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Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa

Quarterly Progress Report

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Council for Scientific and Industrial Research (CSIR), Paige-Green Consulting (Pty) Ltd and St Helens Consulting Ltd

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Abstract

The African continent may be facing a potential direct liability in excess of $150 billion to repair and maintain existing roads damaged from temperature and precipitation changes directly related to projected climate change through this Century. This liability does not include costs associated with impacts to critically-needed new roads, nor does it include indirect socio-economic effects generated from dislocated communities and from loss of rural access.

In order to help address this significant threat to Africa's development, the Africa Community Access Partnership (AfCAP), a research programme funded by UKAid, has commissioned a project that started in April 2016 and is expected to be completed by December 2018, to produce regional guidance on the development of climate-resilient rural access in Africa through research and knowledge sharing within and between participating countries. The output will assist the development of a climate-resilient road network that reaches fully into and between rural communities.

The study focusses on: (a) demonstrating appropriate engineering and non-engineering adaptation procedures; (b) sustainable enhancement in the capacity of three AfCAP partner countries; (c) sustainable enhancement in the capacity of additional AfCAP partner countries; and (d) uptake and embedment across AfCAP partner countries.

This Quarterly Progress Report outlines the progress that has been made since the release of the Inception Report in June 2017. It primarily focusses on the following three activities: (a) progress on the establishment of demonstration sections; (b) the development of a climate threat and vulnerability methodology for application at a local/project level; and (c) the development of a draft *Climate Adaptation Handbook* and three associated guidelines, namely *Change Management Guidelines, Climate Threats and Vulnerability Assessment Guidelines*; and *Engineering Adaptation Guidelines.*

Key words

Capacity Building; Change Management, Climate Adaptation; Climate Change; Climate Impact; Climate Threat; Climate Variability; Demonstration; Risk; Rural Access; Resilience; Vulnerability

AFRICA COMMUNITY ACCESS PARTNERSHIP (AfCAP)

Safe and sustainable transport for rural communities

AfCAP is a research programme, funded by UK Aid, with the aim of promoting safe and sustainable transport for rural communities in Africa. The AfCAP partnership supports knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources. AfCAP is brought together with the Asia Community Access Partnership (AsCAP) under the Research for Community Access Partnership (ReCAP), managed by Cardno Emerging Markets (UK) Ltd.

See www.research4cap.org

Glossary (within the context of this project)

Adaptation	Autonomous or policy-driven adjustments in practices, processes or structures to take account of changing conditions.
Adaptive Capacity	The degree to which adjustments in practices, processes and structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change [in climate].
Adaptation Needs	The circumstances requiring actions to ensure safety of populations and security of assets in response to climate impacts.
Adaptation Options	The array of strategies and measures that are available and appropriate for addressing adaptation needs. They include a wide range of actions that can be characterised as structural, institutional, or social.
Capacity Building	The ability of enhancing strengths and attributes of, and resources available to, an individual community, society, or organisation to response to change.
Change Management	A collective term for all approaches to preparing and supporting individuals, teams and organisations in making organisational or institutional changes in order to equip them to address and resolve new or recurring challenges impacting on them and their stakeholders (e.g. impacts of climate variability and change on their operations)
Climate Change	Change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.
Climate Variability	Variations in the mean state and other statistics of the climate on all spatial and temporal scales beyond those of individual weather elements. Variability may be due to natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability).
Disaster	Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.
Early Warning Systems	The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organisations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Extreme Weather Events	An event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season).
Flood	The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.

Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.
Impacts (Consequences, Outcomes)	Effects on natural and human systems. In this report, the term *impacts* is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.
Impact Assessment	The practice of identifying and evaluating, in monetary and/or nonmonetary terms, the effects of [climate] change on natural and human systems.
Likelihood	The chance of a specific outcome occurring, where this might be estimated probabilistically.
Mitigation	The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability.
Resilience	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.
Risk	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognising the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In this report, the term 'risk' is used primarily to refer to the risks of climate impacts.
Risk Assessment	The qualitative and/or quantitative scientific estimation of risks.
Risk Management	Plans, actions, or policies to reduce the likelihood and/or consequences of risks or to respond to consequences.
Stressors	Events and trends, often not climate-related, that have an important effect on the system exposed and can increase vulnerability to climate related risk.
System Sensitivity	The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
Vulnerability Assessment	Process which attempts to identify the root causes for a system's vulnerability [to climate variability and change).

Acronyms, Units and Currencies

$	United States Dollar
AfCAP	Africa Community Access Partnership
ADB	Asian Development Bank
AfDB	African Development Bank
ANE	Administração Nacional de Estradas (National Roads Administration, Mozambique)
AsCAP	Asia Community Access Partnership
BoQ	Bill of Quantity
CEDR	European Conference of Directors of Roads
CSIR	Council for Scientific and Industrial Research, South Africa
DFID	Department for International Development, UK
EU	European Union
JICA	Japan International Cooperation Agency
LVRR	Low Volume Rural Roads
NDF	Nordic Development Fund
OECD	Organisation for Economic Cooperation and Development
PMU	Programme Management Unit, ReCAP
ReCAP	Research for Community Access Partnership
TS	Transport Services
UK	United Kingdom (of Great Britain and Northern Ireland)
UKAid	United Kingdom Aid (Department for International Development, DFID)
UN	United Nations

Contents

1. Executive Summary

Africa is experiencing dramatic changes to the continent's climate, which is causing widespread damage to road infrastructure and its associated assets. Rural accessibility is being compromised in a number of countries and sub-regions for increasing proportions of the year, with both direct and indirect adverse effects on livelihoods and associated socio-economic development.

In order to help address this significant threat to Africa's development, the Africa Community Access Partnership (AfCAP), a research programme funded by UKAid, commissioned a project in April 2016 to produce regional guidance on the development of climate-resilient rural access in Africa through research and knowledge sharing within and between participating countries. Research is being conducted on appropriate and economic methodologies for risk and vulnerability assessments; prioritisation of adaptation interventions; and optimisation of asset resilience in the context of rural access. In addition, evidence of cost, economic and social benefit links to rural communities arising from more resilient rural access will be required to support wider policy adoption across Africa.

Previous outputs from this project included an overview of current and projected climate threats and their impact on low-volume road infrastructure in particularly AfCAP Partner Countries; risk and vulnerability assessment methodologies; adaptation methodologies; and engineering and non-engineering adaptation options. Preliminary work was also done to establish demonstration sections in three lead countries, namely Ethiopia, Ghana and Mozambique, followed by workshops held in these countries. The purpose of these workshops was to assess these outputs as well as to identify the countries' priorities for uptake and embedment.

The current focus of the project is on demonstrations of appropriate practices, capacity building, and the uptake and subsequent embedment of outcomes at a range of levels, from informing national policies, through regional and district planning, down to practical guidance on adaptation delivery at rural road level. The demonstrations will largely focus on demonstrating the vulnerability assessment and climate adaptation methodologies.

This Quarterly Progress Report presents the progress made since June 2017[1]. It primarily focusses on the following three activities:

a) progress on the establishment of demonstration sections;

b) the development of a climate threat and vulnerability methodology for application at a local/project level; and

c) the development of a draft *Climate Adaptation Handbook* and three associated guidelines, namely *Change Management Guidelines*, *Climate Threats and Vulnerability Assessment Guidelines*; and *Engineering Adaptation Guidelines*.

When approved for release, this Handbook and associated Guidelines will be used as the basis for capacity building and subsequent embedment, with the understanding that these documents will have to be reviewed and updated periodically.

[1] An overview of the activities undertaken between April 2017 and June 2017 are presented in the *Inception Report for Phase 2* (Verhaeghe et al., 2017)

2. Introduction

2.1 Brief Introduction to the Programme and Beneficiaries

The Africa Community Access Partnership (AfCAP) is a programme of applied research and knowledge dissemination funded by the UK Government though the Department for International Development (DFID). AfCAP is promoting safe and sustainable rural access in Africa through research and knowledge-sharing between participating countries and the wider community.

The proposed main beneficiaries of this Regional Project are the AfCAP Partner Countries, which currently consist of the Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Liberia, Malawi, Mozambique, Sierra Leone, South Sudan, Tanzania, Uganda and Zambia. The main focus is on low-volume road network and transport services that serve rural communities.

The AfCAP Partner Countries are shown on the map below:

2.2 Delivery Organisations

The delivery organisation of the project is a Consortium consisting of the Council for Scientific and Industrial Research (CSIR), Paige-Green Consulting (Pty) Ltd and St Helens Consulting Ltd. The Consortium is led by CSIR.

2.3 Key dates

The period of implementation of this project is 33 months, from April 2016 to December 2018. It is conducted in two phases:

- Phase 1: April 2016 to February 2017 (11 months)
- Phase 2: April 2017 to December 2018 (21 months)

3. Project Background

3.1 General

Africa is experiencing more extreme climate events such as droughts, floods, storms and cyclones. Dramatic changes to the continent's climate is causing widespread damage to road infrastructure and its associated assets. Rural accessibility is being compromised in a number of countries and sub-regions for increasing proportions of the year, with both direct and indirect adverse effects on livelihoods and associated socio-economic development.

In order to help address this significant threat to Africa's development, the Africa Community Access Partnership (AfCAP), a two-phased research programme funded by UKAid, commissioned a project in April 2016 to produce regional guidance on the development of climate-resilient rural access in Africa through research and knowledge sharing within and between participating countries. Research is being conducted on appropriate and economic methodologies for risk and vulnerability assessments; prioritisation of adaptation interventions; and optimisation of asset resilience in the context of rural access. In addition, evidence of cost, economic and social benefit links to rural communities arising from more resilient rural access will be required to support wider policy adoption across Africa.

Outputs from Phase 1 address current and projected climate threats and their impact on low-volume road infrastructure; risk and vulnerability assessment methodologies; adaptation methodologies; and engineering and non-engineering adaptation options. Preliminary work was also done to establish demonstration sections in three lead countries, namely Ethiopia, Ghana and Mozambique, followed by workshops held in these countries. The purpose of these workshops was to assess these outputs as well as to identify the countries' priorities for Phase 2 of this project.

Phase 2 will mainly focus on demonstrations of appropriate practices, capacity building, and the uptake and subsequent embedment of outcomes at a range of levels, from informing national policies, through regional and district planning, down to practical guidance on adaptation delivery at rural road level. The demonstrations will largely focus on demonstrating the vulnerability assessment and climate adaptation methodologies.

During Phase 2, synergies will be sought with relevant Development Partners' programmes such as Ethiopia (World Bank), Kenya (World Bank), Mozambique (EU, NDF, World Bank) and Tanzania (DFID), focussing on programmes that are aligned with the general objectives of this project. This is considered important to prevent duplication of efforts and to harmonise approaches that could be deployed across the sub-Saharan region.

3.2 Research Objectives

The overall project objectives remain as follows (quoted from the project's Terms of Reference):

- *The <u>fundamental research objective</u> of this project is to identify, characterise and demonstrate appropriate engineering and non-engineering adaptation procedures that may be implemented to strengthen the long-term resilience of rural access*
- *<u>Capacity Building and Knowledge Exchange</u>. The appointed consultants must engage meaningfully, from project inception onwards, with relevant partner-country Road and Transport Ministries, Departments and Agencies/Authorities in a knowledge dissemination and capacity building programme based on the outputs from the research. Capacity building should include a wide range of targets from central government agencies to village groups.*
- *<u>Uptake and Embedment</u> are integral elements of this project. The appointed consultants must ensure that there is focus on uptake and subsequent embedment of outcomes. This*

> *must be aimed at a range of levels from informing national policies, through regional and district planning, down to practical guidance on adaptation delivery at rural road level.*

The focus of Phase 1 of the Project was primarily on the establishment of an approach to climate adaptation through research and knowledge exchange. A further aim was to provide consensus for the implementation of demonstration sections in Ethiopia, Ghana and Mozambique, and to deliberate on the initial guideline documents produced at workshops held in these three countries.

Phase 2 will mainly focus on demonstrations of appropriate practices, capacity building, and the uptake and subsequent sustainable embedment of Phase 1 outputs at a range of levels, from informing national policies, through regional and district planning, down to practical guidance on adaptation delivery at rural road level. The demonstrations will largely focus on demonstrating the vulnerability assessment and climate adaptation methodologies.

3.3 Scope of Phase 2

The following five distinct parts have been adopted for Phase 2, reflecting the programme's aim and objectives (cf. *Inception Report for Phase 2* (Verhaeghe et al., 2017) for more information on the methodology and programme):

1. *PART A: Demonstrate appropriate engineering and non-engineering adaptation procedures*

   Identify, characterise and demonstrate appropriate engineering and non-engineering adaptation procedures that may be implemented to strengthen the long-term resilience of rural access. Assess the socio-economic impacts of adopting more climate resilient adaptations.

2. *PART B: sustainable enhancement in the capacity of three AfCAP partner countries*

   Engage meaningfully, from project inception onwards, with relevant partner-country Road and Transport Ministries, Departments and Agencies/Authorities in a knowledge dissemination and capacity building programme based on the outputs from the research. Capacity building should include a wide range of targets from central government agencies to village groups.

3. *PART C: sustainable enhancement in the capacity of additional AfCAP partner countries*

   Carry out situational analysis and initiate capacity building programme in additional countries.

4. *PART D: uptake and embedment across AfCAP partner countries*

   Uptake and embedment will assume the format of informing national policies, through regional and district planning, down to practical guidance on adaptation delivery at rural road level.

5. *PART E: Phase 3 recommendations*

   Set out costed long-term monitoring and evaluation proposals, as well as any future actions that may be required to strengthen uptake and embedment.

4 Activity Progress

4.1 Overview of activities completed between April 2017and June 2017

The following activities were reported in the *Inception Report for Phase 2* (Verhaeghe et al., 2017):

1. The outcomes of two workshops on climate adaptation, namely: the Tanzania Stakeholder Workshop (April 2017), and an AfCAP Workshop held at the 8th Africa Transportation Technology Transfer Conference held in Zambia in May 2017;
2. Assessment of methods and/or screening tools used by the World Bank, the EU, the European Conference of Directors of Roads (CEDR) and the ADB to map climate vulnerability regionally, nationally and locally, and benchmarking of the method proposed by the AfCAP Project Team against these four methods;
3. Progress on the drafting of a generic Handbook outlining the climate adaptation methodology, as well as on guidelines for non-engineering adaptation measures.

4.2 Overview of activities undertaken between June 2017 and August 2017

4.2.1 Demonstration sections

Several challenges are still being encountered with respect to the proposed demonstration sections. Sections in Mozambique, Ethiopia and Ghana that were on upgrading/improvement programmes were identified and inspected in the three countries with local staff in Phase 1. Adaptation techniques for each road were identified. The following stage was to do the detailed design for each adaptation. However, since then several changes have occurred, both in terms of (a) the physical demonstration sections themselves and (b) the implementation methodology to be deployed to ensure relevance and maximise uptake.

With respect to (a), the current status of the demonstration sections in the three countries is as follows:

i. The Ethiopian demonstration sections on the Tullubolo - Kela road that were planned to remain unpaved will now be upgraded to paved standard. This will involve a review of some of the proposals and the development of new recommendations and designs for certain of the measures. A Design and Build Contractor has been awarded the contract for upgrading the road. The design work has not yet started but is expected to be initiated soon.
ii. Confirmation is still being awaited on whether the road selected in Ghana will go ahead as planned.
iii. The selected road in Mozambique was found to be unsuitable by the World Bank (funding the project) and three other roads were proposed, with the Mohambe - Maqueze road identified as the most suitable candidate.

With respect to (b), it was emphasised that there can be no disconnection between the Handbook/Guidelines and the Demonstrations. The Handbook and Guidelines need to be validated against the Demonstrations to ensure that they are practical at low-volume rural road level, while the Demonstrations should also form the basis for capacity building of local stakeholders in adaptation design based on the Handbook and Guidelines.

In Section 4.2.1.1, the current status of the Mozambican demonstration sections is presented, while Section 4.2.1.2 outlines a proposed way forward to address Item (b) above. A similar approach, although different scope, will be adopted for Ethiopia and Ghana (cf. Section 4.2.3.4).

4.2.1.1 Current status of Mozambique demonstration project

As part of the AfCAP climate vulnerability project, the selection of a road for construction of Demonstration Sections is required. This road needs to be on an improvement/upgrading/ rehabilitation programme with funding already allocated for their work.

During an initial visit to Gaza Province in Mozambique in September 2016, the road between Chokwe and the dam at Chirrunduo (R440) was selected as suitable for this purpose. This road showed typical examples of 5 major climate-related problems, which were selected for use as demonstration sections. Preliminary designs for the adaptation measures on these sections were developed and included in the Phase 1 final Report.

However, following discussions with Dr Kulwinder Rao of the World Bank on 22 March 2017, it was suggested that the non-classified road between Mohambe and Maqueze be used instead. The reason for this was that the Chokwe road had already been opened to tender as a design and build project and the required changes for the demonstration sections would be difficult to negotiate and implement with the Contractor at that stage. The Mohambe-Maqueze road had been inspected during the initial site visit but had already been assessed by Mott MacDonald and Salomon Lda (2016) and had had some emergency repairs carried out.

During follow-up discussions with Mr Luis Fernandes of ANE and Eng Muonima (Head, Section to Support Local Government) in the week following the World Bank discussions, the following points were highlighted:

1. ANE Eng Muonima would be directly involved in the procurement of the demonstration sections.
2. The estimated bills of quantities for the three roads were currently out for preliminary tender with contractors. These are:
    a) Non-classified road: Mohambe- Maqueze
    b) R441: Chinhacanine- Nalazi
    c) R850: Dindiza-Combomune

Once the preliminary estimates of the costs of these are in, a Consultant(s) will be appointed for the final design of the roads. Following this, the appointed (short-listed) contractor will revise the tender price and the construction will commence. The time-frames for commencing final design and construction of the projects were not known but are expected to be in the second half of 2017.

It was planned that once the final designs are complete, the demonstration sections could be designed on the selected road. At that stage, a variation order to the contractor for the demonstration sections with the difference in costs between the proposed designs and the demonstration sections (covering any additional costs minus any savings) could be prepared. This would allow a direct comparison of the cost of implementing the resilience measures/adaptations compared with the conventional design.

Following discussions with ANE, the Mohambe- Maqueze road was identified as the most suitable road for the demonstration sections. The road was then re-visited with Ms Raquel Langa (ANE, Maputo) and Mr Moises Dzimba (ANE, Gaza Province) during August 2017.

As the World Bank assessment by Mott MacDonald had specifically targeted drainage problems, ANE had carried out a follow up assessment and identified specific areas of the road that required additional attention as well. This assessment was carried out during the wet season and thus identified various problems that would not necessarily be noticed during the dry season. ANE then prepared a detailed summary of additional work to the World Bank estimate, which is essentially a "betterment" programme. No levels or measurements were used and all estimates were based on visual assessments.

During the assessment in August 2017, discussions regarding each of the problems and preliminary solutions were held with Raquel Langa and Moises Dzimba. Moises Dzimba had already initiated the drafting of a revised Bill of Quantity (BoQ) and identified the necessary improvements.

A draft field visit report, inclusive of proposed designs, for the Mohambe- Maqueze road is presented in **Annex A**.

4.2.1.2 Proposed way forward for the Mozambique demonstration project

It is suggested that the Draft visit report (**Annex A**) be sent to ANE for Ms Langa and Mr Dzimba to add or comment. This should then be used to determine a BoQ for the new contractor to carry out the additional work, which will be supervised by CSIR and Dzimba.

The other two roads (Chinhacanine- Nalazi and Dindiza-Combomune) currently fall outside the scope of works of the AfCAP project, but AfCAP could provide assistance as part of overall capacity building. Hence, the following was proposed:

1. Induction training at ANE of ANE staff, and potentially also of consultants and other stakeholders invited by ANE, on the use of the Climate Adaptation Handbook and the three associated Guidelines, these being:
    a. the Change Management Guidelines
    b. the Climate Threats and Vulnerability Assessment Guidelines, and
    c. the Engineering Adaptation Guidelines.
2. The training will focus predominantly on the implementation aspects of the Adaptation Methodologies, and more specifically on the following three Stages of the Methodology:
    a. *Stage 2:* Impact and vulnerability assessment at project level;
    b. *Stage 3:* Technical and economical evaluation of adaptation options; and
    c. *Stage 4:* Project design and implementation
3. An ANE team (possibly including other stakeholders invited by ANE) would then be requested to assess and propose adaptation options for both the Chinhacanine - Nalazi and Dindiza - Combomune roads in terms of Stages 2, 3 and 4 of the Climate Adaptation Handbook and associated Guidelines. *The assessments should be conducted without any technical assistance provided by the AfCAP Project Team* (to check how the Handbook and Guidelines can be effectively utilised by ANE engineers and where they perhaps need improvement)*.* The assessments and proposed designs will then be submitted to the AfCAP Project Team for evaluation.

    The purpose of the workshop and field assessments is to also demonstrate the link between the climate threats (i.e. current and future climate) and the measures proposed
4. Site visits will then be undertaken jointly by the ANE team and members of the Project Team to review and discuss the options proposed.

4.2.2 Climate threat and vulnerability methodology

Previous efforts of the Project Team have mainly been focused on the development and demonstration of a district-level vulnerability assessment methodology, which is basically a top-down geospatial indicator-based approach. The purpose of district-level vulnerability assessment is to identify districts of higher priority in terms of road infrastructure inadequacy, the urgent need of climate proofing and the criticality of improved access as a stimulus for community development.

Since June 2017, the Project Team started to develop a local road vulnerability assessment methodology, which purpose is to identify specific threats that currently affect a particular road segment and to assess how likely such threats would intensify or reduce in future. Particular threats include erosion of embankments, flooding of road surface, loss of road structure integrity, loss of pavement integrity, etc. (Falemo et al, 2015). The intention is that the outputs of the local assessment can be used in the following ways:

- Inform engineering design decisions for the chosen road segments;
- Identification of additional data for inclusion in road asset management systems
- Identify contextual factors that aggravate the effects of climate change on roads, and which can effectively be managed through changes in practices at community, professional or business, or at policy level.

Data availability is one of the greatest challenges when undertaking climate risk and vulnerability studies across African countries. This is the case at district level, but even more so at local level where finer granularity of data is required to produce maps that can support engineering design decisions for climate adaptation of specific road segments. For example, detailed local data on current and historical climate threats typically do not exist electronically or even on paper.

The proposed local road vulnerability assessment methodology has been incorporated in the *Climate Threats and Vulnerability Assessment Guidelines* (le Roux et al., 2017). It discusses communication and stakeholder involvement because local assessments require local involvement in the collection of data in the early stages of the assessment as well as uptake and embedment of recommendations once the assessment has been concluded. It also provides guidance on the method proposed for assessing local road vulnerability to climate threats, including recommendations on input data.

The local road vulnerability methodology is conceptualised in Figure 1 below. The local assessment framework consists of the following:

Phase 1: Identify threats and vulnerability factors for roads within a district

- Step 1.1: Identify hazards that impact roads within a particular district, based on historical climate data
- Step 1.2: Consider future hazards that will likely impact roads within a particular district, based on projected climate data

Phase 2: Local data collection and preparation

- Step 2.1: Data collection (spatial databases, ground survey and community knowledge)
  - What data to collect
  - Where to collect data
- Step 2.2: Data preparation (including digitization of ground and community survey data)

Phase 3: Data Analysis

- Step 3.1 Catchment-level hydrological modelling
  - Under current climate and environmental conditions
  - Under future climate and environmental conditions
- Step 3.2 Determine road exposure to identified threats
  - Under current climate and environmental conditions
  - Under future climate and environmental conditions
- Step 3.3 Evaluate the criticality of the road based on rural accessibility and remoteness
  - Under current socio-economic conditions
  - Under a changing climate and growing population

Phase 4: Adaptation

- Providing inputs for road adaptation according to prioritization

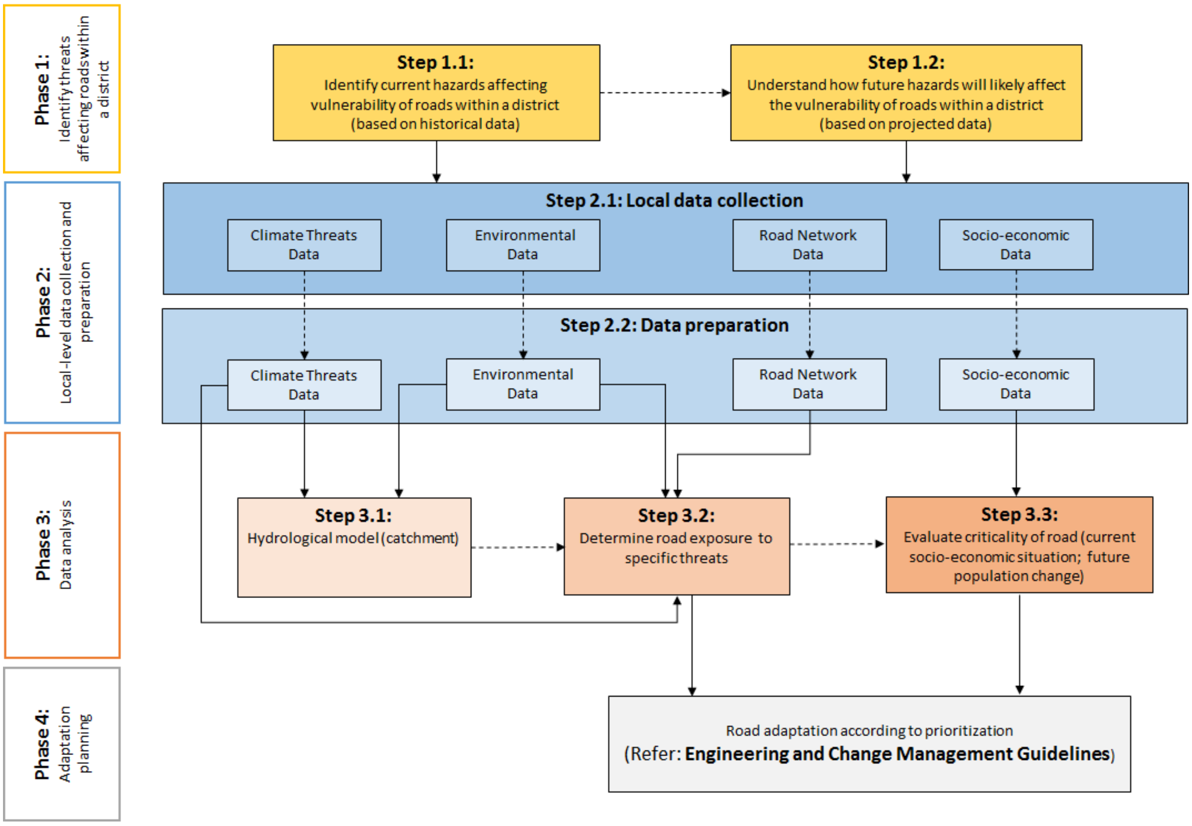


FIGURE 1: The proposed framework for assessing road vulnerability to climate threats at a local community scale

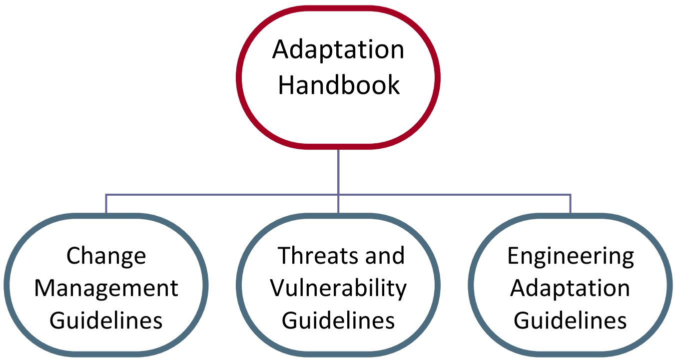
The local assessment is presented in the *Climate Threats and Vulnerability Assessment Guidelines* (le Roux et al., 2017) as a concept that needs to be refined or adapted for each road being considered. Certainly data availability would make every situation different, but the location of the road itself would also add variability into how this assessment is done. For example, for a road in mountainous areas, villages could be located much further from the road and these may be very sparsely populated. Another factor is the availability of resources to perform the assessment. Therefore, the assessment framework needs to be piloted so that recommendations could be made to accommodate disparate situations.

4.2.3 Climate Adaptation Handbook and associated Guidelines

4.2.3.1 General

A *Climate Adaptation Handbook* (Head et al., 2017) and associated Guidelines have been produced which provide relevant information on climate adaptation procedures for rural road access, along with instructions and guidance on appropriate methodologies to address climate threats and asset vulnerability, to increase resilience for the foreseeable future. They have been developed to cover a wide range of climatic, geomorphologic and hydrological circumstances, based on application to Mozambique, Ghana and Ethiopia, but equally applicable to any sub-Saharan country.

The Handbook is an overarching document and illustrates the fundamental principles, processes and steps required for climate resilience. Detail regarding actual adaptation approaches and measures are included in the accompanying Guidelines covering *Change Management* (Head and Verhaeghe, 2017), *Climate Threats and Vulnerability Assessment* (le Roux et al, 2017), and *Engineering Adaptation* (Paige-Green et al., 2017):



The Handbook will be supported by demonstration case studies in three countries, namely Ethiopia, Ghana and Mozambique. These three countries represent nearly the full range of climatic systems in Africa. Mozambique is subject to flooding and extreme events, including tropical cyclones. Both Mozambique and Ghana are on the receiving end of water flowing out of major international river basins, and most of their economic activity and population are concentrated along the coast and in low-lying estuaries and deltas.

4.2.3.2 Application

The Handbook and associated Guidelines have been produced to provide relevant information on adaptive procedures for **new** and **existing** rural road access, along with instructions on an appropriate methodology to address climate threats and asset vulnerability and to increase resilience for the foreseeable future. Although produced for *low volume roads,* the principles also apply to *high volume roads,* although there will be differing priorities and design parameters.

There are three specific, but overlapping applications of the Handbook, see Figure 2:

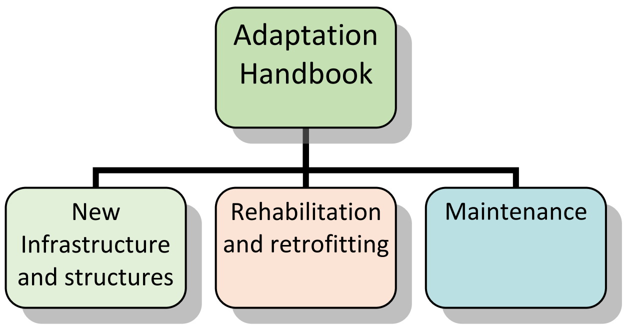


FIGURE 2: Applications covered in the Handbook

New Infrastructure and structures

It is rare to construct new infrastructure. The limited funding available is mostly used for upgrading, repairs and rehabilitation, except for limited areas of realignment necessary to avoid congestion in cities (e.g. ring roads) or to improve geometric and safety conditions.

Rehabilitation and retrofitting

In cases where the required serviceability criteria can no longer be maintained or where future conditions are expected to lead to disruption or failure of the infrastructure components, rehabilitation or retrofitting of the existing facilities is required. This will also be necessary where the risk levels are considered unacceptable, for example where failure of a structure or a large landslide may lead to loss of life, extended periods of road closure or costly rehabilitation works. These types of activity are, however, usually very costly.

Maintenance of existing infrastructure

Many of the potential problems related to climate susceptibility can be minimised by good maintenance. In most sub-Saharan countries, there is a significant maintenance backlog resulting from historical climatic events as well as the inability to fund routine maintenance, resulting in parts of the infrastructure being more susceptible to climate-related damage.

At a strategic level, it is preferable to carry out a national climate vulnerability and threat analysis and develop an adaptation strategy in line with national climate policies. The results would then inform the next steps by identification of specific vulnerabilities and where more resilient infrastructure is needed. This would then be sub-divided into reported on Regional and District levels, possibly at greater resolution, depending on the threat and risks involved and may influence future planning and development decisions. Finally, detailed assessments should be carried out at corridor or project levels and strategies should be refined further; see Figure 3.

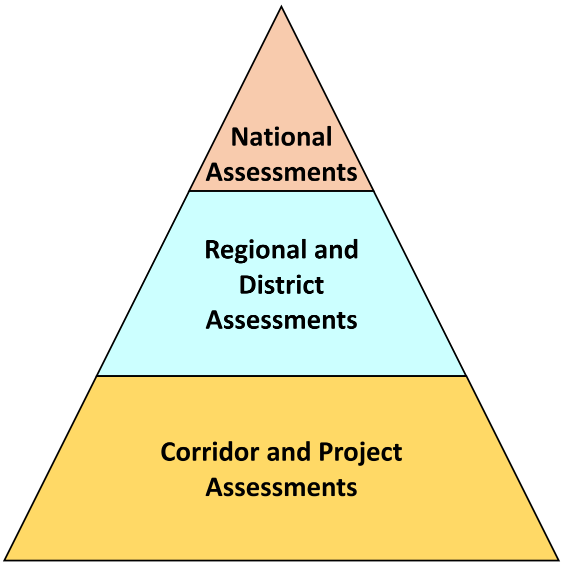


FIGURE 3: Cascade principle of strategic assessments to inform policy

4.2.3.3 Scope of Handbook

The Handbook consists of two parts: **PART A**, which deals with the **Situational Analysis and Management Process**, and **Part B**, which deals with the **Adaptation Methodology**. Part B (Methodology) comprises **five** stages, with each stage comprising several activities as set out in Table 1 (see colour keys at bottom of the table).

TABLE 1: Contents and Scope of the Handbook

PART A	**Situational Analysis and Management Process**	**ASSOCIATED GUIDELINE**
	Problem identification (evidence) Identify probable causes • Poor maintenance • Inadequate budgets • Changing environment Drivers of change (policy) Change management Approach and delivery Effective Data management	**Change Management**
PART B	**Adaptation Methodology**	**ASSOCIATED GUIDELINE**
Stage 1	***Climate risk screening (national/regional)***	
B.1.1	Needs determination	**Change Management**
B.1.2	Identify and mobilise stakeholder/partner involvement	
B.1.3	Setting of policy, objectives and scope (network level)	
B.1.4	Analysis of observed and projected climate effects	**Threats/Vulnerability**
B.1.5	Data gathering and risk analysis	
Stage 2	***Impact and vulnerability assessment (project level)***	
B.2.1	Project-level climate risk screening	**Threats/Vulnerability**
B.2.2	Climate impact assessment	
B.2.3	Data gathering and vulnerability assessment	
Stage 3	***Technical and economical evaluation of options***	
B.3.1	Identify strategies and potential adaptation measures	**Engineering**
B.3.2	Impact assessment of 'do something' and 'do nothing'	
B.3.3	Undertake stakeholder consultations	
B.3.4	Prioritise and select adaptation measures	
Stage 4	***Project design and implementation***	
B.4.1	Develop implementation plan (include 'do-nothing')	**Engineering**
B.4.2	Design parameters and optimisation	
B.4.3	Construction supervision and documentation	
Stage 5	***Monitoring and Evaluation***	
B.5.1	Develop monitoring and evaluation plan	**Engineering**
B.5.2	Report and share implementation experiences	

KEY:

Sections covered by the *Change Management Guidelines*
Sections Covered by the *Threats and Vulnerability Guidelines*
Sections covered by the *Engineering Guidelines*

4.2.3.4 Way forward

The above sets out the basis for the capacity building programmes. At the same time, it is acknowledged that the Handbook and associated Guidelines are mere drafts at this stage, and that they need to be validated in practice. These will be effected as an integral part of the capacity building programmes in the three countries.

The methodology proposed for Mozambique in Section 4.2.1.2 provides a stepping stone in the right direction, and the country feedback will be used to further customise/improve the Handbook and Guidelines.

However, the approach used for Mozambique will have to be modified for Ethiopia and Ghana. The scope of this project does not allow for additional roads to be used for testing the methodology thereon. Hence, for these two countries it is proposed that after a preliminary assessment by the project team to identify/confirm suitable road sections for the demonstrations, and an Induction Workshop presented by the Project Team, that one or more teams of country-appointed stakeholders are send out to the field to conduct the assessments based on lessons learnt. The Project Team will assume the role of observers, consolidate and assess the proposals and designs received from the field assessment teams, and share observations/learning in a final workshop.

4.2.4 Knowledge Dissemination: Briefing Note

As was the case in 2016, regular Briefing Notes will be produced for the Climate Adaptation website and as handouts for the training workshops and seminars to help build awareness, knowledge sharing, participation and feedback.

A first Briefing Note has been produced (see **Annex B**) to sensitise main decision makers in government as to the impacts of climate change and the urgency to act now. This document will be made available as a download from the ReCAP website so that it can be used as part of an awareness campaign.

4.2.5 Embedment of climate adaptation into national policies and plans

On 21 May emails were sent to nominated contacts in Ethiopia, Ghana and Mozambique explaining that the CSIR Project Team had commenced work on Phase 2 and were looking forward to helping address their climate adaptation challenge. The Team requested information on policies, plans, programmes and standards, in addition to those already in their possession, which should be targeted to incorporate into their Climate Adaptation, particularly those in the process of being updated.

Attachments were sent to the three countries listing documents to be forwarded and contacts to be established, as agreed at each national workshop. The Project Team also asked for recommendations for any other documents that should be targeted. Finally, the Project Team asked for assistance on how to make contact with the countries' National Climate Adaptation Committee to determine their agenda and to seek cooperation with them – including an introduction.

The following is a summary of responses received from each country:

Mozambique: The following documents were received on the 29th of May 2017:

- National Climate Change Adaptation and Mitigation Strategy, 2012;
- República de Moçambique Mapa Rodoviário Lista de Estradas Para O Quinquénio (2015-2019);
- Boletim da República Publicação Oficial da República de Moçambique, Terça-Feira, 14 de Abril de 2015, I Série — Número 29;
- Lista de Estradas Programa Quinquenal do Governo, 2015-2019;

- The New Road Sector Strategy (RSS-3) Core Strategy (Final Version), November 2015, Technical Assistance for Capacity Development Support to the Road Sector in Mozambique

Ghana: Ms Paulina Agyekum (ReCAP PMU) is assisting and has forwarded the following information on 18th July:

- National Climate Committee (Contact Person: Mohammed Gyimah); to become a member of the Committee, an application must be made to the Ministry of Science, Technology & Innovation (MESTI);
- National Climate Change discussion document, 2010;
- National Transport Policy, 2008 (2017 draft not yet available);
- Ghana National Climate Change Master Plan, 2015-2020: Contact Persons: Mr. Oppong Boadi (EPA) and Mr. Asumani (Director RSIM, MESTI).

Ethiopia:

- Despite several reminder emails, no information has been received to date (with no indication that agreed actions will be carried out nor information will be collected).

Climate Adaptation Policy reviews are currently underway for both Mozambique and Ghana, with the aim to incorporate the outcomes of the review into their climate adaptation programmes.

At the same time, the AfCAP Project Team is following up on Ethiopia.

4.2.6 Counterpart Researchers/Engineers

In 2016, two (or more) counterpart researchers/engineers from each country were integrated in the Project Team and participated in all in-country activities, inclusive of all engagements with central government agencies and district authorities, and especially in all site visits undertaken in the identified regions for the demonstration projects in all three countries. This will also be the case in 2017, as already witnessed by the active involvement of Ms Raquel Langa (ANE, Maputo) and Mr Moises Dzimba (ANE, Gaza Province) in the Mozambican field investigation that took place in August 2017 (cf. Section 4.2.1.1).

Through interactions with the team and involvement in all in-country activities, all pertinent knowledge on all aspects of this study will be transferred to the counterpart researchers/engineers. They will form henceforth the primary focus of capacity building on behalf of the organisations they represent.

5 Progress against Target Dates

The planned start and completion dates for Work Packages are shown in Table 2 below (note that these are as per the dates determined in the Inception Report). The delivery dates of the Work Packages and/or activities that are at the greatest risk of not being met are shown in red.

These risks, as outlined in Sections 4.2.1 and 4.2.3.4, can be remediated by the solutions offered (on assumption that Ethiopia and Ghana respond and act responsibly), especially since the overall project planning allowed for some drift in the programme to accommodate unexpected events such as those experienced. However, these and other potential risks will have to be managed very carefully from now on to ensure that the Project meets all deliverables by the set deadline of December 2018.

Key to the above is to obtain acceptance that the Handbook and associated Guidelines can be used as training material to induct in-country stakeholders, and especially those that will be involved in the assessment of, and provision of adaptation options/designs for, the demonstration sections in the three countries.

TABLE 2: Anticipated start and end dates of Work Packages

WORK PACKAGE	START DATE	END DATE
Inception Phase	15 May 2017	15 June 2017
Management & Recommendations for Phase 3	15 May 2017	31 December 2018
PART A: DEMONSTRATIONS		
A.1: Mozambique demonstration programme • *Detailed design* • *Construction* • *Monitoring & evaluation* • *Demo vulnerability assessment & RAMS*	15 June 2017 *1 July 2017* *To be determined* *End construction* *1 July 2017*	30 November 2018 *31 July 2017* *To be determined* *30 November 2018* *27 July 2018*
A.2: Ghana demonstration programme • *Detailed design* • *Construction* • *Monitoring & evaluation* • *Demo vulnerability assessment & RAMS*	15 June 2017 *10 July 2017* *30 October 2017* *5 February 2018* *1 July 2017*	30 November 2018 ***18 September 2017*** *19 March 2018* *30 November 2018* *27 July 2018*
A.3: Ethiopia demonstration programme • *Detailed design* • *Construction* • *Monitoring & evaluation* • *Demo vulnerability assessment & RAMS*	15 June 2017 *7 August 2017* *13 November 2017* *5 February 2018* *1 July 2017*	30 November 2018 ***13 November 2017*** *19 March 2018* *30 November 2018* *27 July 2018*
PART B: CAPACITY ENHANCEMENT (three countries)		
B.1: Engagement with key stakeholders in 3 countries	1 April 2017	*16 October 2017*
B.2: Generic handbook on climate adaptation • 1st draft • 2nd draft • Final version	 1 April 2017 24 July 2017 11 December 2017	 24 July 2017 11 December 2017 30 April 2018
B.3: Training modules and training workshops • 1st set of workshops • 2nd set of workshops	 15 June 2017 2 April 2018	 ***16 October 2017*** 27 July 2018
B.4: Translation of documents in Portuguese	24 July 2017	30 April 2018
B.5: On-site training	Linked to the Design & Construction components of Part A	
B.6: Journal articles & conference papers	1 April 2017	15 December 2018
PART C: ENHANCEMENT OF CAPACITY (OTHER COUNTRIES)		
C.1: Identification of priorities	1 April 2017	20 August 2018

WORK PACKAGE	START DATE	END DATE
C.2: Capacity development events	1 April 2017	15 December 2018
C.3: ReCAP website	1 April 2017	15 December 2018
PART D: EMBEDMENT		
D.1: Review of policies, strategies and plans	15 May 2017	20 August 2018
D.2: Provision of advice and technical assistance	21 August 2017	15 December 2018

6 ReCAP Log Frame

In the Inception Phase of Phase 1, an initial assessment was made of the potential contribution of the project to the ReCAP Log Frame indicators. This assessment has been updated based on the activities and outcomes of Phase 1, and are summarized in tabular form in **Annex C** over the period of the project (i.e. Phases 1 and 2).

This project has good potential to contribute to ReCAP's objectives and has very relevant outputs and outcomes. It will inform a wide spectrum of regional and national authorities, policy makers, government officials, technical specialists and associated projects (cf. Output 3). It should attract and leverage additional funds and contributions from other Development Partners, Roads Boards and financial institutions, and its outputs are likely to be implemented throughout and outside Africa (e.g. AsCAP countries). There is a probability that its subsequent uptake and implementation will make significant improvements to national climate resilience leading to improved socio-economic development. It should be noted, however, that most adaptation strategies might increase the initial construction cost of road provision over current practice.

Phase 1 review period was April 2016 to February 2017 and covers Milestone 1 (to July 2016) and part of Milestone 2 (only to end February 2017). Within the period covered by Phase 1 of the project, there were few reportable contributions, particularly as most of the work impacting on the Log Frame is planned for Phase 2. Contributions come from the results of circulation the Briefing Documents and Milestone reports, participation by African researchers/engineers in this study (inclusive of the site visits), and the workshops held in three countries.

Phase 2, given a start date of 15 May 2017 for a further 84 weeks, takes the end of the project target date to December 2018 (covering Milestone 3 and parts of Milestone 4). Several assumptions have been made for Milestones 2 and 3, but they might be speculative at this stage given the subjective nature of “capacity building, uptake and embedment” at this stage.

Climate Adaptation funding is available from various Development Partners such as DFID, the World Bank, the EU, NDF, JICA , AfDB and others. It is expected that the scope of this project will be augmented by synergies created between this project and those planned by the other Development Partners. Based on preliminary discussions held in particularly Mozambique and Ethiopia, closer collaboration between DFID, the World Bank and the EU are likely to materialise. The implication of this on this project and on the Log Frame are still to be determined.

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Annex A: Mohambe-Maqueze Demonstration Section (Mozambique)

(by P Paige-Green, August 2017)

A.1 Background

As part of the AfCAP climate vulnerability project, the selection of a road for construction of Demonstration Sections is required. These roads need to be on an improvement/upgrading/ rehabilitation programme with funding already allocated for their work.

During a visit to Mozambique in September 2016, the road between Chokwe and the dam at Macarratane (R440) was selected as suitable. However, following discussions with the World Bank, it was suggested that the non-classified road between Mohambe and Maqueze be used instead (Figure 1). This road is in a particularly problematic area with the Changane River flowing to the east of it consisting of numerous large lakes and two large lake areas on tributaries of the Changane River to the west of the road about two thirds of the way down (Figure 2).

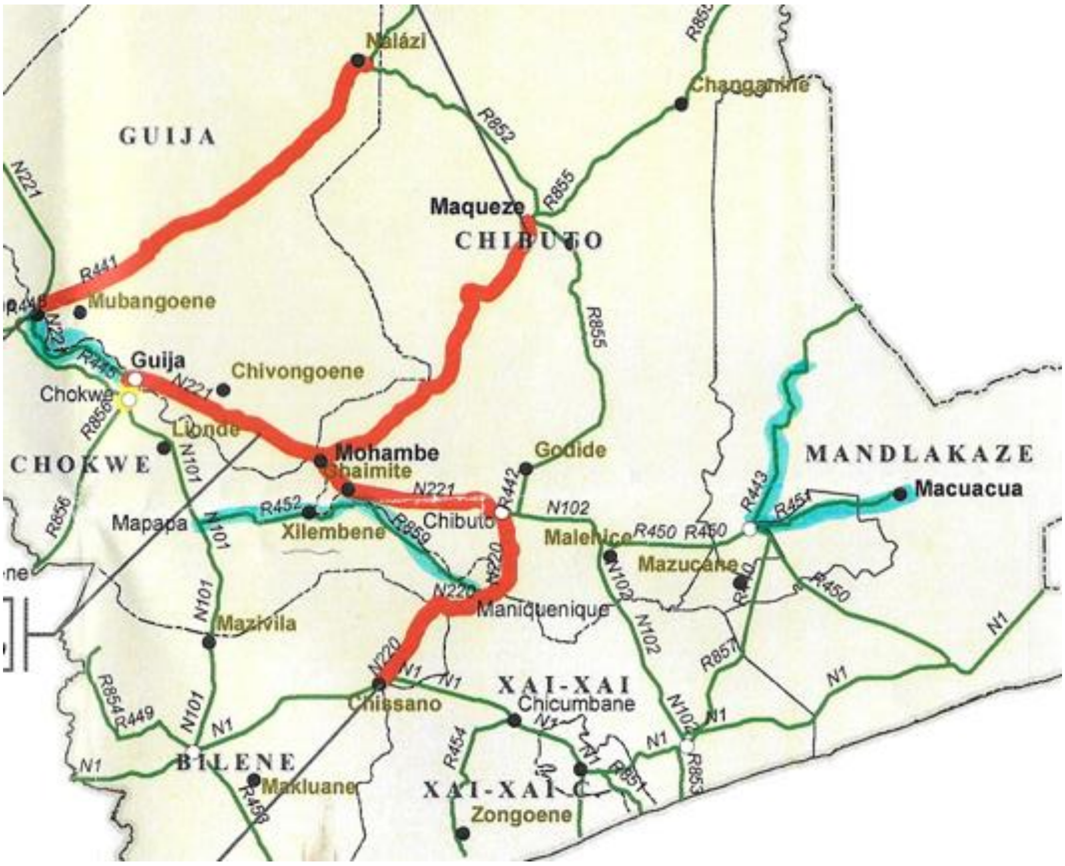


Figure 1: Part of Gaza province showing location of Mohambe- Maqueze road

Figure 2: Road location showing main drainage features in the area

Although this road had been identified by Mott MacDonald for a climate resilient exercise funded in a World Bank project, their conclusions were primarily related to improving the existing drainage structures and did not cover the road outside these drainage areas. The following recommendations (minimum) were made:

- Reshaping of the existing embankments so the top level of the embankment is horizontal (i.e. at a constant level)
- Reshaping of the sides of the embankment to reduce the side slopes to a maximum slope of 1:4
- Extending the existing pipe culverts to suit the wider embankment
- Construction of a 100mm thick trapezoidal shaped concrete slab laid on the embankment slopes at each culvert inlet and outlet. The slab will extend from the road shoulder to the culvert invert. For single pipes the slabs will be 2m wide at the shoulder and 5 m wide at the invert
- Modify the wing walls of the box culverts and drifts/fords both upstream and down using gabions, which will be turned and extended about 6 m along the toe of the embankments parallel to the road centre line (for all 4 wing walls)
- Provision of a 150 mm gravel wearing course on the road surface across the embankments (preferably calcrete gravel meeting minimum wearing course specifications)
- Planting of deep rooted local grass varieties on the embankment slopes (ideally the grass should come with the clay top soil material used to clad the embankment slopes).

The road was visited during the initial trip in September 2016 with Ms Raquel Langa (ANE, Maputo), Mr Rogerio Simione (ANE, Nampula Province) and Mr Nelson Horacio (ANE, Gaza Province). After the discussions with the World Bank, it was revisited during a triop to Mozambique between the 8th and 11th August 2017 together with Ms Raquel Langa (ANE, Maputo) and Mr Moises Dzimba (ANE, Gaza Province).

As the World Bank assessment by Mott MacDonald had specifically targeted drainage problems ANE carried out a follow up assessment and identified specific areas of the road that required attention as well. This was carried out during the wet season and thus identified various problems that would not necessarily be noticed during the dry season. ANE then prepared a detailed summary of additional work to the World Bank estimate (Table 1 and Table 2), which is essentially a "betterment" programme. No levels or measurements were used and all estimates are based on visual assessments.

Two contractor had already been appointed for Road Maintenance in 2015 and 2016 but had been removed for non-performance. A third contractor (a consortium consisting of a Maputo (CCH) and a Xai Xai (CBC) based contractor) had been appointed subsequently and had started mobilising during the visit. A small site camp was seen at about km 13 from the start with various stockpiles of aggregate, rip-rap, some 1.2 m concrete pipes and several pieces of plant. The project was still awaiting appointment of the Supervision Engineer.

Table 1: Summary of additional work (locations and estimated quantities

Data : 14 de Janeiro de 2017

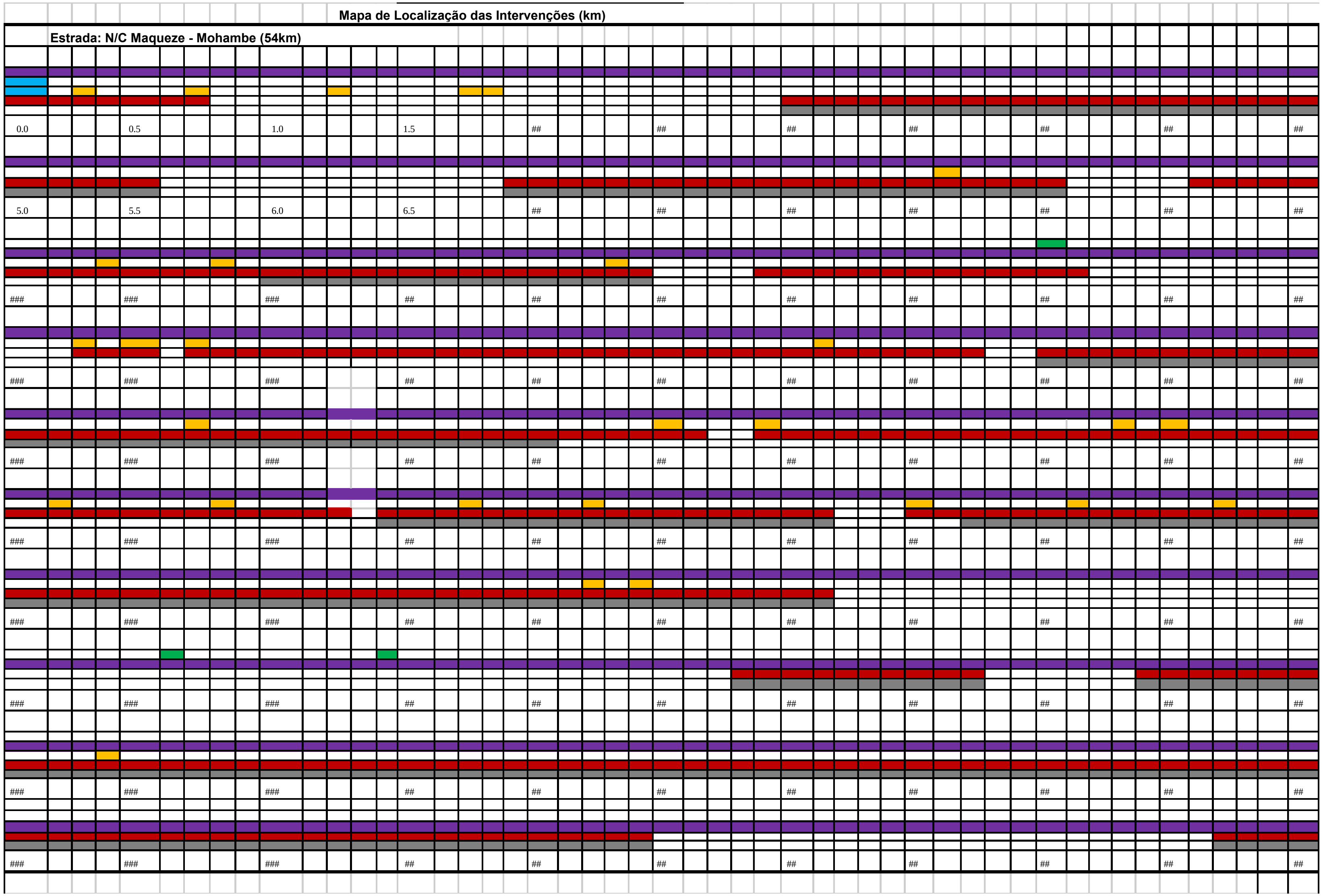
Levantamento dos Trabalhos Criticos de Drenagem

Estrada NC, Maqueze - Mohambe(54km)

Item	Actividade	Localização (KM)	Estimativa de Quantidades	
1	Abaulamento e formação da plataforma da estrada (largura da estrada = 6m)	3 -5.5, 6.9 - 9, 11- 12.4, 19- 22, 26.4 - 28.1, 28.7 - 33.1, 37.8- 38.7, 39.4 - 47.4, 49,7 - 54	169,800.0	m2
2	Aterros /camada de desgaste para levantamento da cota da estrada por 0,15m	3 -5.5, 6.9 - 9, 11- 12.4, 19- 22, 26.4 - 28.1, 28.7 - 33.1, 37.8- 38.7, 39.4 - 47.4, 49,7 - 54	25,470.0	m3
3	Aterros para levantamento da cota da estrada por 0,3m (2 x 150mm)	12.9 -14.1, 15.2 -15.5, 17.7 -18.7, 22 - 22.6, 22.9 - 25.1	9,540.0	m3
4	Aterros para levantamento da cota da estrada por 0,45m (3 x 150mm)	0 - 0,7	1,890.0	m3
5	Aterros para levantamento da cota da estrada por 0,6m (4 x 150mm)	9.6 - 11, 15.7 - 19, 25 -26.2, 28.5 -28.7	21,960.0	m3
6	Abertura de novas sanjas	0 - 54	16,200.0	m
7	Construção de aquedutos em caixa de alivio construido ``in-situ`` em betão armado B25 com dimensões de 1,2m x 0,8m de acordo com o desenho tipo da ANE (o comprimento minimo do aqueduto para garantir a inclinação de 1:4 nos taludes = 12m)	0.2, 0.7, 1.2, 1.7, 1.8, **8.6*, 10.3*, 10.8***, **12.3***, 15.2, **15.5*, 15,7***, 18.1, 20.7, **22.5***, 32.2, **22.9***, 24.3, 24.5, 32.4, 25.1, 25.8, 26.7, 27.2, 28.5, **29.1***, 29.7*, 40.3	336	m
8	Construção de aquedutos em caixa construido ``in-situ`` em betão armado B25 com dimensões de 1,5m x 1,2m de acordo com o desenho tipo da ANE (o comprimento minimo do aqueduto para garantir a inclinação minina de 1:4 nos taludes = 18m)	**0.00* (2 linhas)**	36	m
9	Construção de aquedutos em caixa construido ``in-situ`` em betão armado B25 com dimensões de 2,1m x 1,8m de acordo com o desenho tipo da ANE (o comprimento minimo do aqueduto para garantir a inclinação minimo de 1:4 nos taludes = 20m)	0	0	m
13	Betão B20 para muros e laje de protecção	14, 36.4, 35.6	20	m3
14	Protecção em pedra argamassada nos drifts existentes	14, 36.4, 35.6	30	m3

8.6* **Sitios criticos com cortes na estrada**

Table 2: Strip chart of identified "betterment" requirements



50.0				50.5					51.0					51.5					###					###					###					###					###					###					55.0

NB : KM 0+000 localizado em Maqueze

LEGENDA

- Abaulamento e formação da plataforma da Estrada
- Aterros para levantar a cota da estrada /Base de solos estabilizados
- Construção de aquedutos em caixa de 1.2m x 0.8m
- Construção de aquedutos em caixa de 1.5m x 1.2m
- Construção de aquedutos em caixa de 2.1m x 1.8m
- Abertura de novas sanjas
- Protecção em betão e pedra argamassada nos drifts

A.2 Observations

A.2.1 September 2016 visit

This is an unpaved (appears mostly earth but has apparently been “gravelled” with local soil) road, which is about 50 km long and is currently on an upgrading programme partly funded by the World Bank. It is also part of a climate adaptation programme carried out by Mott MacDonald under a World Bank Project. Significant damage was done to this road during the 2013 flooding and six concrete fords (emergency repairs) were installed to improve passability in 2014 and various short sections were spot re-gravelled with a blend of sand and calcrete. The road appears to be particularly troublesome as it weaves among and along the edge of various large natural lakes with the altitude varying between only 11 and 30 m above sea level along the entire 50 km of road. Although no traffic counts were available during the visit, it is estimated that the road probably carries about 25 vehicles per day on average, with very few heavy vehicles.

The road was driven over initially from south to north and various points were inspected. These included mostly the emergency concrete fords, which took various forms. They were all raised above the surrounding natural ground level and most had erosion protection measures on their eastern sides. These varied from “stepped gabion baskets” (Figure 3) to concrete walls enclosing gabion lined stilling ponds (Figure 4). In general, these appear to be effective, although relatively costly to construct, especially in view of the lack of aggregate in the area to manufacture the concrete and fill the gabion baskets (it was apparently hauled from Maputo). A suggestion to reduce the costs would be to construct the fords at natural ground level. This would also reduce likely erosion - it would mean that the road would be closed for a slightly longer duration while the flood water subsided.

Figure 3: Concrete ford with stepped gabion protection baskets

Figure 4: Concrete ford with gabion lined stilling pond to minimise water velocities and erosion

The road appeared to be an un-engineered earth road with minimal side drainage, some ineffective mitre drains and made use of the local silty-sand material as the wearing course. The road mostly had only two wheel tracks and had very few corrugations indicating the low traffic volumes and speeds. The local sandy materials (reddish and grey) appeared to be suitable for the light traffic on this road, and had been compacted into a hard wearing course, probably mostly by traffic, although many sections apparently become impassable (slippery) when saturated.

At the northern end of the road, numerous culverts had been assessed as part of the upgrading project. These are spaced at various intervals, but with the flat grades prevailing in the area, many of them appear (visually, although no water was present during the visit) to be unable to move the water away from the road effectively (Figure 5).

Figure 5: Culvert in flat terrain

The culverts were all to be re-constructed according to the proposed design (Figure 6).

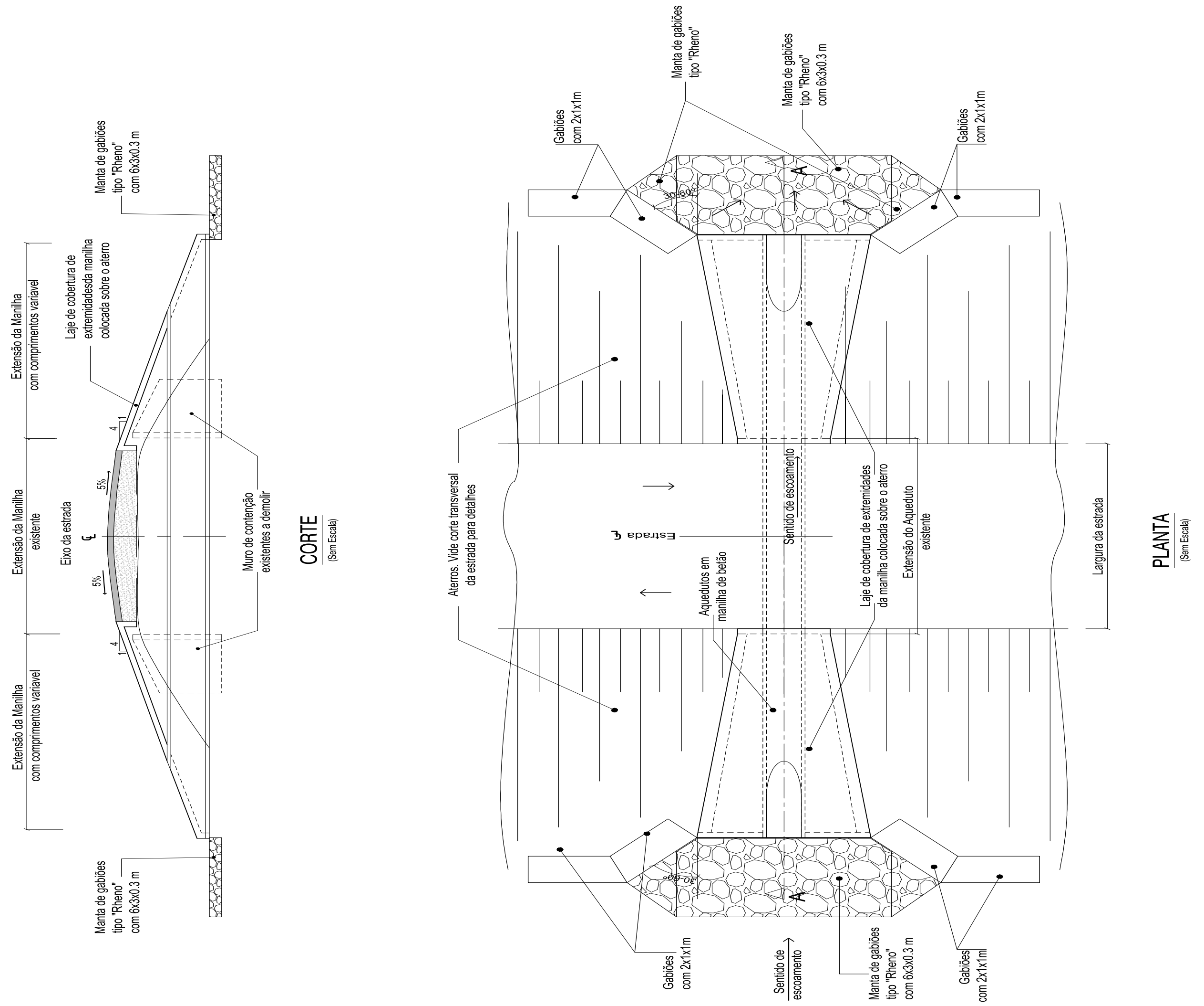


Figure 6: Proposed modified culvert designs (Mott MacDonald)

Other culverts (Figure 7) had been constructed under the World Bank emergency repair programme in 2014 and these would remain untreated, as would the concrete fords.

Figure 7: Culvert constructed under emergency repair programme in 2014)

A.2.2 August 2017 Visit

During the most recent visit the road was initially driven from south to north and then slowly driven southwards stopping and assessing various problems. GPS coordinates were taken at each stop, the kilometre reading on the vehicle and time were recorded and a Dash-cam video was obtained over the entire route. Unlike the previous visit to this road specific sites for possible demonstration sections were targeted.

Assessment of the road had been extended slightly from the original section in the ANE evaluation and started about 1.9 km north of Maqueze. However, this was not included in the current assessment, although the drive over survey started at the new zero point but the road was only assessed fully from km 1.9 (GPS 24°16.684' S and 33°33.950'E) at the northern end of Maqueze locality. The first 1.9 km before this essentially required raising of the road and improvement of two poor drainage locations.

The section of road between about 2.7 and 2.9 km through Maqueze locality is poor and needs to be improved by raising the level and applying a better wearing course material. The culvert at the end is also ineffective and improved drainage is recommended.

One of the suggestions by ANE is to improve the mitre drains along the entire road. Currently many of these are too short (less than 5 or 6 m) and do not remove water from the road (some even lead uphill). The recommendation by ANE is to make these at least 30 m long with proper grading to remove water. As observed previously, a section of the road (3 or 4 km) has been gravelled with a calcrete material. Although there is some oversize in the material, the gravel makes quite a good wearing course (Figure 8).

Figure 8: Section of road with calcrete wearing course

At km 10.6 (GPS 24°21.014'S and 33°32.242'E), the culvert was showing significant damage due to erosion. There was severe erosion and undercutting beneath the water exit slabs, loss of parts of the grouted stone protection and erosion of the approach embankment to the south (Figure 9). The approach road on both sides of the culvert is very poor and needs significant lifting and improvement (Figure 10). In addition, the drainage channels are incorrectly handled by the structure and require some re-alignment. This area was identified as a potential demonstration section.

Figure 9: Damage to structure and erosion protection measures at km 10.6

Figure 10: Southern approach to culvert

A major drainage problem has occurred at km 15.7 (GPS 24°22.478'S and 33°29.925'E). An old borrow pit has become a dam to the north west of the road section. After rain, the dam overflows and creates a stream that leads onto the road with no drainage provided. This has cause extensive erosion adjacent to the road as well as severe damage to the road (Figure 11). This area requires significant erosion repair and protection and the installation of an appropriate drainage structure.

Figure 11: Erosion damage to road at km 15.8

The concrete ford constructed under the World Bank emergency repair programme in 2013 at km 17.6 (GPS 24°22.769'S and 33°28.927'E) has performed relatively well although the gabion baskets show significant signs of rust and failure (Figure 12). Closer examination indicates that the mesh on these baskets appears to be thinner and poorly galvanised and generally of poor quality.

Figure 12: Deformation of damaged gabions

The road at the northern approach to this ford is badly deformed and eroded and requires repair (Figure 13). It is clear that the ford does not extend sufficiently up the slope to avoid erosion of the road during overtopping and this should be addressed in a demonstration section.

Figure 13: Erosion, subsidence and deformation of northern approach to ford

At km 23, the road is only about 3 m wide (Figure 14) and is mostly in a channel. The road requires widening and lifting in this area with good side and mitre drains.

Figure 14: Narrow road in a channel with no drainage (km 23.8)

The culvert at km 24.5 (GPS 24°26.272'S and 33°28.120'E) was ineffective as it was at the incorrect location. Although there was some evidence of water accumulating at the culvert exit (there was nowhere for it to flow to), the inlet was overgrown with grass and there was significant erosion damage to the road about 15 m away from the culvert.

The two culverts at km 24.9 (GPS 24°26.459'S and 33°27.979'E) both had problems affecting their erosion protection measures as well as deformation of the road in the area, apparently due to poor compaction of the fill and wearing course.

Figure 15: Deformation of road between the two culverts at km 24.9

When the dam next to the road at km 28.4 (GPS 24°28.331'S and 33°27.733'E) fills up (seen in the central background of Figure 16) and overflows, it moves over the road causing severe erosion and damage to the road. More culverts have been proposed by ANE. It is planned that these will be about 40 m up the road from the current crossing point and the dam overflow will be diverted through these by blocking the current channel on the left of Figure 16. The embankment at the bottom of the sag curve will also need to be raised and levelled at about 2 m above current road level.

Figure 16: Dam next to road which overflows damaging road – channel on left side requires modification

A similar situation caused by uncontrolled water crossing the road at km 29 (GPS 24°28.673'S and 33°27.665'E) exists. Installation of a culvert and raising of the road level is planned in this area. The surface material in the area is quite expansive and shows significant surface cracking, which allows water to penetrate and initiates erosion (Figure 17)

Figure 17: Cracking of exposed in situ material in shoulder area of road with erosion at left top

The triple box culvert at km 33.4 (GPS 24°30.227'S and 33°26.432'E) that was constructed in 2014 as part of the World Bank emergency repair programme has suffered significant distress (Figure 18). The concrete works are mostly undamaged other than collapse of the one outlet slab. However, the soil behind the protection works has been badly eroded leading to collapse of large portions of the stone-pitching. This can be compared with Figure 7 taken in September 2016 where the considerable recent loss of material from beneath the outlet slabs is notable.

Figure 18: Damage to culvert at km 33.4

Although the concrete ford at km 34.8 showed no distress to the actual structure the protection works on the right side had been severely undercut and either cracked or collapsed (Figure 19).

Figure 19: Damage to ford protection works at km 34.8

The left side of the structure was not damaged, although there was significant erosion of the stream-bed next to the road.

Figure 20: Erosion of stream-bed to left of ford at km 34.8

The ford at about km 35.9 the second last ford appeared to be in good condition at first sight, but closer examination indicated that the right side had been severely eroded and undercut, to the point that the slab would probably collapse under a heavy vehicle (Figure 21).

Figure 21: Undercutting of ford at km 35.9

As expected, the water-stilling features on the left side had performed well, but had collected significant amounts of sediment. This will, however, probably improve the performance of these features in the long term.

Figure 22: Accumulation of sediment in water-traps of ford at km 34.9

A similar situation of undercutting was also noted at the next ford with even more severe undercutting of the ford support (Figure 23).

Figure 23: Undercutting of ford at about km 36

A.3 Problems identified during site visits

Being able to revisit the road after a “normal” wet season allowed the effectiveness of those adaptation measure that had been implemented in 2014 to be assessed. It is interesting to note that although there were some expensive measures constructed, most of them had not performed satisfactorily.

A.3.1 Erosion and undercutting of concrete fords

This was observed at two of the “new” concrete fords and gave rise to some discussion. It is not apparent whether this was caused by:

- Overtopping of the ford by the stream flowing from the east
- Wave erosion of the unprotected material beneath the concrete as the level of the lake to the west of the ford gradually dropped

Whichever cause is dominant, the underlying soils (expansive clay) are unsuitable and will slake and collapse when the material moves from a dry to a saturated state.

A.3.2 Damage to culverts and erosion protection

Numerous culverts had been damaged by flooding. Most of the damage was due to erosion at the exits with undercutting and cracking. However, the incidence of undercutting of erosion protection measures (mostly grouted stone pitching) was evident at many of the structures. This was often due to poor compaction of the embankment material allowing access of water behind the structures as well as surface erosion – improved anchoring and drainage are needed at these structures. The main areas affected are:

- Parts of the approach fills that are eroded during flooding
- Protection works that are left unsupported or washed away
- Scour of the stream-bed at outlets

A.3.3 Damage to road surface

The damage to the unpaved road surface was seen at several locations resulting from different causes:

- Erosion by uncontrolled water
- Poor compaction of the materials
- Use of erodible materials as the wearing course

Damage has also occurred at the approach to one of the fords (km 23) where the concrete does not extend sufficiently up the slope.

A.3.4 Ineffective drainage of road surface – poor shape and side-drains

Very few areas have properly constructed and maintained side drains. Mitre drains are constructed regularly along the road but not always in the correct positions and usually too short and poorly graded resulting in ponding of water in the drains and onto the adjacent road.

A.4 Proposed preliminary designs

A.4.1 Improved gravel road

There are currently no plans to improve the road through Maqueze town itself. The road is in a poor state with areas that would appear to be impassable during wet weather. It is proposed that a section of road 200 m long is upgraded to illustrate that a well-constructed unpaved road can be climate resilient. The section rises about 1 m between the proposed northern start area and the culvert that is to be improved under the existing contract giving an overall negative 0.5% grade to the north.

Figure 24: Proposed demonstration section for 200 m up to culvert just past start of sunny area

Figure 25: Proposed demonstration section in town of Maqueze (red line)

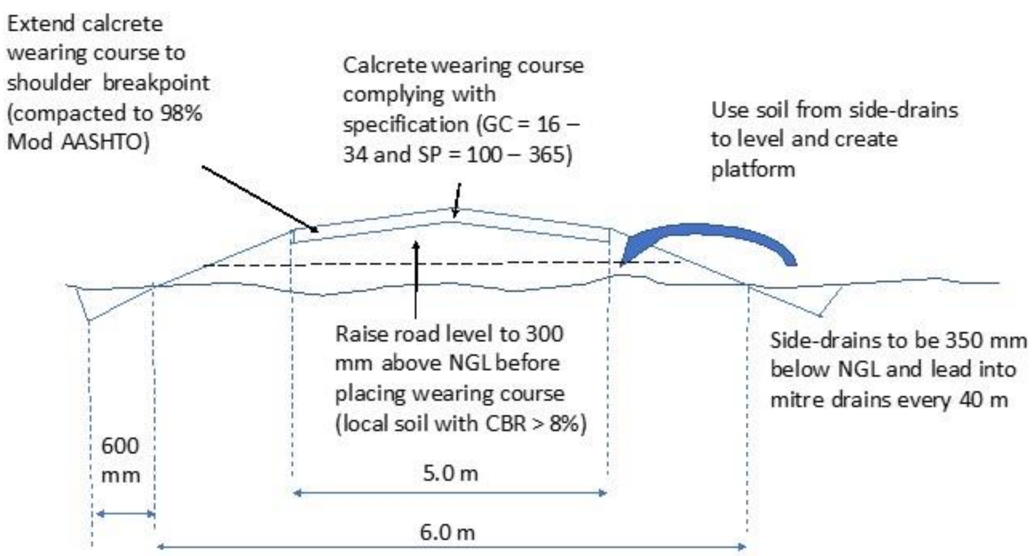


Figure 26: Cross section of improved gravel roads through Maqueze

It is essential that the wearing course material complies as closely as possible with the standard specification and is compacted properly. The camber of the wearing course after construction should be 5%. If no suitable calcrete is located for the wearing course, a blend of 75% crusher run aggregate and 25% local silty clay material (PI about 15 – 20%) should be used.

The culvert at the end of the section should be constructed according to the Mott MacDonald design (Figure 6) but the concrete apron across the shoulder should be omitted. Instead, the approach to the culvert on the northern side should be perfectly level at the culvert height for the last 25 m before being graded down to road height. The side drains should lead into the culvert from the highest point to the north of the culvert and also to the north away from the culvert at this point (the actual highest point could not be determined during the site visit), with a grade of at least 0.5%.

It may also be useful to consult with the local community whether the side and mitre drains should be used for "water harvesting". In flat areas, the removal of water from mitre drains is difficult and their general configuration observed in the area made drainage almost impossible. Most of those observed along the route did not extend more than a few metres away from the road and effectively acted as small sumps. It could be useful to lead the side and mitre drains into a purpose-built depression or sump 30 or 40 m from the edge of the road that will allow the water to be collected and used by the community and also to percolate slowly into the ground which would help in raising the groundwater level in the area.

A.4.2 Undercutting of concrete fords

The undercutting of the fords is a major problem requiring urgent repair. This is mostly restricted to the lake side of the fords and is either the result of over-topping from the downhill side or more likely softening of the support material (black clay in this case) and subsequent wave action as well as alternative wetting/drying of the clay. This black clay will slake and collapse on wetting and drying.

It is important that the catchment areas and the run-off from the various catchments along the east side of the road are determined and a proper hydrological analysis is done before final designs are prepared. As the damage may be due to water from either side of the road (downhill river flow/lake overflow or downstream river or lake rising), it is essential that these analyses are carried out.

The damaged areas can be repaired in two ways.

- The existing exposed clay should be cleaned out and replaced with a more stable (PI < 15) material or stabilised material that is well compacted into the voids. This may be difficult to accomplish in the present situation. In addition, the support concrete has degraded significantly and will also need to be replaced.
- The second option is to construct a vertical wall near the edge of the concrete ford slab, backfill the voids with an inert fill and a high slump concrete and then extend the concrete slab to the top of the wall. The wall will need to be founded beneath the black clay in a competent layer and have a concrete protection slab at the base (Figure 27).

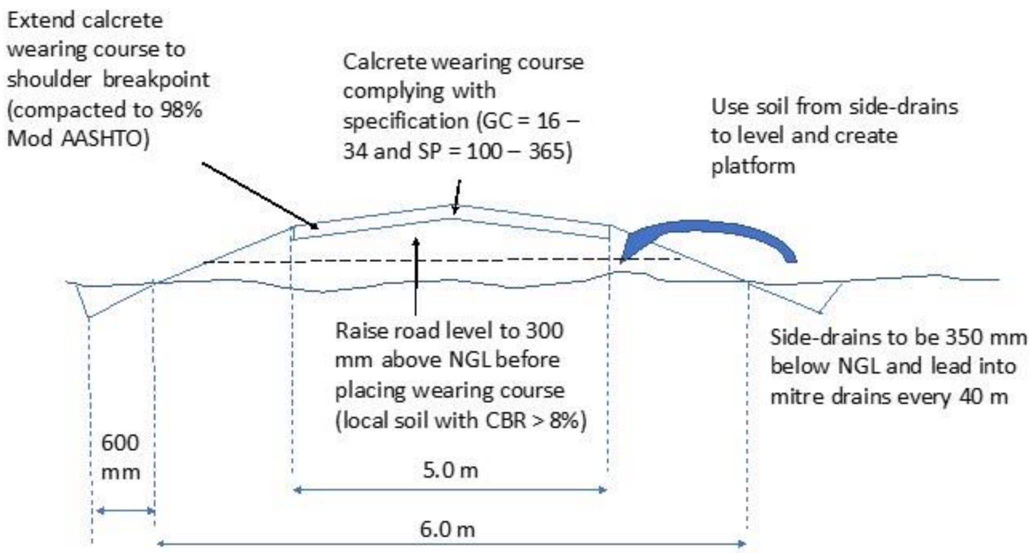


Figure 27: Proposed design of rehabilitation to undercut ford

The actual concrete dimensions and depth will depend on the founding conditions, which are unknown at present. In addition it may be necessary to toe the concrete wall back into the soil with some reinforcement (geogrid, or similar) and to provide some "weep-holes" in the concrete wall.

A.4.3 Damage to culverts and erosion protection

Overtopping of the road has resulted in damage to the road, culverts and recently constructed protection works in several places (Figure 28 and km 10.6). This could be eliminated by keeping the road at natural ground level as far as possible where the water flows across the road but would mean that the road could be closed for unacceptable periods while the water levels drop. The following adaptation measures are thus proposed for the two culverts at km 10.6 (GPS 24°21.014'S and 33°32.242'E).

1. The road should be properly shaped and levelled off at the top of the culverts with the grade from 5 m to the north of the first culvert to 5 m to the south of the second culvert being perfectly flat. The road must have a camber of 5% with a well compacted wearing course, preferably of a suitable gravel complying with the specification (Appendix A).

Figure 28: Damaged protection works at km 10.6

Figure 29: Approach to the two culverts at km 10.6 from north

2. All damaged protection works should be removed. The materials in these areas must be replaced with inert material and compacted to at least 95% Mod AASHTO density. (The existing material is quite plastic and cracks on drying out as shown in Figure 30).

Figure 30: Cracking of material in embankment at km 10.6

3. The stone pitching should then be repaired with a cement grout filling all joints. The top and bottom of the stone pitching must be cemented to concrete strips as shown in Figure 31. To

avoid undercutting and erosion of the soil adjacent to the stone pitching, lined drains 150 - 200 mm deep and 250 mm wide must be constructed at the edges of the stone pitching and integral to it to guide water from the shaped road surface down the embankments.

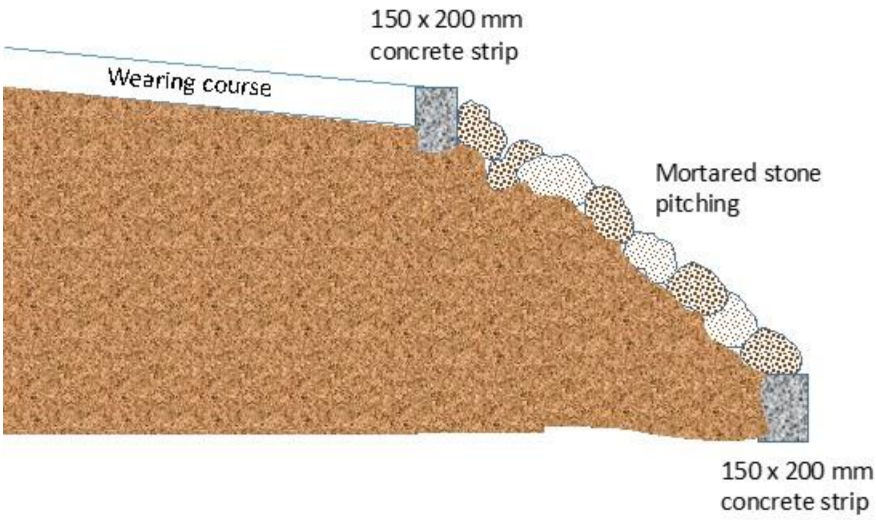


Figure 31: Concrete strips to retain stone pitching

Figure 32: Erosion damage at edge of stone pitching

4. It was clear at this site that much of the runoff water “misses” the culverts and crosses the road 10 or 15 m south of them (Figure 33). It is necessary to construct an additional culvert in this area to control this water.

Figure 33: Area of crossing water that misses the culverts – the water moves from the right to the left and then almost parallel to the road to re-join the stream below the two culverts, causing a lot of the erosion.

5. It will also be necessary to divert this water straight across the land in front of it to meet the stream in a direct path and remove it from the toe of the embankment.
6. The erosion at the outlet slabs of the existing culverts will need to be repaired with Reno mattresses beneath the culvert outlets.

A.4.4 Damage to road approaching concrete ford

The damage on the approach fill to the first concrete ford at km 17.6 will continue to occur if the design is not changed. In this area, it is proposed that a continuous (i.e. unjointed) roller compacted no-slump concrete ("rollcrete") slab 150 mm thick and 60 m long (the same width as the existing ford) should be constructed. The rollcrete should have a nominal strength of 25 to 30 MPa with a water cement ratio of 0.36 – 0.4.

The rollcrete will be excavated into the existing layer and the material removed, with additional material where required, will be used to flatten the embankment slopes to at least 1: 4, which should then be revegetated with indigenous grasses.

The damaged gabion baskets next to the ford should also be repaired or replaced.

A.5 Recommendations

Based on the observations during the site visit various adaptation measures should be implemented on the Mohambe to Maqueze road. Various adaptation measures had already been implemented, but none of these managed to resist damage caused by an apparently almost normal wet season. No large-scale flooding was reported during the period.

A survey has indicated several problems affecting the road and four sites have been identified to implement adaptation measures that are climate resilient and to minimise these problems in future. However, the road will remain an unpaved road and without application of a good selected gravel wearing course over the entire length of the road, its surface can never be expected to become fully climate resilient.

APPENDIX A: Gravel wearing course material requirements

To ensure that gravel wearing courses are climate resilient, it is essential that the materials selected and the construction and maintenance are well controlled and supervised.

The materials should comply with the following criteria (Table A1 and Figure A1):

***Table A1:** Wearing course material selection criteria*

CRITERION	LIMIT
Maximum size	37.5 mm
Max oversize index	5 %
Shrinkage product (S_P)	100 – 365 (240)
Grading coefficient (G_c)	16 – 34
Min CBR (%)	15 at 95% Mod AASHTO
Treton Impact value (%)	20 - 65

Sp – Weighted bar linear shrinkage (BLS * P0.425)
Gc – (P26.5 – P2)*P4.75/100

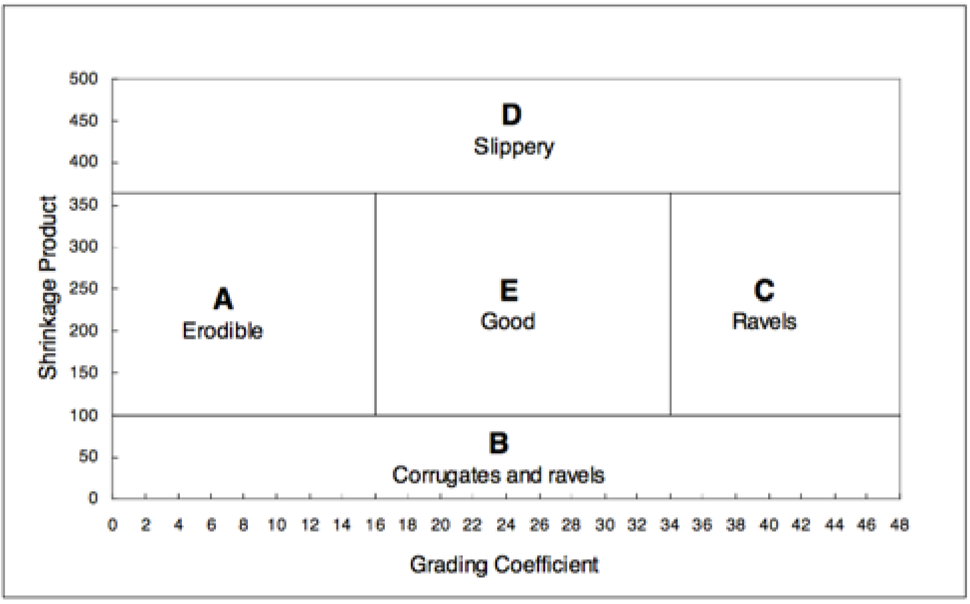


***Figure A1:** Wearing course material selection criteria*

In the case of this road, with its very low traffic, allowance of oversize material up to 10% could be made. However, the grading coefficient and shrinkage product limits should be complied with. This could be achieved with the local calcrete or by blending a crusher run aggregate with some local plastic material.

In addition to the material specifications, it will be essential that the layer is compacted to 98% of Mod AASHTO density (with full density control during construction) and shaped to provide an initial camber of 5% which should not be allowed to fall to below 3% during the monitoring period of the demonstration sections.

Annex B: Briefing Note

AfCAP
Africa Community Access Partnership

UKaid
from the British people

BRIEFING DOCUMENT:

Devastating damage to African Rural Road Infrastructure from Climate Impacts - with worse to come

AfCAP Project on *Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa* (Reference GEN2014C, August 2017)

Summary

The African Development Bank (AfDB) states that Africa is one of the most vulnerable regions in the world to the impacts of climate change. The majority of studies suggest that damages to roads from climate change, relative to population and GDP, will be higher in Africa than in any other region in the world (AfDB, 2011). Its studies suggest adaptation costs in Africa in the region of $20-30 billion per annum are required over the next 10 to 20 years. This Briefing Document has been prepared for Governments and Senior Management to alert them to the scale of the challenge and to inform them of new guidance on how to deal with the threats economically; how to make road infrastructure more resilient; and thereby improve socio-economic development through improved accessibility.

Africa has experienced dramatic changes to the continents' climate, which is causing widespread damage to road infrastructure and its associated assets. Rural accessibility is being compromised in a number of countries for increasing proportions of the year, creating both direct and indirect adverse effects on livelihoods and associated socio-economic development.

In the past four decades (1975-2015) African countries have experienced more than a 1,400-recorded weather-related disasters. These disasters have had significant impacts on affected countries' economies and, in particular, on rural communities and their livelihoods. The impacts of these natural hazards (floods, storms, droughts, extreme temperature, landslides and wildfires) were also felt across all economic sectors and Infrastructure. Many communities and countries in Africa are socially and economically vulnerable to extreme climate events. Low adaptive capacity, as well as their high exposure to natural hazards, has resulted in the death of more than 600,000 people (majority due to droughts), left 7.8 million people homeless (99 per cent due to flooding and storms) and affected an estimated 460 million people over the past four decades (CRED, 2016).

Governments are facing a substantial backlog of damage to existing infrastructure assets caused by the effects of changing climate and are unable to confidently deal with either appropriate design or maintenance of roads.

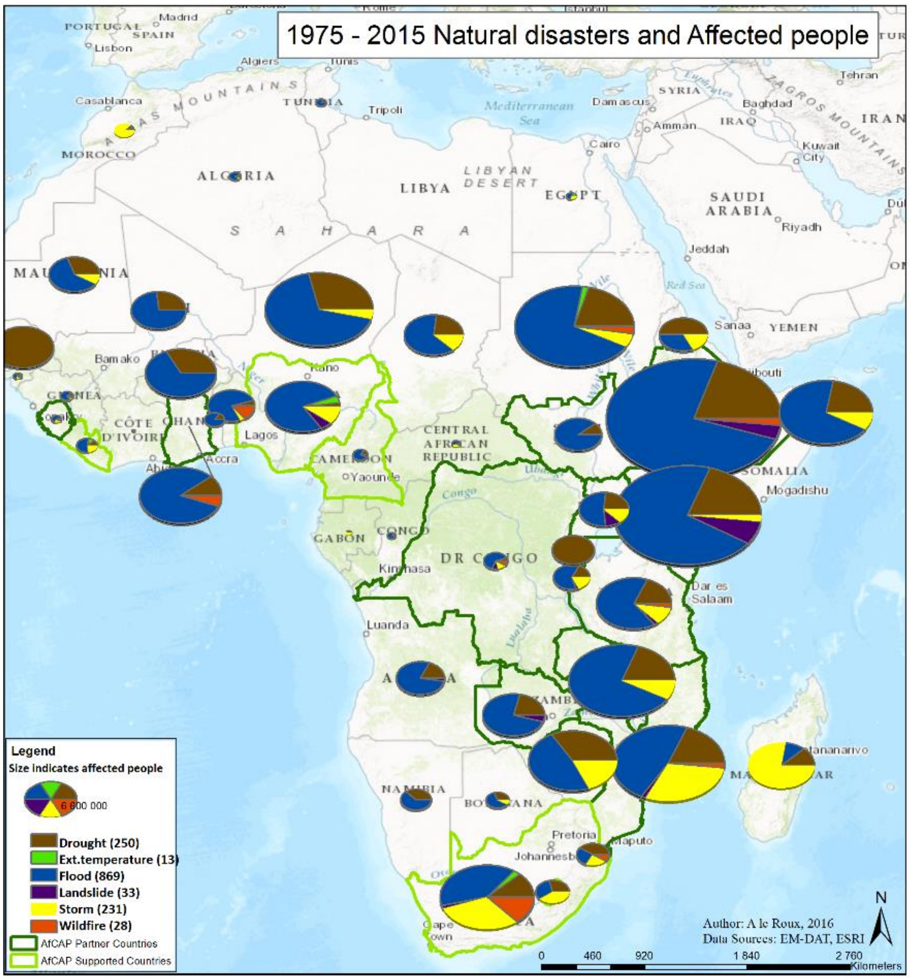
These adverse effects can now be dealt with much more effectively in order to minimise disruption to rural communities. New Guidance on a methodology for dealing with climate effects and threats; with formulation of appropriate adaptation measures to make road infrastructure more resilient, is shortly to be published. A new Handbook is being developed to help deal with climate effects on rural maintenance backlogs, road rehabilitation and also for new road infrastructure. Also, the principles are being tested at Demonstration Sites in Ethiopia, Ghana and Mozambique.

The Scale of the Challenge

There is clear evidence that climate change has already affected the magnitude and frequency of climate extremes causing damage to infrastructure and dislocating rural communities. Particularly vulnerable AfCAP partner countries are Ethiopia, Kenya, Mozambique, Ghana, South Sudan, Tanzania, and Uganda; however, all African countries are affected. The predominant types of recorded weather-related disasters and the amount of people that have historically been affected are illustrated below.

> Internationally, Development Partners are substantially increasing their Adaptation programmes. For example, the Asian Development Bank (ADB)'s total adaptation financing increased from $558 million in 2011 to a planned $988 million in 2013, an increase of approximately 77% (ADB, 2011).

The African continent is facing a potential direct liability of over $150 billion to repair and maintain existing roads damaged from temperature and precipitation changes directly related to projected climate change. The liability does not include costs associated with impacts to critically-needed new roads, nor does it include indirect socio-economic effects generated from dislocated communities and from loss of rural access (Chinowsky et al., 2013). The predominant types of recorded weather-related disasters for each country and the amount of people that have historically been affected, are illustrated below. The size of the pie charts depicts numbers of people affected relating to the significance of the events.

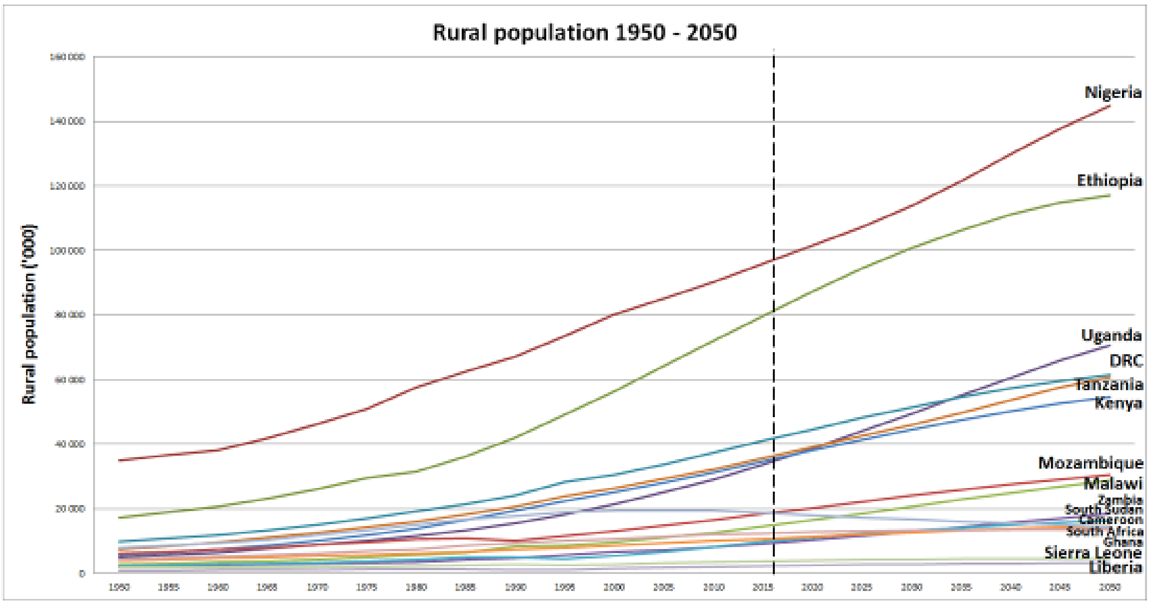


Recorded weather-related disasters and affected populations

It is estimated that an additional 230 million people will live in rural areas in the 15 AfCAP supported and partner countries by 2050, making rural accessibility a high priority in Africa (UN-ESA, 2014), see table and chart below.

Rural Population growth in AfCAP supported and partner countries

AfCAP countries and partner countries	*2015 - 2050 Rural growth ('000)*	*Urban % 2015*	*Urban % 2050*
Nigeria	49 032	47.8	67.1
Ethiopia	37 375	19.5	37.6
Uganda	37 033	16.1	32.1
Democratic Republic of the Congo	20 456	42.5	60.4
United Republic of Tanzania	25 085	31.6	53.0
Kenya	19 766	25.6	43.9
Mozambique	12 105	32.2	49.1
Malawi	14 274	16.3	30.2
Zambia	9 278	40.9	58.3
South Sudan	6 490	18.8	33.9
Cameroon	3 924	54.4	70.0
South Africa	- 4 526	64.8	77.4
Ghana	1 075	54.0	70.5
Sierra Leone	607	39.9	57.2
Liberia	1 005	49.7	65.2



Guidance is needed to identify the threats that are posed by climate change, to develop adaptation approaches to the predicted changes, to incorporate changes into mid-range and long-term development plans, and to secure funding for the proposed and necessary adaptation.

A CSIR led Consortium has been commissioned in 2016 to deliver this guidance. The fundamental ***project objective*** is to identify, characterise and demonstrate appropriate engineering and non-engineering adaptation procedures that may be implemented to strengthen long-term resilience of rural access. The second objective, which focusses on ***capacity building and knowledge exchange***, is to meaningfully engage with relevant road and transport Ministries, Departments and Agencies/Authorities in a knowledge dissemination and capacity building programme based on the outputs from the research.

Situational and needs analysis

A survey of affected countries, followed by meetings with relevant Governments and Workshops, has revealed similar experiences and circumstances to be addressed urgently:

- Road damage backlogs from climatic effects are increasing at an alarming rate and need appropriate guidance to address
- Maintenance budgets are not adequate to deal effectively with climate effects requiring better *Return on Investment* and help with a *Do Nothing / Do Minimal* approach
- Appropriate new policies and strategies need to be embedded in plans, programmes and projects
- Knowledge and capacity on climate adaptation needs strengthening
- Relevant climate-related data needs to be collected to support a new approach
- A manual, supported by Guidelines, should be published and training given on its approach and implementation
- The manual should be used on demonstration sites to show good practice
- Training should be all levels and across all relevant stakeholders
- Need to provide assistance to allow more effective engagement with, for instance, the African Development Bank, Asian Development Bank, European Union, World Bank; Nordic Development Fund; Japan International Cooperation Agency; UKAid, with evidence to support funding applications.

New Guidance Implementation

Based on the needs analysis, research is being carried out into appropriate and economic methodologies for vulnerability and risk assessments; prioritisation of adaptation interventions; and optimisation of asset resilience in the context of rural access. In addition, evidence of cost, economic and social benefit links to rural communities arising from more resilient rural access, is required, to support wider policy adoption across Africa.

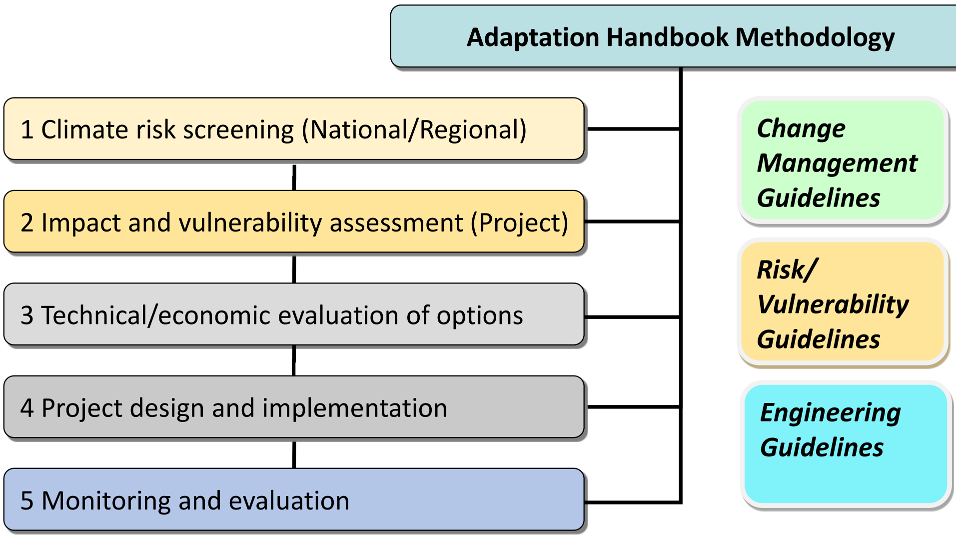
The programme focusses on: (a) demonstrating appropriate engineering and non-engineering adaptation procedures; (b) sustainable enhancement in the capacity of three AfCAP partner countries; (c) sustainable enhancement in the capacity of additional AfCAP partner countries; and (d) uptake and embedment across AfCAP partner countries.

A Handbook has been developed (Head *et al,* August 2017) to address climate adaptation in a new and practical way. It covers a wide range of climatic, geomorphologic and hydrological circumstances, based on application to Mozambique, Ghana and Ethiopia, but equally applicable to any Sub-Saharan country. Although produced for *low volume roads,* the principles also apply to *high volume roads,* although there will be differing priorities and design parameters.

There are three specific, overlapping applications of the Handbook:

- New Infrastructure and structures
- Rehabilitation and retrofitting
- Maintenance

There are five stages in the adaptation process, as follows:



The Handbook sets out the overall approach and is supported by the following technical Guideline documents:

- Change Management Guidelines (Head and Verhaeghe, August, 2017)
- Climate Threats and Vulnerability Assessment Guidelines (Le Roux et al, August 2017), and
- Engineering Adaptation Guidelines (Paige Green et al, August 2017).

What outcomes are expected?

It is expected that, through application of the Handbook and Guidelines:

- **the existing road network will be made more climate resilient**
- **much improved investment decisions will be possible**
- **maintenance costs will be reduced**
- **most of the threatened damage will be averted**
- **Improvements in accessibility will bring significant socio-economic development**

What actions are required?

The following actions should be considered for implementation:

- Issue of a policy statement setting out the scope and purpose of *Climate Adaptation for Roads* and associated assets.
- Nomination of an officer responsible for Climate Adaptation implementation
- Drafting and consultation on a Climate Adaptation Strategy
- Consultation on augmenting National Adaptation Committees
- Development of a *Climate Adaptation* implementation programme
- Development of a capacity building programme
- Augmentation of national design Standards.

Who do you contact for assistance?

The project team is working in Ethiopia, Ghana and Mozambique until the end of 2018 and is supporting other AfCAP countries who are interested in sharing experiences. A CSIR led consortium comprises:

Benoît Verhaeghe (Team Leader)	bverhaeg@csir.co.za
Mike Head (Knowledge and Capacity Building)	mikehead7@gmail.com
Phil Paige-Green (Engineering Adaptation)	paigegreenconsult@gmail.com
Alize Le Roux (Risk and Vulnerability Assessments)	aleroux1@csir.co.za

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(Prepared by the Council for Scientific and Industrial Research (CSIR), Paige-Green Consulting (Pty) Ltd and St Helens Consulting Ltd Consortium).

Annex C: Contribution to ReCAP Log Frame

An initial assessment has been made of the estimated contribution of the project to the ReCAP Log Frame indicators. This assessment is summarized in the following Table over the period of the project. Indicators forming the basis for calculation and recording are contained below. Phase 1 review period is April to October/November 2016 and covers Milestone 1. The Phase 2 option of a further 70 weeks takes the end of project target date to April 2018, covering Milestone 2, and is speculative at this stage. Milestone 3 assumptions are based on a project extension.

Intervention Logic	Indicator	Source of Verification	Baseline (Date)	Milestone 1 - 31 July 2016	Milestone 2 31 July 2017	Milestone 3 31 July 2018	End of Project Target (Date)	Assumptions
Outcome: Sustained increase in evidence base for more cost effective and reliable low volume rural road and transport services, promoted and influencing policy and practice in Africa and Asia	1. SUSTAINABILITY: Partner Government and other financiers co-funding research with ReCAP. Contributions in kind (K) relates to 3No demonstration sites, staff time and research programme and Core Contributions (C)			K=£1,000 C= £0	K=£85,000 C=£200,000	K=£200,000 C=£10,000,000		Two staff months for participating countries. Climate fund contributions from World Bank, EU, DFID, AfDB and others.
	2. Concrete examples of change (applied or formally adopted), influenced by ReCAP research that will be allied to #km of road in focus countries.			0 km	500 km	30,000km		Improved access through targeted interventions on network of 11 countries
	3. Number of citations in academic articles of ReCAP peer reviewed articles and/or working papers, conference papers etc.			0	0	8		Journal article and peer-reviewed paper at regional conference (e.g. Ghana), followed by several key conferences events
Output 1: RESEARCH and UPTAKE: Generation,	1.1 LVRR: Number of peer reviewed papers generated from ReCAP supported or related LVRR research projects made available in open			0	2	5		Venues to be determined

Intervention Logic	Indicator	Source of Verification	Baseline (Date)	Milestone 1 - 31 July 2016	Milestone 2 31 July 2017	Milestone 3 31 July 2018	End of Project Target (Date)	Assumptions
validation and updating of evidence for effective policies and practices to achieve safe, all-season, climate-resilient, equitable and affordable LVRR and transport services in African and Asian countries. (Low Volume Rural Roads : LVRR / TS – Transport Services)	access format.							
	1.2. TS: Number of peer reviewed papers generated from ReCAP supported or related LVRR research projects made available in open access format.			0	1	3		Based on climate effects on transport sub-regionally
	1.3 Engineering Research: National policies, manuals, guidelines and/or research outputs that have been fully incorporated into Government/Ministerial requirements, specifications and recommended good practice as a result of ReCAP engineering research (including climate change adaptation and AfCAP and AsCAP adaptations). To include introduction of new policies and modification to existing policies.			0	4	12		Refers to policy and guidelines Targeting all AFCAP partner countries with 3 in Phase 2
	1.4 TRANSPORT SERVICES Research: National policies, regulations and/or practices for rural transport services modified or introduced as a result of ReCAP research to include introduction of new policies and modification to existing policies.							
	1.6. LVRR and TS information generated for dissemination, and disseminated, that is not peer reviewed. Total to include research papers, final research reports,							Inception Report Monthly Reports

Intervention Logic	Indicator	Source of Verification	Baseline (Date)	Milestone 1 - 31 July 2016	Milestone 2 31 July 2017	Milestone 3 31 July 2018	End of Project Target (Date)	Assumptions
	workshop reports, manuals and guidelines.			4	11	19		Briefing Document Guideline document Final report Phase 1 and 2
Output 2: CAPACITY BUILDING: The building of sustainable capacity to carry out research on low volume rural roads, and rural transport services in African countries.	2.1. African / Asian experts or institutions taking lead roles in ReCAP Research Projects.			16	14	20		Project Team Country Counterpart Team
	2.3. Research projects with female researcher inputs at senior technical level.			3	5	8		Project Team Country Counterpart Team
Output 3: KNOWLEDGE: Generated evidence base of LVRR and TS knowledge widely disseminated easily accessible by policy makers and practitioners (including education and training institutions).	3.2. ReCAP generated knowledge presented and discussed at high level international development debates and conferences			0	4	8		Sub-Saharan regional and national authorities
	3.3. ReCAP generated knowledge disseminated through significant workshops and dedicated training, virtually or physically, that are rated by participants as effective.			3	6	11		Phase 1: 3 countries Phase 2: 11 countries International, participation, multiple stakeholder groups, multi-topic, multi-country, regional, or local.