsibility of the national government). This technical assistance is financed by the World Bank's Transport Sector Reform Project and will directly support the Government of Cabo Verde (GoCV) by bringing about transformative change in the way that climate change is addressed in the road sector.

3. Scope of Activities

The Consultant will conduct the following activities:

A. Climate Change and Natural Hazard Vulnerability and Risk Assessment (This assessment is envisaged to comprise about 45% of the input of the total assignment.)

   (i) **Hazard.** Based on available hazard information, identify existing hazard types and current intensity levels in Cabo Verde (e.g. floods, tropical storms/hurricanes, landslides, droughts, etc.). Identify the effect of different climate change scenarios on future levels of hazard. For available information on hazards in Cabo Verde, refer to Annex 1. (This section should be brief and only comprise up to 5% of the input of the total assignment.)

[4] Special Report of the Intergovernmental Panel on Climate Change (IPCC), 2012
[5] Willows and Connell, 2003

(ii) **Exposure.** Based on existing data and knowledge such as Government development plans and consultations with relevant authorities (e.g. the Road Institute, FAMR, etc.), as well as the use of satellite imagery, or visual inspection, identify the exposure to adverse natural hazards in terms of: (This section should comprise up to 10% of the input of the total assignment.).

a) **Road network.** Map out or gather detailed georeferenced information of the current status of the road network, road technical characteristics, replacement costs, traffic data, etc. This data may be available from the Road Institute.
b) **Demographic and socioeconomic** data and identify areas with high densities of population, especially poor or other vulnerable people.
c) The location of (i) **critical services** and (ii) **major economic activities**, both existing and planned.

In addition, undertake a critical assessment of the future economic potential of the exposed areas and rank these on a rigorous and context-appropriate methodology that the Consultant proposes.

(iii) **Assess the risk to natural disasters of all major links of the road network**. Using relevant resources, the analysis will forecast possible impacts of severe weather events on the road network, according to its level of hazard, exposure, and vulnerability, and estimate economically the physical damages of the expected current and future climate-related events. The consultant might use a Probabilistic Risk Assessment of the road network to estimate physical damages. The consultant must prepare GIS linked maps to visually illustrate at-risk areas, as well as critical road transport links and locations of critical services and facilities identified (This section is envisaged to comprise about 20% of the input of the assignment).

(iv) **Assess the impact of loss of connectivity and access in priority areas based on the experience of recent severe weather events.** (This section is envisaged to comprise about 5% of the input of the total assignment.)

a) Review existing data and conduct key informant interviews or focus groups, assess the extent of the loss of connectivity and basic access.
b) Identify the road transport links that were disrupted in recent severe weather events or considered to be susceptible to disruption during a disaster.
c) Identify critical road transport links that could serve as important means of escape, access to emergency relief, or for the transport of agricultural or other economic assets.
d) Assess the impact of such loss of connectivity and access on the lives and livelihood of vulnerable populations and overall economic activities.

(v) Utilize the precedent information to classify, following a methodology to be proposed by the Consultant, the road network links into: First/Second/Third **priority areas**, according to their level of risk to existing and future levels of hazard, and the impact

of the loss of connectivity. First priority areas should include road transport links critical for local socioeconomic development. The methodology should consider the size of the population affected by loss of connectivity, the level of poverty, concentration of critical social services and major economic activities, among other indicators that the Consultant proposes that are appropriate in the context of Cabo Verde. (This section is envisaged to comprise about 5% of the input of the total assignment.)

B. Climate Resilience and Adaptation Strategy for Cabo Verde's Road Network

The Consultant will prepare a Climate Resilience and Adaptation Strategy for Cabo Verde's road network based on the analysis from the risk assessment, as described above. (This strategy is envisaged to comprise about 55% of the input of the total assignment.) It will (i) outline a general climate change adaptation policy framework and objectives for the road sector; (ii) recommend a program of priority investments and other interventions at specific risk locations; and (iii) propose specific policy reforms required to provide a foundation for climate change adaptation and to address disaster and climate-related risks in the road sector. This will be achieved by the following:

(i) Identify potential adaptation options that respond to the risk assessment and that are technically feasible and appropriate in the context of Cabo Verde. The analysis should include:
   a) Specific interventions at high-risk locations; and
   b) Measures that can be taken at a national level to reduce vulnerabilities and enhance the resilience of the road network, as described in the following tasks.

(ii) Develop a prioritized program of investments at specific locations to improve the resilience of the road network, and define the general nature of each of the proposed investments. The priority investments should be grouped into time bands, such as short-term (1-5 years), medium term (5-10 years), and long-term (10+ years), considering the urgency of the required response, the design life of the proposed investment, and a cost-benefit analysis of each investment. The Consultant should propose a methodology to deal with the uncertainty related to climate change projections.

(iii) Review current road planning processes, the institutional and legal framework for the roads and traffic sector (e.g. relevant legislation), national road construction standards, maintenance (routine, periodic, and emergency) methods, and related processes and assess their adequacy in the light of projected climate change and natural hazard vulnerability. The Consultant should recommend suitable reforms, such as (but not limited to):
   a) Embedding consideration of climate change and disaster risk management issues into all road planning processes;

b) Updating road design standards;
c) Employing new approaches to road maintenance that take into account climate change and natural hazards; and
d) Mainstreaming climate change adaptation and disaster risk management into the road sector from infrastructure and operational perspectives.

(iv) Review the institutional and legal framework as relevant to the implementation of the disaster and climate resilience strategy, and recommend specific reforms needed to:
a) Improve management of traffic and road access during and following natural disasters; and
b) Enhance quick response procedures to ensure that roads are repaired and restored quickly following severe weather damage.

(v) Provide training and capacity building to the Road Institute's engineers to ensure the analysis and tools developed to carry out the assignment can be utilized and updated following the assignment.

4. Deliverables and Corresponding Payment Schedule

The Consultant is expected to submit versions of each report in Portuguese and English (or French) including a soft copy and two hard copies.

(i) Inception report that summarizes the initial result of the literature review and the study plan that is proposed, including the shortlist of priority areas, to be submitted within one month of the commencement of the assignment. Acceptance of this report would account for 10% of the contract amount.

(ii) Mid-term report that provides the summary of findings and preliminary conclusions of the study, to be submitted three months after the commencement of the assignment. Acceptance of this report would account for 40% of the contract amount.

(iii) Draft Final report that provides stylized dataset, summarizes the conclusions and policy recommendations of the study and presents all data and information obtained under the assignment. This report is to be presented at a workshop attended by all relevant stakeholders. It is to be submitted within six months of the commencement of the assignment. Acceptance of this report would account for 20% of the contract amount.

(iv) Presentation and consultation with stakeholders, acceptance of which would account for 10% of the contract amount.

(v) Final report incorporating all comments on the Draft Final report, within eight months of the commencement of the assignment. Acceptance of this report would account for 20% of the contract amount.

5. Team Composition and Qualification Requirements

Consulting firms are encouraged to develop their own methodology as well as the staffing plan, level of effort and work approach to accomplish the TOR. This technical assistance assignment will require the firm to staff an appropriate mix of highly qualified international and local staff. An example of possible key team members may include a number of, but not necessarily limited to, the staff noted below. Where key experts proposed by firms do not have experience in small island countries, it is expected that they would be assisted by non-key experts with such experience. It is up to the firm to propose which of the staff on its team is Team Leader, among the positions: Senior Economist; Senior Road Engineer; Disaster Risk Assessment Specialist; Climate Change Specialist; Lawyer / Policy Specialist. That individual will have overall responsibility for the direction, technical excellence and successful completion of the project and must have at least 15 years of Project Management experience having leadership qualities in addition to the requisite qualifications of one of the key staff positions noted below.

Key Staff	Qualifications	Experience
1. Senior Economist	Master's degree in Economics required, PhD preferred.	At least 12 years of experience in micro-economics. Experience with statistical modeling; designing, implementing household, commercial properties, etc. surveys; and performing complex econometric analysis strongly preferred. At least 3 years of experience in similar studies, preferably in small island countries.
2. Senior Road Engineer	1st degree in civil engineering, with post-graduate qualification in roads-related discipline. Full membership of national or international professional institution.	20 years or more experience in the field of road engineering, out of which a minimum 7 years of post-graduate experience in roads and drainage design in small island states. Some CCA and/or DRM-related project experience preferred.
3. Climate Change Specialist	Master's degree in climate sciences, urban planning, or related field is required.	Minimum of 10 years of experience working on climate change; at least 5 of which should be with a developing country or emerging nation, preferably in a small island country.
4. Disaster Risk Assessment Specialist	Bachelor's degree in Civil Engineering, Urban Planning, Geology or other relevant Disaster Management subject required as well as a relevant post graduate qualification.	He/she should have at least 10 years of experience in the fields of natural disaster assessment, mitigation and remediation; at least 5 of which should be with a developing country or emerging nation, preferably in a small island country.
5. Lawyer / Policy Specialist	JD, LLB, LLM or equivalent preferred. Alternatively, individuals with Master's degree in relevant discipline with at least eight years' experience in policy and legal	At least eight years of experience in policy and legal reform and regulatory issues. An international legal counsel with experience in Cabo Verdean road policies and legislation or assisted by a Cabo Verdean lawyer with

	reform and regulatory issues may also be considered.	knowledge of Cabo Verde road policies and legislation is essential.
6. Engineering Hydrologist	Bachelor's degree in Hydrology, Physical Geography, Earth Science, Engineering, or Environmental Science required with a strong focus on hydrology. Preferably Master's degree.	At least 7 years relevant experience in engineering hydrology including 3 years of experience of hydrodynamic analyses and modelling, flood risk assessment with hydrologic modelling software. Some CCA and/or DRM-related project experience preferred.
7. Meteorologist	Bachelor's degree in Meteorology or relevant discipline.	At least 5 years of experience in weather forecasting and analyzing data.
8. GIS/Mapping Specialist	Bachelor of Science or Engineering Degree required.	Minimum of 5 years of GIS experience and experience working with various data formats such as CAD, GPS, etc. Knowledge of environmental resource management, transportation, or geography strongly preferred.
9. Environmental Specialist	At a minimum, a Bachelor's degree in science or engineering discipline (Biology, Chemistry, Geology, Civil or Chemical Engineering).	At least 10 years of experience in positions requiring proficiency with the analysis and application of environmental regulations; skills in the application of environmental and technical concepts is also required. At least 3 years' experience in similar studies preferable in small island countries.
10. Social Development Expert	Master's degree in a relevant field such as sociology, anthropology, urban planning, or other social sciences.	At least 10 years of relevant social development experience and proven track record in working on projects covering a broad range of resettlement and social development issues. Experience working in small island countries preferred. Having good knowledge of World Bank polices and framework for social development.

6. Administrative Personnel and Other Staff

The Consultant shall have its own office and field staff to assist in carrying out the services. The staff provided shall be experienced and capable of performing their allotted duties, in particular:

(i) Office administration and clerical personnel; and
(ii) Field assistants for team members in carrying out field work, etc.

7. Duration and Level of Effort

It is expected that the study will be completed within eight months of commencement.

8. Counterpart Input, Personnel and Facilities

(i) Data and Information: The client will provide unimpeded access to relevant data and information to assist the Consultant in this project on an "as available" basis. This includes maps, execution projects/designs, list of urgent works and respective contractual pieces, and access to the road database. The documents produced by the Consultant including reports, drawings, software, data, models etc. will be the exclusive property of the Road Institute.

(ii) Counterpart personnel: The GoCV will provide a local liaison officer, who will liaise with local communities and vulnerable persons on matters concerning the project field work and related matters. The Road Institute will also facilitate contacts with relevant stakeholders.

(iii) Office accommodation and logistics: The mission will take place in the Road Institute headquarters, during which the Road Institute will facilitate a room for the Consultant's work. The Consultant shall be responsible for providing all accommodation, computing, software, and drafting equipment, etc. The Consultant will also be responsible for all land transportation arrangements during the project.

(iv) Capacity building: The Consultant will do their best to pass on knowledge to the Road Institute engineers and other staff by training and advising in a hands-on manner.

Annex 1: Available Hazard Data in Cabo Verde

Description of Available Hazard Data in Cabo Verde			
Hazard	**Source**	**Description**	**Resolution & Coverage**
Coastal Flood	**UNDP**	Not assessed. Instead, two susceptibility layers were produced by weighting different geomorphological parameters: (1) the susceptibility of beaches to coastal erosion and (2) coast susceptibility to landslides. Both layers were produced in current climate conditions.	Shapefile Available for all the islands
	GFDRR	Wave setup and peak water levels for 10, 25, 50, 100, 250, 500, and 1000-year RP in current and future conditions (due to climate change) were modelled in 10 selected sites. This was used to interpolate water levels for the rest of the country for the different RPd events. In addition, a hydrodynamic simulation of the water level during hurricane Fred (2015) was carried out. No further hurricane simulation was performed in Cabo Verde.	Raster with 3 arcsec resolution (~100m) Available for all the islands
Riverine Flood	**UNDP**	Riverine flood events of 10, 20, 50, and 100-year RP were modelled in rivers of 55 selected basins on current climate conditions. Water depth and speed were calculated (although not available in the INGT repository), combined and classified into five classes (very low, low, medium, high, and very high hazard) following a methodology intended to "*assess risk to people*". **Final layer classifies the studied area according to the preceding categories.**	Shapefile Rivers of 55 selected basins (Whole country not assessed)
	GFDRR	Currently under review.	-
Landslide	**UNDP**	Available layers (for current climate): 1. **Earthquake-triggered landslide hazard layer:** by combining a susceptibility layer with data on a 475-year RP earthquake event. 2. **Rainfall-triggered landslide hazard layer:** by combining a susceptibility layer with data on a 100-year RP rainfall event. Layers don't have a RP associated, and only represent landslide propensity.	Shapefile Available for all the islands
	GFDRR	Available layers (for current climate): 1. **Earthquake-triggered landslide hazard layer:** by combining a susceptibility layer with data on a 500-year RP earthquake event. 2. **Rainfall-triggered landslide hazard layer:** by combining a susceptibility layer with data on a 100-year RP rainfall event.	The data was processed and resampled. Final maps are rasters with resolution

		A future (2050) version of both layers is also available, accounting for future climate conditions (rainfall) and the changes in terrain susceptibility to landslides due to increased population. Layers don't have a RP associated, and only represent landslide propensity. At the **country level**: GFDRR and UNDP agree on the most landslide-prone islands. **Within islands**: significant differences.	of 15 arc seconds. Available for all the islands
Drought	**UNDP**	**Standardized Precipitation Index** (SPI) and **Normalized Difference Vegetation Index** (NDVI) were combined following a simple procedure to produce drought susceptibility maps on current climate conditions.	Shapefile Available for all the islands
	GFDRR	Currently under review.	-
Earthquake	**UNDP**	Final map has the value of the **Peak Ground Acceleration of a 475-year return period (RP) event**, obtained by weighting 12 different intermediate hazard maps (all for a 475-year event) with different assumptions on the attenuation and site effect models. Spectral Acceleration was not estimated.	Shapefile Available for all the islands
	GFDRR	Both **Peak Ground Acceleration and Spectral Acceleration** were modelled (for eight structural periods, between 0 and 2 sec.) for earthquakes with RP of 10, 25, 50, 100, 250, 500, and 1000 years. Modelling was done **with and without site effects**. Site effects were estimated from topographic slope using a methodology developed by the USGS, and could be refined with local soil information if available. For most of the islands, the UNDP profile underestimates EQ hazard with respect to the GFDRR profile.	Raster with 0.05º (~5Km) resolution Available for all the islands
Volcanoes	**UNDP**	Only **Santo Antão, Brava** and **Fogo** face non-negligible volcanic hazard. Different eruption scenarios were modelled (VEI 2, 3, 4), including Pyroclastic Density Currents (PDC), lahar, and tephra hazard zones. Scenarios were combined to produce the final hazard layer, which indicates the hazard level in the selected islands classified into 5 categories (negligible, residual, very low, low and moderate).	Shapefile Santo Antão, Brava and Fogo
	GFDRR	PDC and Lahar distribution was modelled in Fogo, Brava and Santo Antão, as well as the tephra distribution for eruptions of different magnitudes and wind conditions. Final maps identify the area exposed to the PDC, lahar and tephra. UNDP and GFDRR profiles show general agreement on the RP of volcanic eruptions and the area exposed to sub hazards.	Shapefile Santo Antão, Brava and Fogo

1. The UNDP report of the hazard assessment (in Portuguese): [http://arcgis.gov.cv/bo/Delivareble3_FinalReport_HazardAssementandMappingCV.pdf]
   The hazard layers hosted in the open data platform of the Instituto Nacional de Gestao do Territorio, INGT: [http://idecv-ingt.opendata.arcgis.com/]
2. The GFDRR profile is current under review and is expected to be available by August 2018.