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

Final Report for Phase 1

B Verhaeghe, FC Rust, M Head, A le Roux, P Paige-Green

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

AfCAP Project GEN2014C

February 2017

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Cover Photo: Benoît Verhaeghe

Quality assurance and review table			
Version	Authors	Reviewer(s)	Date
1	B Verhaeghe, FC Rust, M Head, A le Roux, P Paige-Green	L Sampson, J Cook	28 February 2017
2	B Verhaeghe, FC Rust, M Head, A le Roux, P Paige-Green	L Sampson, J Cook	25 March 2017

ReCAP Project Management Unit
Cardno Emerging Market (UK) Ltd
Oxford House, Oxford Road
Thame
OX9 2AH
United Kingdom

Abstract

The African continent may be facing a potential direct liability of $184 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, commissioned a project, which started 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. The output will assist the development of a climate-resilient road network that reaches fully into and between rural communities.

Research will be 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.

This Final Report reflects on the achievements of Phase 1 of this project, which spanned a period of approximately 50 weeks. It addresses the project outcomes with respect to aspects such as: 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. The report also summarises the preliminary work done to establish demonstration sections in three priority countries, namely Ethiopia, Ghana and Mozambique, and reflects on the outcomes of workshops held in these countries. The purposes of these workshops were to expose and to deliberate the products of Phase 1 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. The Recommendations for Phase 2 are also presented in this report.

Key words

Capacity Building; 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.
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

°C	Degrees Celsius
£	British Pound Sterling
$	United States Dollar
AfCAP	Africa Community Access Partnership
AfDB	African Development Bank
ADB	Asian Development Bank
ANE	Administração Nacional de Estradas (National Roads Administration, Mozambique)
AR5	Assessment Report Five
AR6	Assessment Report Six
ARTReF	African Road and Transport Research Forum
AsCAP	Asia Community Access Partnership
CMIP5	Coupled Model Inter-comparison Project Phase 5
CORDEX	Coordinated Regional Downscaling Experiment
CPIA	Country Policy and Institutional Assessment
CRED	Centre for Research on the Epidemiology of Disasters
CSIR	Council for Scientific and Industrial Research, South Africa
DFID	Department for International Development, UK
DFR	Department of Feeder Roads (Ghana)
EDF	European Development Fund
EM-DAT	Emergency Events Database
ERA	Ethiopian Roads Authority
EU	European Union
GDP	Gross Domestic Product
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LVRR	Low Volume Rural Roads
MRH	Ministry of Roads and Highways (Ghana)
NDF	Nordic Development Fund
PIT	Project Implementation Team
PMU	Programme Management Unit, ReCAP
PO-RALG	President's Office – Rural Administration and Local Government, Tanzania
PPCR	Pilot Program for Climate Resilience
ReCAP	Research for Community Access Partnership
UK	United Kingdom (of Great Britain and Northern Ireland)
UKAid	United Kingdom Aid (Department for International Development, UK)
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reconstruction
URRAP	Universal Rural Road Access Program (Ethiopia)
WP	Work Package

Contents

1. Executive Summary

The African continent may be facing a potential direct liability of $184 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.

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Research will be 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.

The goal of Phase 1 was to produce practical guidelines on how to conduct vulnerability assessment and on how to develop adaptation strategies and plans, and to lay the foundation for the establishment of demonstration sections in three AfCAP Partner Countries. In order to achieve the latter, several in-country engagements with key stakeholders were held, and counterpart engineers/researchers were identified and incorporated in the Project Team to provide in-country support for the attainment of the project objectives.

This Final Report reflects on the achievements of Phase 1 of this project, which spanned a period of approximately 50 weeks. It addresses the project outcomes with respect to aspects such as: 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. The report also summarises the preliminary work done to establish demonstration sections in three priority countries, namely Ethiopia, Ghana and Mozambique, and reflects on the outcomes of workshops held in these countries. The purposes of these workshops were to expose and to deliberate the products of Phase 1 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. Benchmarking against and possible harmonisation of the vulnerability assessment method developed in Phase 1 with the methodologies and screening tools used by the World Bank and the EU, as well as the amendment of the 20-step adaptation methodology of the Asian Development Bank into a methodological approach appropriate to low-volume access roads, will form part of this process.

Recommendations for Phase 2 are also presented in this report.

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 of 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 the Phase 1 of the Climate Adaptation project was from 1 April 2016 to 28 February 2017 (Contract Amendment 2). Phase 2 of the project is due to start on 1 April 2017 and will span over a period of 85 weeks.

3. Background

3.1 General

A recurrent theme in the analysis of poverty in low income countries is isolation. Poor rural communities struggle with physical access to markets, jobs, services and information because of poor infrastructure, particularly transport infrastructure and services. This lack of physical access results not just in physical isolation but political, social and economic isolation (DFID, 2014). Severe weather events, which tend to occur at high frequencies in some parts of sub-Saharan Africa, may increase rural community isolation thus rendering them more vulnerable.

Part of this project is to identify the vulnerability of rural transport infrastructure and its impact on rural communities, assess the risks, and propose preventive approaches/measures that are sustainable (i.e. cost-effective climate resilient solutions).

Climate is changing and the most immediate impact is likely to be from extreme climate events such as droughts, floods, storms and cyclones. The 2012 Intergovernmental Panel on Climate Change Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (Field et al, 2012) provides clear evidence that climate change has already affected the magnitude and frequency of some climate extremes. Particularly vulnerable, are countries in Africa and include: Burkina Faso, Chad, Ethiopia, Kenya, Mali, Mauritania, Mozambique, Niger, Senegal, South Sudan, Sudan, Tanzania, and Uganda.

The UK's Humanitarian and Emergency Response Review predicted that globally 375 million people each year would be affected by climate-related disasters by 2015, and recommended that DFID should (as are other donors) integrate the threat from climate change, and other potential hazards, into disaster risk reduction.

The African continent is facing the potential of a $184 billion liability to repair and maintain roads damaged from temperature and precipitation changes directly related to projected climate change through 2100 (Chinowsky et al, 2012). This cost is strictly to retain the current road inventory. This cost does not include costs associated with impacts to critically-needed new roads. In many African countries, limited or non-existent funds for adaptation are challenging these countries to identify the threats that are posed by climate change, to develop adaptation approaches to the projected changes, to incorporate changes into midrange and long-term development plans, and to secure funding for the proposed and necessary adaptation.

Although there are good examples of multi-sectoral African National Climate Adaptation Strategies (e.g. United Republic of Tanzania, 2012), national adaptation policies have not, hitherto, been applied widely to the road and transport sector and even less to low volume rural roads. Overarching risk assessment descriptions of methodologies exist, internationally, to address vulnerability from climate extremes (World Road Association, 2013). Although there are general principles for creating resilience in road networks, country-specific adaptation methodologies are needed for vulnerable African countries. Research is needed into appropriate and economic methodologies for risk and vulnerability assessments; prioritisation of interventions based on whole-life costings; optimisation of resilience approaches with monitoring and evaluation programmes to determine current best and most economic practice that are relevant 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.

DFID identified this research gap and ReCAP initiated a Regional Research Programme on Climate Adaptation specifically geared towards rural roads and communities to bridge this gap.

3.2 DFID's Rural Roads and Transport Services Research Business Case

In the DFID Research Business Case for ReCAP (DFID, 2014), it is noted that: "Access to services and markets are essential for increasing people's adaptive capacity and their resilience to shocks to their livelihoods. Rural roads are vital in connecting remote and vulnerable populations, particularly in times of hardship (e.g. prolonged drought; natural disasters such as flooding; conflict). The 2010 World Bank Economics of Adaptation to Climate Change highlights the importance of roads in many of its country case studies (World Bank, 2010). In Ghana, changes in road design standards alone were found to provide significant reductions in welfare losses under most future climate scenarios. In Mozambique, sealing unpaved roads was found to restore about one-fifth of the welfare loss owing to climate change".

It was also noted that: "Roads are particularly important for agricultural economies, where improving market access and maintaining reasonable prices (transportation increases production costs) for agricultural goods is crucial. In Tanzania, for instance, where 65 per cent of the population is engaged in agriculture, almost all roads somehow service farmers (Watkiss et al, 2011). The research associated with this programme will help build the evidence base for appropriate design, construction and maintenance of all-weather rural roads, which will in turn help boost adaptive capacity for vulnerable populations, particularly in the face of climate changes and extreme events".

The following are extracts from DFID's Research Business Case for ReCAP (DFID, 2014) which were pertinent to the subject of this study:

- Climate change (adaptation and mitigation) has not been a focus of AFCAP1. This therefore will be one theme within the overall research programme of ReCAP, which it is crucial to the sustainability of rural transport investments;
- Challenges of climate change adaptation and mitigation pose difficult questions about how to design, plan and build resilient rural roads and transport services without incurring even greater costs, either on the environment or on strained government budgets;
- The ReCAP Research Programme has three key functions: Research and Uptake; Capacity Building; and Knowledge Management. The outputs of *Research and Uptake* have to focus on the generation, validation and updating of evidence for *effective policies and practices to achieve all-weather, climate resilient, equitable and affordable rural transport*, with one of the activities being *the researching of road designs, materials and construction/maintenance methods adapted to climate change* (i.e. being robust to more severe weather incidents);
- The individual research projects to be funded will focus on both engineering (including materials, testing, design, construction and maintenance methods) and transport services (including road safety, affordability, frequency). It is important that issues of climate change and environment are mainstreamed across the portfolio of research, notably for climate change adaptation, where the greatest opportunities exist;
- The interaction of roads and associated transport with the natural environment must be recognised early in infrastructure planning and design phases. Road construction and maintenance can have significant direct climate change and environmental impacts. Investment in road programmes carry high risks of contributing to environmental degradation, exploitation of natural resources and climate change, if not well managed. The

research outputs (e.g. standards, manuals, specifications) could help to establish and encourage best-practice in rural road engineering that reflects climate and environment issues. With respect to climate resilience and adaptation, the following:

- There is a substantial opportunity for the programme to contribute to the evidence base for incorporating climate change adaptation into rural road planning, design, construction and maintenance. The impact of climate change, climate variability and extreme events (such as floods and droughts) may have is likely to influence choices of design and associated planning decisions for rural roads.
- ReCAP should build on this and other knowledge products already available, such as the Asian Development Bank's Guidelines for Climate Proofing Investment in the Transport Sector (ADB, 2011). The Guidelines aim to help project teams to incorporate climate change adaptation measures into transport sector investment projects and includes guidance on the entire implementation process from appropriate design standards, through to foundation conditions and effective maintenance.
- Overall, the programme has significant opportunities to boost adaptive capacity for vulnerable populations through improved access to services. The programme has an opportunity to become a world-leading source of evidence and research on rural roads and the associated climate and environment impacts in developing countries.

3.3 ReCAP Research Strategy

In the ReCAP Research Strategy it is acknowledged that:

- Transport infrastructure and transport services are particular vulnerable to climate threats and associated impacts. The risks arising from these impacts are considerably increased when the likelihood of increasing climate threats from future climate change is taken into account; and that
- In many countries the rural road infrastructure is already below acceptable resilience levels for current climatic environments. Climate change is accepted as likely to contribute towards more extremes of weather and hence exacerbating the situation of .increasing the frequency in which rural areas are cut-off (landslides, bridges swept away and roads washed out). These are likely to continue and the consequences for rural access need to be researched. The positive and negative environmental effects of rural roads need to be assessed and ways of mitigating negative externalities (e.g., runoff, erosion, deforestation) need to be shared.

The ReCAP Research Strategy identified the following possible research topics:

- Guidance on how to build more climate resilient rural transport infrastructure at an affordable cost (e.g. though spot improvement approaches);
- Best practice on how rural transport planning should take into account more frequent extremes of weather (e.g. through research into clear frameworks of threat assessment, vulnerability, impact assessment and adaptation assessment); and
- The negative environmental externalities associated with rural roads (e.g., runoff, erosion, deforestation) and best practice solutions for limiting them.

4. Research Objectives

4.1 Overall aim of the Programme

The overall aim of the Programme is to move forward from previous AfCAP research and deliver sustainable enhancement in the capacity of AfCAP Partner Countries to reduce current and future climate impacts on vulnerable rural infrastructure. This is to be achieved through the research and consequent uptake and embedment, at both policy and practical levels, of pragmatic, cost-beneficial engineering and non-engineering procedures based on the recognition of locally-specific current and future climate threats.

4.2 Overall objectives

The fundamental ***research 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 based on a logical sequence of defining:

- Climate threats
- Climate impacts
- Vulnerability to impact (risk)
- Non-engineering adaptations
- Engineering adaptations
- Prioritisation

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.

The third objective is to ensure that there is focus on ***uptake and subsequent embedment*** of outcomes 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.

4.3 Objectives for Phase 1

The ultimate goal of the project is to build enduring capacity in AfCAP Partner Countries to deal with the impacts of current and future climate on vulnerable rural access in a sustainable manner, from policy to practical level, and particularly in those countries that are most vulnerable to such effects and where adaptive capacity is low, often being hindered by financial, technical and other constraints.

In Phase 1, the first as well as aspects of the second primary objectives set for the overall project, as presented in Section 4.2, were addressed as follows:

(1) **Objective A:** *To identify, characterise and demonstrate*[1] *appropriate engineering and non-engineering adaptation procedures that may be implemented to strengthen the long-term resilience of rural access.* This has been addressed under the heading "*Climate Threats, Vulnerability and Adaptation*", which consisted of the following five Work Packages (WPs):

   a. WP A.1: Observed current climate: variability and trends
   b. WP A.2: Climate change projections

[1]The physical implementation of the *demonstration programme* forms part of Phase 2, but the conceptual design of the demonstration programme has been undertaken in Phase 1.

c. WP A.3: Development of risk assessment methodology and vulnerability indices
d. WP A.4: Engineering and non-engineering adaptation options and their prioritisation
e. WP A.5: Establishment of a demonstration programme

(2) **Objective B:** *To build capacity and disseminate knowledge* has been addressed under the heading "*Capacity Enhancement of AfCAP Partner Countries*". In addition to meaningful engagements with stakeholders in the three identified AfCAP Partner Countries, also through workshops held in the three countries, additional vehicles for diffusing knowledge to all AfCAP Partner Countries (and beyond) have been implemented. These include the publishing of regular Briefing Notes and the establishment of a project webpage on the ReCAP website with an associated discussion forum.

Four Work Packages associated with Objective B were as follows:

a. WP B.1: Establishment of website/portal for interaction with AfCAP Partner Countries
b. WP B.2: Development of training material
c. WP B.3: Training workshops to be held in three AfCAP Partner Countries
d. WP B.4: Regional ARTReF Seminar on the impact of current and future climate impacts on rural transport infrastructure and services

A description of the main activities conducted under each of the Work Packages associated with Objectives A and B are provided in Section 5.

5 Approach and Methodology

This section describes the approach and methodology that were followed in order to achieve the objectives defined in Section 4.3. It consists of two parts, namely: (a) the activities undertaken to satisfy *Objective A: Climate Threats, Vulnerability and Adaptation*, and (b) the activities undertaken to satisfy *Objective B: Capacity Enhancement of AfCAP Partner Countries*.

5.1 Objective A: Climate Threats, Vulnerability and Adaptation

Objective A consists of five Work Packages (WPs) as outlined in Section 4.3. It had been structured in accordance with typical steps that would be undertaken in order to develop and implement a climate change adaptation plan, these being:

1. Assessment of current climate trends and future projections for the geographical region; identification of climate effects that would impact on rural accessibility; and quantification/qualification of their degree of uncertainty (addressed in WP A.1 and WP A.2);
2. Undertake a climate vulnerability assessment of access roads within the geographic region (addressed in WP A.3);
3. Development of adaptation action plans: undertake a risk appraisal to categorise the nature of risk associated with each vulnerability, and identify, assess and prioritise available options to respond to the risks associated with each of the vulnerabilities (addressed in WP A.4).
4. Implementation of adaptation action plans (addressed in WP A.5).
5. Monitoring and evaluation of the interventions on an ongoing basis, and regular review and modification of the plans at predefined intervals (also addressed conceptually in WP A.5).

The main outcomes of *Objective A* were appropriate processes, procedures, supporting data and information to enable AfCAP Partner Countries (as well as non-AfCAP Partner Countries) to undertake risk and vulnerability assessments and to provide guidance on the implementation of engineering and non-engineering adaptation options to render rural road networks more climate resilient.

These were presented in the following Milestone reports: (a) *Climate Threats Report*; (b) *Climate Adaptation Options Report*; and (c) *Recommendations for Phase 2 Report*.

WP A.1: Observed current climate: variability and trends

In this Work Package historical data on weather patterns and climatic events were aggregated and presented in a series of regional maps. For the three priority countries (Ethiopia, Ghana and Mozambique) high resolution (8x8km) maps were produced for climate metrics such as maximum temperature, number of very hot days, rainfall and extreme rainfall days, spanning the period 1961 to 1990. From the climatic data warehouse that has been established, maps on wind velocity, drought index, fire-hazard days, evapotranspiration and other climate-derived metrics can be produced, also to support vulnerability assessments and project level investigations.

Task A.1.1: Determine the present-day frequency of occurrence of regional droughts and periods of above normal rainfall over each of the AfCAP areas of interest, thereby characterising climate variability for these regions.

Task A.1.2: Determine the present-day frequency of occurrence of extreme events (e.g. heat-wave days, prolonged rainfall events, heavy rainfall events) for each of the areas of interest.

Task A.1.3: Identify the trends that have occurred in recent decades over the AfCAP areas of interest, in terms of annual and seasonal average rainfall and temperature.

Task A.1.4: Identify the trends that have occurred in recent decades over the AfCAP areas of interest in terms of the extremes of rainfall and temperature (e.g. heat-wave days, prolonged rainfall events, heavy rainfall events).

Task A.1.5: Collect and analyse local data from historical records.

WP A.2: Climate change projections

Future projections of high-impact climate events that could pose a threat to rural road infrastructure in African countries have been conducted in accordance with the following tasks:

Task A.2.1: AR5-CMIP5 model projections of global climate change as described in the Africa Chapter of AR6 have provided background information for a narrative on the range of large-scale (subcontinental) projected African climate futures, for both low and high mitigation futures.

Task A.2.2: Statistical analysis of the CORDEX ensemble of regional projections (for both low and high mitigation futures) have been performed to obtain insight into how the range of extreme events relevant to road infrastructure will change over the AfCAP areas of interest under climate change. The CORDEX simulations of climate trends observed to date have also been evaluated against observed trends identified in WP A.1.

Task A.2.3: CSIR 8 km resolution projections of regional climate change over the selected AfCAP countries have been performed to provide additional information on projected changes in rainfall rates, extreme rainfall events, maximum temperatures and number of very hot days.

The above analyses were conducted for periods 2020-2050 and 2070-2100 to provide insight into both the near-future (taking note that this near-future period is the key focus for the present-day planning around the maintenance of existing and the planning of future road infrastructure) and far-future impacts of future climate change (mainly to understand likely impacts on long-life structures such as bridges). Whereas most engineering adaptation measures (apart from major structures) would predominantly focus on the period 2020-2050, non-engineering options would need to be considered for both periods.

Climate metrics such as maximum temperature, number of very hot days, annual rainfall and extreme convective rainfall events have been assessed. The base data are available to assess other climate metrics such as average temperature, minimum temperature, prolonged rainfall events that could lead to large-scale flooding, rainfall intensity, run-off, wind velocity, soil moisture, droughts, high fire-danger days and heat-wave days. Additional climate metrics to be considered in the analysis will be identified during Phase 2 through a co-production approach by the Project Team and asset owners/managers in the three priority countries in particular.

WP A.3: Development of risk assessment methodology and vulnerability indices

The intention of this work package was to develop an acceptable risk and vulnerability methodology and to apply the said methodology to determine risk profiles of regions within the selected and agreed upon AfCAP Partner Countries. Outputs from WP A.3 included:

- Decisions regarding the geographical areas to select, namely (a) countries, and (b) appropriate regions within countries;
- Indices to be used for assessing exposure, vulnerability and asset criticality. The vulnerability indices were done in two parts, namely a more general set of indices which can be used to assess a bigger geographical area, such as an entire country or large region of interest within a country, as well as a more detailed set of indices that can be used at a local/community level to assess a particular road or combination of roads.
- Testing of the methodology on one of the priority countries as well as on areas of interest in the three priority countries.

Specific tasks with regards to this work package that were completed are outlined below:

Task A.3.1: Select and confirm AfCAP Partner Countries and review their climate threats and vulnerabilities.

Selection of AfCAP Partner Countries were based, amongst other factors, on a geospatial analysis process in which the following criteria were used:

- Countries known for significant climate variability, including high-impact weather events with a clear hazard footprint in terms of road infrastructure, and where there is evidence of future climate change worsening the vulnerabilities to high-impact weather events. Countries were selected to represent different climate environments to ensure climate variability with regards to various events.
- Countries' ratings in terms of vulnerability to climate variability and change, taking factors such as rural population density, road density, rural access index, road type and quality, and capital investment in consideration.
- Countries representing differentiation with regards to its topography. This was deemed necessary due to the effects that slope, drainage, land use practices

and soil stability have on both the non-engineered and engineered nature of most low-volume rural roads.

- Geographical representation to account for different geology, topography, petrography and soil types, regional climates, and road engineering policies/standards.

On the basis of the above, three countries were selected: Ethiopia (East Africa), Ghana (West Africa) and Mozambique (Southern Africa).

Task A.3.2: A *Climate Threats Report* was compiled based on the outputs of WP A.1, WP A.2 and Task A.3.1 of WP A.3, reflecting current and future climate effects and their impacts on road infrastructure and rural accessibility.

Task A.3.3: Creating appropriate flexible indexes and frameworks for assessing low-volume access road infrastructure's exposure, vulnerability of criticality.

The approach adopted in Task A.3.1 for the identification of the three priority countries was further refined to develop a *vulnerability assessment tool* to identify vulnerable regions/districts within a country, as well as vulnerable roads within a region/district based on a basket of measures that include, inter alia: road asset information; climate exposure (current and projected); environmental conditions; and socio-economic factors. The vulnerability assessment tool is presented in the Chapter "Quantification and prioritisation of risks" of the *Climate Threats Report.*

Task A.3.4: *Testing indexes and frameworks:* Risk profiles were compiled through utilising the developed indices in Task A.3.3 and its feasibility was tested in a fair amount of detail using Mozambique as a case study. The results are reported in the Chapter "Contextualizing climate threats on rural road access" of the *Climate Threats Report*.

Task A.3.5: *Scientific output:* A scientific paper based on the outputs of WP A.1, A.2 and A.3 was produced (cf. Annex A) and will be submitted to a Journal subject to approval by ReCAP.

WP A.4: Engineering and non-engineering adaptation options and their prioritisation

In this Work Package, engineering and non-engineering adaptation options were identified. Engineering adaptation techniques for handling the expected changes in temperature and precipitation, windiness, seal-level rise and more frequent extreme events are identified and discussed. These are specifically related to unpaved roads, paved roads, subgrade materials, earthworks and drainage within and outside the road reserve as well as possible implications for construction activities. The importance of timely and good maintenance practices was also identified and guidance has been provided.

Similarly, non-engineering adaptation options were addressed in the Work Package. These options (and associated activities) tend to be more strategic in nature and are generally used in conjunction with engineering options in their application. Recognised components of these options and activities include:

- Modification of goals and policies
- Alignment, master planning and land use planning
- Improved network and programme management to anticipate and mitigate impacts
- Improved asset management resilience
- Maintenance planning and early warning
- Environmental management

- Research
- Building adaptation capacity into roads: Policy, Planning and Standards

The following primary tasks were undertaken in WP A.4:

Task A.4.1: State-of-the-art review on:

a. the likely impact of all conceivable primary climate effects and secondary climate change effects on rural accessibility and low-volume access roads in sub-Saharan Africa;

b. engineering and non-engineering adaptation options;

c. (cost-effective) risk mitigation measures;

d. prioritisation methods and decision rules taking into consideration financial resources/constraints, technical feasibility and social acceptability;

e. implementation processes and strategies;

f. monitoring and evaluation.

Task A.4.2: Development of a database capturing information from AfCAP Partner Countries and information on the engineering and non-engineering aspects related to climate adaptation and adaptive capacity.

Task A.4.3: Development of a questionnaire, its distribution to all ARTReF member countries, and assessment of the outcomes of the questionnaire. A synthesis of the questionnaire responses is provided in Section 6.2, whereas the individual country responses are presented in Annex B.

Task A.4.4: Following the selection and confirmation of the three AfCAP Partner Countries of interest to this project [WP A.3], the Project Team engaged with relevant key stakeholders in Ethiopia, Ghana and Mozambique to:

a. Introduce them to the AfCAP Climate Adaptation study and present progress achieved to date;

b. obtain information on their current climate threats and on the vulnerability of their road network; obtain and discuss their current policies, strategies and programmes on how they currently (or intend to) deal with the impact of climate variability/change on their road network; and identify their constraints;

c. identify and agree on Counterpart Staff to work hand-in-glove with the AfCAP Project Team;

d. extract information from their road asset management systems to support the activities of WP A.3 (i.e. risk and vulnerability assessment framework).

Meetings were held with members of the AfCAP National Steering Committees in the three countries. Other stakeholders such as the Ministry of the Environment and the Weather Bureau also attended the meetings.

Task A.4.5: A *Climate Adaptation Options Report* has been compiled. In this report, both engineering and non-engineering adaptation options were presented. Adaptation techniques for handling the expected changes in temperature and precipitation, windiness, seal-level rise and more frequent extreme events were identified and discussed. These relate to unpaved roads, paved roads, subgrade materials, earthworks and drainage within and outside the road reserve as well as possible

implications for construction activities. The importance of timely and good maintenance practices was also highlighted in the report. The report also provides and adaptation methodology at project level based on the methodology proposed by the Asian Development Bank (ADB, 2011).

Task A.4.6: A scientific paper on the assessment of road infrastructure for climate adaptation has been prepared and will be submitted to a peer-reviewed regional conference. The paper has been based on the outputs of Task A.4.5, but also addresses aspects of WP A.5.

WP A.5: Establishment of a demonstration programme

The aim of this Work Package was to identify and define pragmatic engineering and non-engineering adaptation options that can be implemented, as part of Phase 2 of the overall project, on a road (or roads) within an identified region of the three priority countries (Ethiopia, Ghana and Mozambique).

In order to achieve the above, the following tasks were executed:

Task A.5.1: Identification of potential roads in each country for the demonstration programme. The need was identified at the meetings held with the members of the AfCAP National Steering Committee in the three countries (Task A.4.4).

Task A.5.2: After identification of the targeted regions and candidate roads for the demonstration programme, the Project Team organised visits to the candidate roads.

Task A.5.3: The Project Team visited roads identified as candidates by the three countries, interacted with district/municipal engineers. The Project Team conducted a visual appraisal of the candidate roads as well as a risk appraisal to categorise the nature and level of risk associated with each of the vulnerabilities identified. The following activities were executed:

1. Identification, assessment and prioritization of available options to respond to the risks associated with each of the vulnerabilities identified on the roads;
2. Establishment of a prioritised list of adaptation options to make the road (and associated structures) more climate resilient;
3. Carry out preliminary designs (i.e. concept designs);
4. Propose a demonstration programme.

The outcomes of the above formed the basis for the selection of appropriate roads to be included in the demonstration programme.

Task A.5.4: A draft report for each project site was prepared, summarising the outcomes of Task A.5.3. The draft reports were subsequently integrated in a final report for WP A.5, entitled *Recommendation for Phase 2*.

Tentative recommendations for activities to be undertaken in Phase 2 of the study, focussing on demonstrations, capacity building, uptake and embedment, were also included in this report.

5.2 Objective B: Capacity Enhancement of AfCAP Partner Countries

Following the selection and confirmation of the three targeted AfCAP Partner Countries of interest to this project, two counterpart researchers from each of the countries were identified and integrated in the team. They participated in all in-country activities, inclusive of site visits to the candidate roads for the demonstration programme. Through interactions with the team and involvement in all in-country activities during Phase 1 and especially during Phase 2 of the study, it is expected that pertinent knowledge on all aspects of this study will be transferred to the counterpart researchers and subsequently diffused within their respective organisations.

The following Work Packages and tasks were successfully completed to address *Objective B*:

WP B.1: ***Establishment of website/portal for interaction with AfCAP Partner Countries***

One of the tools used for knowledge dissemination is the ReCAP website. Regular Briefing Notes were produced during the course of Phase 1 in order to share information and progress to interested parties.

Task B.1.1: Establishment of a Project Webpage: Discussions with the ReCAP Knowledge Management and Communications PMU were held to determine how best to make use of the ReCAP website to disseminate knowledge. This led to the design and implementation of a dedicated webpage for this project under the tab "Regional Projects" on the ReCAP website. Linked to this webpage is a discussion forum designed to elicit discussion on subjects related to the theme of this study. However, despite having a number of registered forum members, none of the members have as yet posted a comment or discussion point. In Phase 2, the Project Team will attempt to initiate discussion by introducing a "frequently asked questions" posting on the discussion forum.

Task B.1.2: Produce and publish Briefing Notes, subject to peer review by ReCAP: Four Briefing Notes have been published on the ReCAP website, one after each completion of a Milestone Report (i.e. Inception Report, Climate Threats Report; Climate Adaptation Options Report; and Recommendations for Phase 2 Report).

WP B.2: ***Development of training material***

The training material listed in Tasks B.2.1 to B.2.3 were prepared for the workshops held in the three countries (Ethiopia, Ghana and Mozambique). The training material was customised for the three countries hosting the workshops, and will be uploaded to the project's webpage subject to the approval of ReCAP.

Task B.2.1: Training materials for summary review of the current and future climate threats and consequent likely impacts to AfCAP Partner Countries with a particular focus on regional rural road networks;

Task B.2.2: Training material on how to conduct vulnerability assessments, and for engineering and non-engineering adaptation options that could be deployed to reduce the likely climate impacts/threats;

Task B.2.3: Training material for the selection of sites or areas within which to undertake climate impact assessments and to demonstrate climate adaptation options, using the three demonstration sites as case studies (cf. WP A.5).

WP B.3: ***Training workshops held in three AfCAP Partner Countries***

Based on feedback received from the workshop participants, successful two-day workshops were held in Mozambique (Maputo; 30-31 January 2017), Ghana (Accra; 2-3 February 2017) and Ethiopia (Addis Ababa; 8-9 February 2017). The counterpart

researchers played a significant role in organising the workshops. A Workshop Report has been produced highlighting and summarising the main discussion topics and recommendations.

The following tasks were completed:

Task B.3.1: In partnership with the two counterpart researchers from each country, set up and organise training workshops in three countries, inviting relevant stakeholders and national experts.

Task B.3.2: Hold two-day training workshops in each country

Task B.3.3: Produce Workshop summary reports and distribute

WP B.4: ***Regional ARTReF Seminar on current and future climate impacts on rural transport infrastructure and services***

No regional ARTReF Seminar has been held yet. The ARTReF Members were only exposed to the project:

- through a questionnaire sent out to the 16 Members (nine Members responded – see Section 6.2), and
- at the Project Implementation Team (PIT) meeting held in November 2016 in Caledon (South Africa), which focused primarily on Asset Management and Knowledge Management but where a short progress report on the Climate Adaptation project was also presented.

At the Stakeholder Workshops planned in April and November 2017, and the T^2 Conference to be held in May 2017, it is expected that more ARTReF Members will become exposed to the project.

It should be noted that this Work Package was not budgeted for.

6 Review of Key Documents

6.1 Introduction

This section provides a summary of the contents and findings of the reports prepared for AfCAP for the Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa project. The individual reports are:

- The Inception Report;
- The Climate Threats Report;
- The Climate Adaptation Options Report;
- The Recommendations for Phase 2 Report; and
- The Workshops Report.

6.2 Summary of questionnaire responses

A questionnaire was compiled and sent to the 16 ARTReF Member Countries. Nine countries responded to the questionnaire, namely: Botswana, Ghana, Malawi, Namibia, Nigeria, Tanzania, Uganda, Zambia and Zimbabwe. Their responses are reproduced in Annex B.

The following main issues were raised in the responses received:

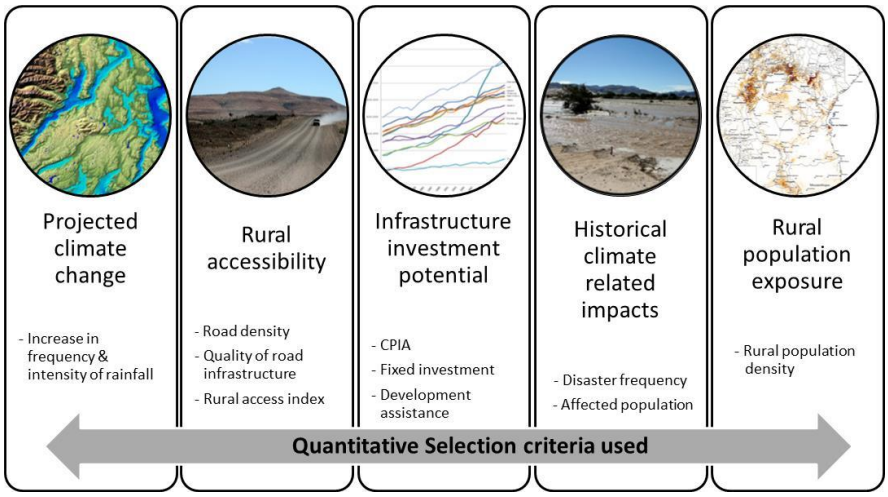
- Perceived increase in the frequency of high precipitation events causing (flash) floods, damaging road infrastructure (mainly drainage structures and bridges) and impacting on rural accessibility;

- Poor condition of roads in rural areas has negative effects on agricultural activities which is the major source of income of residents, thereby increasing the poverty rate;
- Motorized transport costs become very high during rainy season as public transport operators hike up their fares because of the increased vehicle running cost, often occasioned by the prevalent very bad road conditions;
- Road authorities should place greater emphasis on disaster management and emergency responses;
- Inadequate financial resources to address current challenges caused by climate events;
- Need to conduct a study to establish the impact of climate change on the construction, maintenance and emergency response costs;
- Very few studies on the impact of climate on roads have been conducted, and the uptake of climate change in road/transport policies is almost non-existent;
- Some countries will be initiating a review of their norms and standards for road construction (e.g. Malawi, Mozambique, Nigeria), and it is expected that climate effects will be addressed in such revisions;
- Challenges in achieving compaction densities where water is scarce, and excessive dustiness (and loss of fine material) of gravel roads during dry spells;
- Need to upgrade unpaved roads to paved standards, but also concerns that temperature increases will impact the performance of bituminous bound layers (e.g. surfacing seals);
- Lack of political will by Government to effectively address the issue, inadequate advocacy and public awareness;
- Need to build local capacity to incorporate climate change adaptation and resilience considerations throughout the transport infrastructure design and management processes at practical and policy levels;
- Need for awareness or advocacy programmes on the improvement of the capacity of professionals in adapting to climate change.

6.3 Country selection criteria

A set of selection criteria was developed (as discussed in the Inception Report). The main categories were (see figure below):

- Projected climate change parameters;
- Rural accessibility;
- Infrastructure investment potential;
- Historical climate related impacts, and
- Rural Population exposure.



The final scores achieved for eleven AfCAP Partner Countries considered are given in the table below:

TABLE 1: Scores achieved for the 11 countries evaluated

Ranking	Country	Score
1	ETHIOPIA	19.7
2	KENYA	18.8
3	MOZAMBIQUE	18.7
4	TANZANIA	16.8
5	UGANDA	15.2
5	ZAMBIA	15.2
7	DRC	15.0
8	MALAWI	14.7
9	GHANA	12.8
10	SIERRA LEONE	12.3
11	SOUTH SUDAN	N/A

In addition to the above, the following institutional and operational knowledge/qualitative selection criteria were also used:

- Country selection should ensure regional inclusion (i.e. Eastern, Southern and Western Africa representativeness);
- The country should have national and/or sectoral (i.e. road/transport related) Climate Change policies or response strategy in place, or should have expressed their commitment to preparing them to ensure the integration of Climate Change into development strategies, plans and budgets;
- The country should have sufficient human and financial capacity available to prepare and implement appropriate climate resilience/adaptation responses in order to provide and maintain rural access sustainably, and should, in particular, have expressed a commitment to financially and technically support the establishment of demonstration sections (i.e. to support Phase 2 of this project);
- The country should be willing to assign at least two competent engineers/researchers to support the activities of the AfCAP Project Team at national and regional level.

Based on the above, the three countries selected for the project were: Ethiopia, Ghana and Mozambique.

6.4 Climate Threats Report

In spite of rapid urbanisation all over Africa, rural populations continue to grow and rural roads are vital in supporting delivery of essential utility services. More than 218 million people in Sub-Saharan Africa live in extreme poverty and the highest concentrations of these rural poor people can be found in Eastern and Southern Africa. Accessible paved roads and railroad networks are limited and there are less than 1 000 km of unpaved roads per 1 000 persons, this being “a level of service that is an order of magnitude smaller than the amount of paved roads in many industrialised countries” (Hearn, 2014). The impact of rural roads stretches from socio-economic impact, fertility and mortality impact, and improved agriculture.

6.4.1 Observed climate, projected climate change and roads

African countries tend to be particularly vulnerable to the effects of climate variability, and historical weather related disasters have shown just how susceptible these countries can be. Figure 1 provides an overview of the predominant types of recorded weather related disasters and the amount of people that have historically been affected.

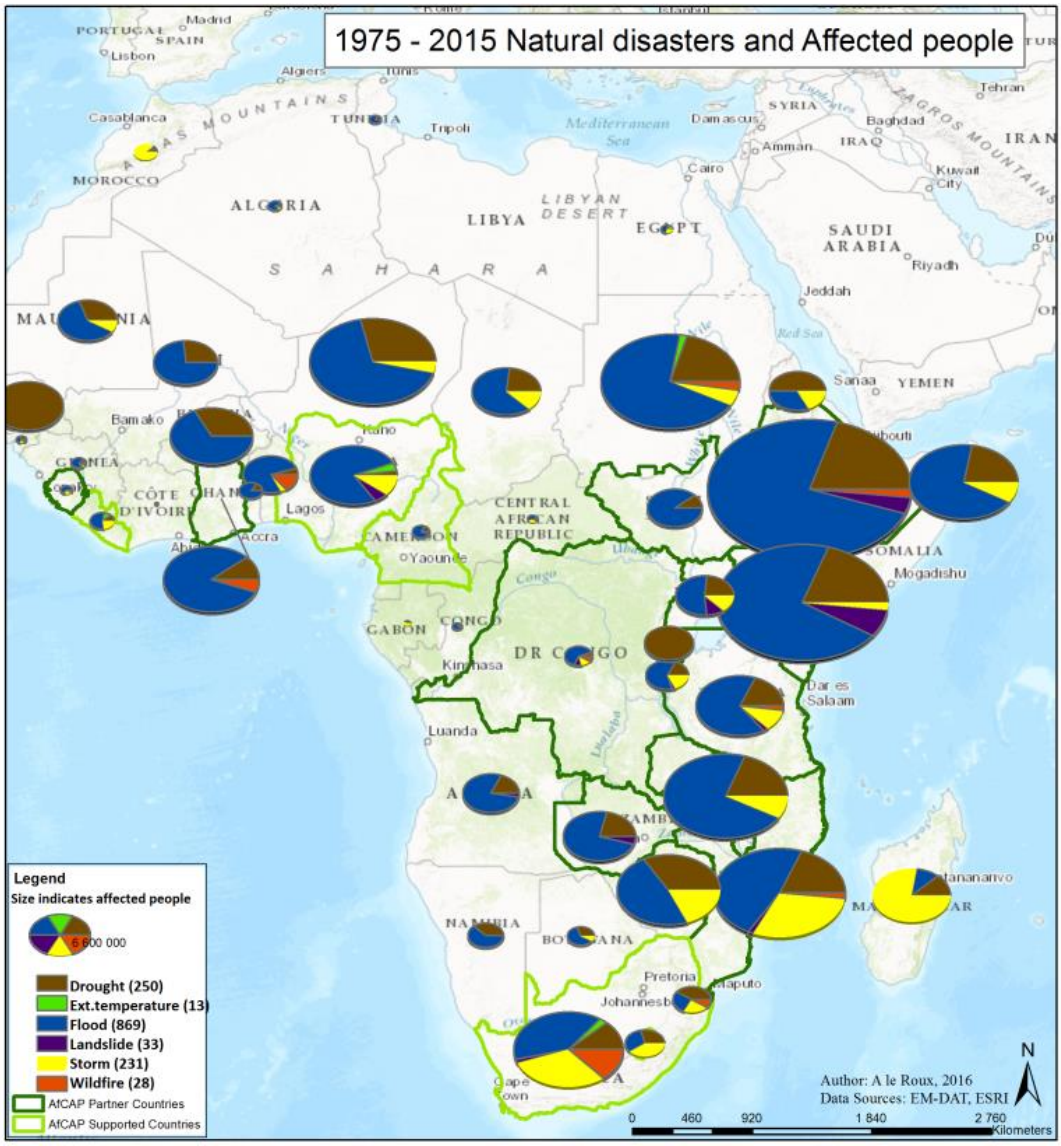


FIGURE 1: Recorded weather related disasters and affected populations[2]

A recent study by CRED and UNISDR (2016) suggest that 90 per cent of all global disasters are caused by weather related events such as floods, storms, droughts and extreme temperature. Communities in Africa are projected to be some of the worst affected by climate change, in part due to their high socio-economic vulnerability, growing rural populations and high dependency on natural resources, but also due to the projected frequency and intensity increase of weather related natural hazards (CRED and UNISDR, 2015 and Engelbrecht et al., 2015). In the past four decades (1975-2015) African

[2]Map produced by the CSIR based on collated and verified information obtained from various sources, including the Centre for Research on the Epidemiology of Disasters (CRED) & the United Nations Office for Disaster Risk Reduction (UNISDR).

countries have experienced more than a 1 400 recorded weather related disasters (meteorological, hydrological and climatological). The high social vulnerability and low adaptive capacity of communities as well as their high exposure to natural hazards has resulted in the death of more than 600,000 people (95 per cent 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).

6.4.2 Projected Climate Change over Africa

Given the observed impacts that weather related disasters have had on communities, infrastructure and economies it can be expected that climate change will impact drastically on the African continent during the 21st century under a low mitigation future.

Examples of future climate change over Africa that were determined in this project are displayed in Figure 2. Extreme rainfall events are defined as 20 mm of rain occurring within 24 hours over an area of 0.5 degrees longitude by 0.5 degrees latitude (about 2500 km^2). Similarly, Figure 3 provides an example of the projected changes across a range of downscalings for rainfall (left) and average value of the Keetch-Byram drought index (right), for the period 2080-2100 relative to 1961-1990 under a low mitigation scenario.

African temperatures are projected to rise rapidly, faster than the global average temperature, and in the subtropics at a rate of about twice the global rate of temperature increase (James and Washington, 2013; Engelbrecht et al., 2015). Moreover, the southern African region and Mediterranean North Africa are likely to become generally drier under enhanced anthropogenic forcing (i.e. forcing due to human factors), whilst East Africa and most of tropical Africa are likely to become wetter (Christensen et al., 2007; Engelbrecht et al., 2009; James and Washington, 2013; Niang et al., 2014). More uncertainty surrounds the projected climate futures of West Africa and the Sahel, with some climate models projecting wetter conditions and equally credible models projecting drier conditions under climate change (e.g. Christensen et al., 2007; Niang et al., 2014).

Climate change is not to take place only through changes in average temperatures and rainfall patterns, but also through changes in the attributes of extreme weather events**.** For the southern African region, generally drier conditions and the more frequent occurrence of dry spells are likely over most of the interior (Christensen et al., 2007; Engelbrecht et al., 2009). Flooding events related to Cut-off Low weather systems are also projected to occur less frequently over South Africa (e.g. Engelbrecht et al., 2013). Tropical cyclone tracks are projected to shift northward, bringing more flood events to northern Mozambique and fewer to the Limpopo province in South Africa (Malherbe et al., 2013). Further to the north, over Tanzania and Kenya, more large-scale flood events may plausibly occur should the future climate regime be characterised by a higher frequency of occurrence of strong El Niño events. Intense thunderstorms are likely to occur more frequently over tropical and subtropical Africa in a generally warmer climate (e.g. Engelbrecht et al., 2013). More uncertainty surrounds the climate futures of West Africa, the Sahel and the Horn of Africa, particularly within the context of how climate change may impact on the occurrence of mega-droughts over these regions (Lyon and DeWitt, 2012; Williams et al., 2012; Roehrig et al., 2013).

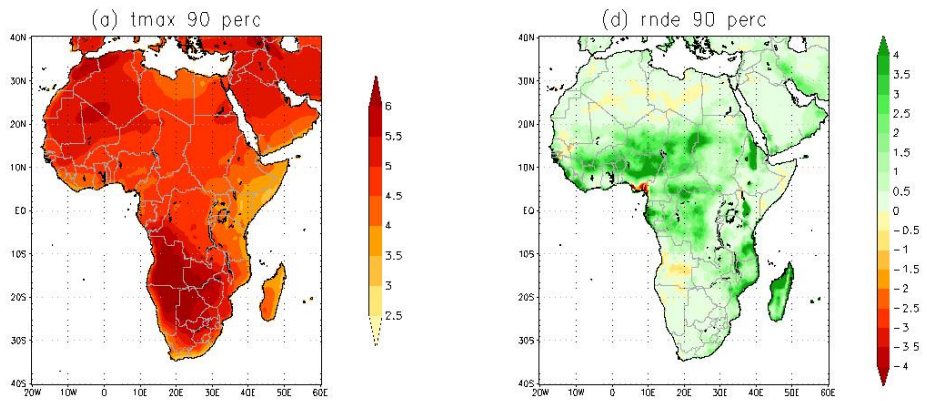


FIGURE 2: Example of projected changes in maximum temperature and extreme rainfall events

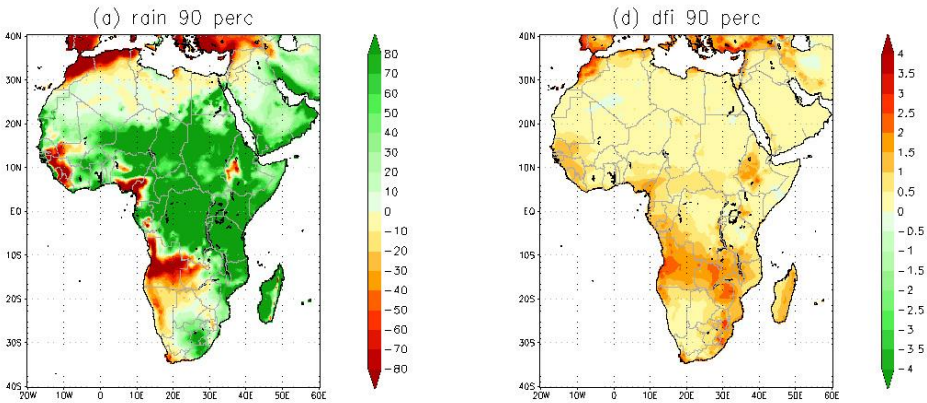


FIGURE 3: Examples of projected changes in rainfall and the average value of the Keetch-Byram drought index as determined in this project

6.4.3 Impact of climate on rural roads

6.4.3.1 Introduction

For low-volume rural road networks (less than 1 million cumulative equivalent standard axles over their service life), the environment (mainly climate) plays a much larger role in contributing to deterioration than traffic does. Low-volume rural roads should thus be designed to 'fit' into a local environment and to withstand the variety of environmental forces that could destabilise the integrity of the infrastructure and therefore could impact on mobility and accessibility. Changes in climate conditions will be detrimental in cases where current designs do not sufficiently cater for the effects of such changes and/or inadequate infrastructure maintenance has been performed. This poses a challenge to one of the basic principles on which many roads are being designed, namely that historic climate records provide a good indication of future climate. Greater climate variability in the future could stress present road infrastructure beyond the range of impacts that it is currently able to resist.

6.4.3.2 Climatic factors impacting on roads

From the overall road infrastructure perspective, it is important to understand which of the primary climate change factors and secondary climate change effects will have the greatest impact on the vulnerability of road infrastructure.

Examples of primary factors and secondary effects and impacts are listed below:

- Primary climate change factors:
  - Increase or decrease in temperature (average and maximum);
  - Increase or decrease in average rainfall and extreme rainfall events;
  - Increase or decrease in wind velocity (associated with, for instance, cyclones).
- Secondary climate change effects:
  - Increase or decrease in road surface temperatures;
  - Sea level rise;
  - Flooding/drought;
  - Raising or lowering of groundwater level and soil moisture content;
- Secondary climate change impacts:
  - Increase in wildfire events (and subsequent increased risk for erosion);
  - Changes in ecological equilibrium, growing season (shorter/longer) and agricultural produce (impact on traffic patterns);
  - Changes in the construction season and impacts on construction (e.g. compaction water in prolonged periods of drought).

6.4.3.3 Summary of climate effects and their consequences

There are a number of aspects of road provision that are likely to be impacted by climate. These are:

- *Unpaved roads:* prone to shearing, rutting, and erosion in wet conditions
- *Flexible paved roads:* susceptibility to moisture, susceptible to high temperatures
- *Rigid pavements:* less susceptible to moisture, some challenges with excessive expansion in high temperatures
- *Earthworks:* potential slope instability (cuts/fills), and erosion of cuts and embankments
- *Subgrade:* variable moisture conditions can influence subgrades where for example expansive clays, dispersive soils, saline materials, collapsible sands, etc. are present

To ensure greater climate resilience of road structures, especially for low-volume access roads, greater attention needs to be devoted to particularly: (i) ***water***, both within and outside the immediate road environment; (ii) ***compaction*** density of pavement layers and geotechnical structures (e.g. embankments, fills), and (iii) routine and periodic ***maintenance***. Water, compaction and maintenance are recurring themes in the adaptation design of to low-volume access roads.

The above, as well as several other aspects impacting on the climate resilience of rural access, are addressed in the report by Paige-Green et al (2016a). Some extracts from this report dealing with the issues of *water*, *compaction* and *maintenance* are provided below:

Water (within the immediate road environment):

Water falling directly onto the road carriageway, shoulders and embankment slopes and which ultimately flows into the side drains requires particularly good control. The primary objective is to make sure that this water does not get into the pavement structure, whether it is an unpaved or a paved road. Other requirements are that the water does not accumulate on the surface of unpaved roads (leading to softening and deformation), the water flows off paved roads so as to minimise the risk of skidding/aquaplaning, movement of the water off the surface does not lead to erosion of the road surface (paved or unpaved) or the shoulders, and that the water actually gets into the side drains where it can be effectively removed from the road environment.

Water (outside the immediate road environment):

The water from outside the road immediate road environment is characterised by the precipitation that is collected in catchment areas and moves downslope towards the sea or large dams or can be

the result of local flooding of large rivers. This water crosses the roads at strategic points, typically the lowest part of the valley, and usually requires a bridge, culvert or some other (major) structure to permit the water to flow underneath (or sometimes over) the road. It should be borne in mind that the major catchment areas of large rivers (e.g. Limpopo, Zambezi, Volta, etc.) may be located outside the country's boundaries – this, together with the presence of large dams that allow river flow to be controlled, could make quantification of river flows very difficult in-country.

In the design of drainage structures (e.g. culverts, bridges), the expected maximum flow related to the catchment area of the river/stream is usually used to determine the flow capacity and required openings. The rain falling in the catchment area is determined on the basis of the expected return period of specific storm events usually based on past measurements. It is this return period that is likely to change (i.e. under more severe storm event scenarios the amount of rain falling during a future storm with a return period of 100 years will be more than that currently experienced during a 100 year return period storm) and needs to be modified for future designs. Extreme events after extended dry periods will result in more of the precipitation being "absorbed" by the ground, but high intensity precipitation will also result in rapid flows before the water can soak into the ground, depending on the hydrologic properties of the ground surface.

Water crossings need to be designed with a capacity to handle the expected change in rainfall intensity and runoff such as to balance construction costs with the economic and societal costs of not having sufficient drainage capacity and consequently suffering excessive erosion damage or even collapse of larger structures. The high costs of structures relative to overall low volume rural roads costs could dictate the increased use of appropriate fords and drifts that are designed to be "overtopped" for limited periods, without damage to the structures.

Compaction:

In order to minimise problems with climatic changes on roads it is essential that construction at least complies with the minimum requirements in the recommended standard specifications, if not exceeds them. For example, compaction (of subgrades, formations, embankments, abutments and pavement layers) to higher densities than those specified immediately increases the stiffness, reduces permeability and erosion potential and reduces voids and rutting potential. Compaction is one of the cheapest construction activities and should not be skimped on.

Maintenance:

Given that design and construction were performed optimally, maintenance is probably the most critical issue affecting climate resilience and vulnerability of infrastructure assets. Increased time and expenditure on maintenance will be essential to minimise vulnerability of roads and structures as climatic conditions change.

6.4.4 Quantification and prioritisation of risks

A geospatial climate-related road infrastructure risk and vulnerability assessment can provide key geographic information to inform adaptation decisions for rural access road construction and maintenance in the light of climate change. Core to such an assessment is the translation of climate change projections into increased/decreased risks for rural access roads. The intention is to develop a generic semi-quantitative rapid assessment method which can be applied in any country, even though there may be variations in the availability and quality of data.

Risk is defined as a function of hazards, rural access road exposure and vulnerability in terms of rural community access. The following definitions apply:

- **Hazards:** Climate-related events that can possibly cause damage to and/or interruption of service of rural low volume access road infrastructure as well as potential loss of life (e.g. floods);

- **Exposure:** Location of low volume road facilities, the associated structures and road environment as well as rural communities in places that could be adversely affected (within the hazard footprint);
- **Vulnerability:** Propensity to be adversely affected, considering the dependence of rural communities on these low volume access roads.

Conceptually, the detailed risk and vulnerability assessment is similar to typical protocols used internationally for assessing adaptation needs in the road infrastructure sector (Dowds and Aultman-Hall, 2015), and is based on four key phases (see Figure 4 below):

1. Data preparation
    a. Road asset classification
    b. Climate threats assessment
    c. Environmental conditions
    d. Socio-economic vulnerability
2. Evaluate asset vulnerability
3. Evaluate asset criticality
4. Identify adaptation options

For road management and maintenance and rehabilitation planning purposes, visual condition assessments of the road network are usually routinely carried out at specified frequencies. These normally look at the road condition, classifying problems such as cracking, deformation, rutting, potholing, etc., by degree and extent to prioritise and budget for follow-up management operations. Generally, only the road carriageway area is assessed. It is, however, necessary to add to this information to provide the required inputs for climate resilience assessments and the implementation of adaptation techniques. The additional data to be collected could include aspects such as: erosion; problem soils; drainage from the road and its near environment as well as from outside the road reserve; instability of embankments and cuttings; construction issues, and maintenance problems.

The prioritisation of roads for intervention can be done based on a number of fundamentals.

1. Potential loss of life – failure of engineering/geotechnical structures may lead to loss of life;
2. Accessibility – this is a social factor and depends on the population affected
3. Cost and consequences of closure
4. Cost of repair
5. Available funds
6. Environmental/sustainability issues (i.e. pollution, aesthetics, etc.)
7. Accessibility requirements

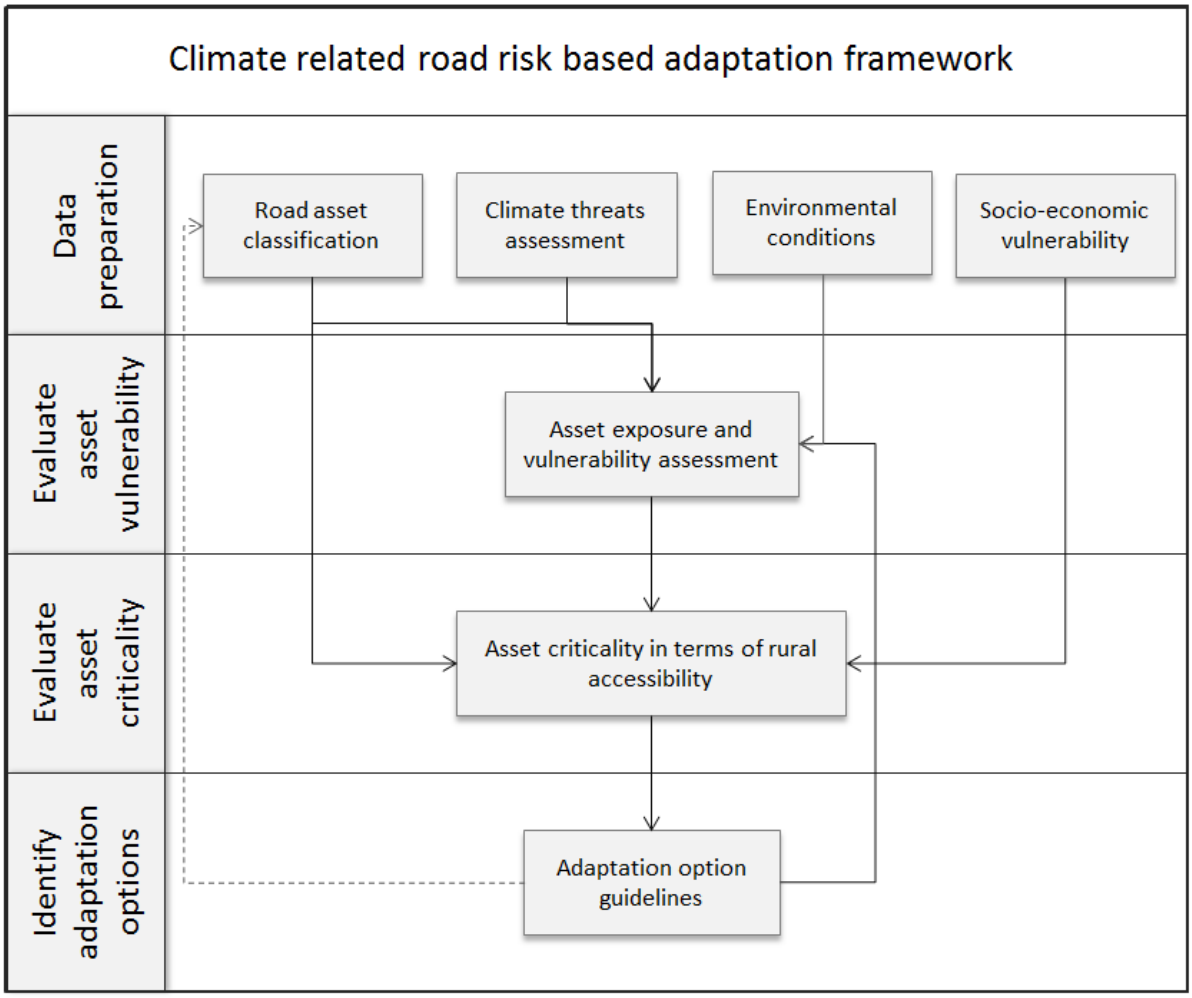


FIGURE 4: A framework for the detailed rural access road risk and vulnerability assessment based on a core adaptation framework by Dowds and Aultman-Hall (2015)

6.4.5 Contextualizing climate threats on rural road access (Mozambique case study)

The first step in developing a climate adaptation strategy for rural access roads, and to also guide the investment decision framework, is to undertake a risk and vulnerability assessment. In this project, a methodology for undertaking such an assessment at a national and local (district) level has been proposed. It consists of four phases:

(i) Collation of road facility, climate, environment and socio-economic data;
(ii) Assessment of asset vulnerability;
(iii) Evaluation of asset criticality; and
(iv) Identification of adaptation options

Phases (i) to (iii) of the methodology were applied to Mozambique, as a first case study, to identify vulnerable regions/districts from a rural accessibility and climate threat perspective. As part of this study, the following information was produced on the current situation in Mozambique:

- Weather related hazards and impacts (1975 to 2015)
- Weather variability and trends
- Population distribution and socio-economic status

- Road network data (density and condition)
- Rural accessibility and isolation (in relation to the density of the road network)

The information has been presented in the form of GIS maps. For the mid-future projections (up to 2050), the following maps have been produced:

- Projected changes in urban and rural population distribution
- Projected changes in annual average maximum temperatures
- Projected changes in average rainfall and changes in extreme rainfall events
- Exposure of road network to increases in very hot days
- Exposure of road network and vulnerable communities to increases in extreme weather events

The above information has shown that Mozambique is particularly at risk of loss of life, livelihoods and economic activity due to its high dependency on natural resources, high social vulnerability, low adaptive capacity and frequent exposure to intense weather related hazards. With the vast majority (70 per cent) of poor households being located in rural areas, and Mozambique having a very low overall road network density (considered to be amongst the lowest in Africa), many rural households do not have adequate access to a road network. Relatively frequent high precipitation events in rainfall catchment areas, often resulting in floods and damages to road infrastructure, place rural communities at risk of not being able to access markets and essential services.

From the information produced, vulnerable districts have been identified, which have formed the basis for the selection of candidate roads for the climate adaptation study. Similar information to that prepared for Mozambique will be developed for two other countries, namely Ethiopia and Ghana, in Phase 2.

6.5 Adaptations Options Report

Appropriate and economic methodologies for risk and vulnerability assessments, prioritisation of adaptation interventions, and optimisation of asset resilience in the context of rural access low volume roads were developed and reported. In addition, evidence of economic and social benefit links to rural communities arising from more resilient rural access were provided to support wider policy adoption across Africa. The work concentrated on future road scenarios in Mozambique, Ghana and Ethiopia, for which detailed climate projections have been developed within this overall project. The general findings, however, cover a wide range of scenarios and should be applicable to similar scenarios that unfold in other sub-Saharan African countries.

The objectives were delivered through the following:

i. Conceptual climate vulnerability and adaptation strategies
ii. A methodology for mitigation and adaptation
iii. Provision of options to create resilience
iv. Provision of guidance for building adaptation strategies into roads policy, planning and standards.

The following work was conducted/developed:

- A summary of climatic classifications currently used in road engineering;
- An inventory of all road elements that should be considered when addressing climate change effects;
- A 20-step methodology approach, prioritisation needs and options for adaptation strategies, including engineering and non-engineering options (after: ADB, 2011 – to be reviewed, consolidated and validated in Phase 2 of the AfCAP Climate Adaptation project);

- The potential hazards relating to the different expected climate stressors for all relevant facilities were identified.
- The critical importance of adequate drainage, with timely and good maintenance practices, is also highlighted and guidance given.

Non-engineering adaptation options and activities were discussed covering the following:

- Modification of goals and policies
- Alignment, master planning and land use planning
- Improved network and programme management to anticipate and mitigate impacts
- Improved asset management resilience
- Maintenance planning and early warning
- Environmental management
- Do nothing or minimum
- Research
- Building adaptation capacity into roads: Policy, Planning and Standards

The main recommended adaptation strategies include:

- Upgrade earth roads to at least engineered earth roads or gravel road standards;
- Improve material selection, construction practices, compaction and maintenance practices;
- Use innovative compaction techniques and water reducing technologies;
- On paved roads, use appropriate designs and surfacings including good drainage and maintenance;
- Apply the correct remedial procedures for problematic subgrades;
- Improve culvert and bridge designs and maintain properly;
- Improve maintenance procedures and training, consider community maintenance programmes;
- Upgrade gravel roads to paved standard where applicable;
- Stabilise slopes, including the application of vegetation, bio-engineering techniques;
- Use appropriate bituminous binders for surfaced roads (e.g. higher viscosity yet ageing-resistant binders for high road surface temperature environments);
- Enhance concrete mix designs and reinforcing;
- Apply precautionary measures against sand accumulation due to increased windiness;
- Use soaked subgrade designs for increased storm surges;
- Increase road level to a minimum of 0.5m-0.65m above normal groundwater level where possible and appropriate;
- Protect weaker subgrades with thicker pavements, and
- Make use of sub-surface drainage systems, where appropriate.

Ideally, some of the above measures should be embedded in norms and standards so as to ensure that they are applied routinely.

6.6 Demonstration programme and recommendations

As part of the project, three demonstration roads were selected:

- The Tullo Bollo to Kela Road, south of Addis Ababa in Ethiopia;
- Road R448 from Chokwe to Macarretane in the Gaza Province of Mozambique; and
- The Tampion-Tibognaayili-Tidjo Road, north of Tamale in Ghana.

Preliminary recommendations for the adaptation of these roads are provided in the report by Paige-Green et al (2016b). The main problems observed on the roads visited are shown in the table below.

PROBLEMS IDENTIFIED ON ROADS VISITED	SELECTED COUNTRIES AFFECTED		
	Mozambique	Ghana	Ethiopia
Shear failure due to excessive subgrade moisture			X
Erosion of wearing course and side-drains on grades		X	X
Slope instability			X
Erosion of embankments near structures	X	X	X
Collapse of structures	X		X
Loss of surfacing on low lying roads during flooding	X		
Pavement failures due to raised moisture contents in sub-layers	X (P)		X (U)
Erosion of high embankments and loss of surfacing during flooding	X		
Undermining of embankment due to flooding	X		
Poor road condition - unsuitable gravel			X
Flooding of the road		X	
Impassability due to poor materials and local ponding of water		X	

6.7 Training Workshops

6.7.1 Workshop objectives

Two-day Workshops were held in Mozambique (30-31 January 2017), Ghana (2-3 February 2017) and Ethiopia (8-9 February 2017). The outcomes of the workshops are presented in the report: *Workshops held in Mozambique, Ghana and Ethiopia*.

The Workshops had two primary objectives:

(a) to sensitise and brief the Workshop delegates on climate threats and their impacts on vulnerable rural access, and on how these could be addressed through the implementation of engineering and non-engineering adaptation options, within a framework of applicable vulnerability assessment and climate adaptation methodologies;

(b) to identify specific country needs and requirements so as to enable AfCAP to formulate appropriate support programmes to capacitate the countries and to assist them with the uptake and embedment of the outcomes in, for instance, policies, planning (e.g. through road asset management systems), norms and standards.

Objective (a) formed the basis of the discussions on the first day of the workshops held in the three countries. Two of the project's Milestone Reports ("*Climate Threats Report*" and "*Climate Adaptation Options Report*") were used as a starting point for ensuing discussions.

A third Milestone Report, namely "*Recommendations for Phase 2*", formed the basis for discussion on *Objective (b)* above. These took place on the second day of the workshops.

Overall, the outputs of these workshops defined the objectives and scope for Phase 2 of the Climate Adaptation Programme, which main focus will be on the practical demonstration of engineering and non-engineering adaptations; capacity building; and the uptake and embedment of outcomes.

6.7.2 Workshop recommendations

Based on the feedback obtained at the workshops held in the three countries, there appears to be a general lack of awareness on the effects of climate on road infrastructure, and the consequential impacts thereof on not only rural accessibility, but also on the cost of maintaining and reinstating access, especially after the occurrence of severe climate events. In Phase 2 of the Climate Adaptation programme, more effort will have to be invested in creating greater awareness, from the level of key stakeholders (decision-makers) to that of district engineers.

Creating awareness is, however, not sufficient. What the road authorities are after are also (and especially) cost-effective, implementable solutions for:

a) Better understanding the vulnerabilities within their road network, and the socio-economic consequences on rural communities in the event that accessibility is curtailed as a result of weather events;

b) Prioritising the limited funding at their disposal, both pro-actively and reactively;

c) Implementation (almost immediately) of simple, affordable and effective engineering options in order to better protect current infrastructure (e.g. through back-strengthening maintenance, or built into rehabilitation/new designs);

d) Greater embedment of the notion of 'climate adaptation' in policies and strategic plans, cascaded down to its embedment in norms, standards, manuals and guidelines, and hence then also the integration of climate adaptation in all aspects of road engineering (i.e. planning, design, construction and maintenance).

Building of local capacity will be key to achieve the above. A significant number of the workshop participants expressed the need for guidance, coaching and hands-on training. This could be achieved through several means, which could include:

a) Demonstration of engineering adaptation on site: at least one demonstration section will be established in each one of the three countries. This creates the opportunity for local practitioners to become involved in site investigations, the identification of appropriate adaptation options (and the reasoning behind those), the design phase, the construction phase (with due attention devoted to quality of construction), and subsequent monitoring and evaluation;

b) 'Soft' demonstrators to guide practitioners through the processes of, for instance:

    a. Identifying vulnerable districts and road links within those, using the vulnerability assessment framework developed in Phase 1 of the programme (with the necessary customisation), and capacitate them to apply this methodology on a wider scale; and

    b. Embedding 'climate adaptation' in road asset management systems so as to support prioritisation and decision-making based on a broader spectrum of attributes, in addition to present road conditions. This will also require road condition assessors to be trained to identify potential environment-related risks and threats within and outside the immediate road environment.

c) Development of a dedicated handbook and associated training material on all aspect related to "risk management and resilience optimisation for vulnerable road access", which could be

used as a basis for the training of public and private sector practitioners in how to address climate variability and change, and the implementation of a train-the-trainer programme.

The above summarises the primary needs and recommendations expressed by the Workshop participants. The Workshop Report contains additional specific items. These will be further analysed by the AfCAP Project Team and will inform the programming of activities to be carried out in Phase 2 of the Climate Adaptation programme.

7 Project Team

The project called for a team of professionals with proven track record in the professional areas of: climate and climate change assessments; risk and vulnerability assessments; road engineering and management, with a particular focus on both engineering and non-engineering adaptation options; and knowledge dissemination and capacity development. All of the members of the Project Team who worked on Phase 1 of the project were well qualified for carrying out their assignments given their accumulated previous experiences in similar types of projects. The members of the Project Team, as well as their Core Areas of responsibility, are indicated in the organisational chart shown below, while the panned and actual inputs in Phase 1 of the study are summarised in Table 2.

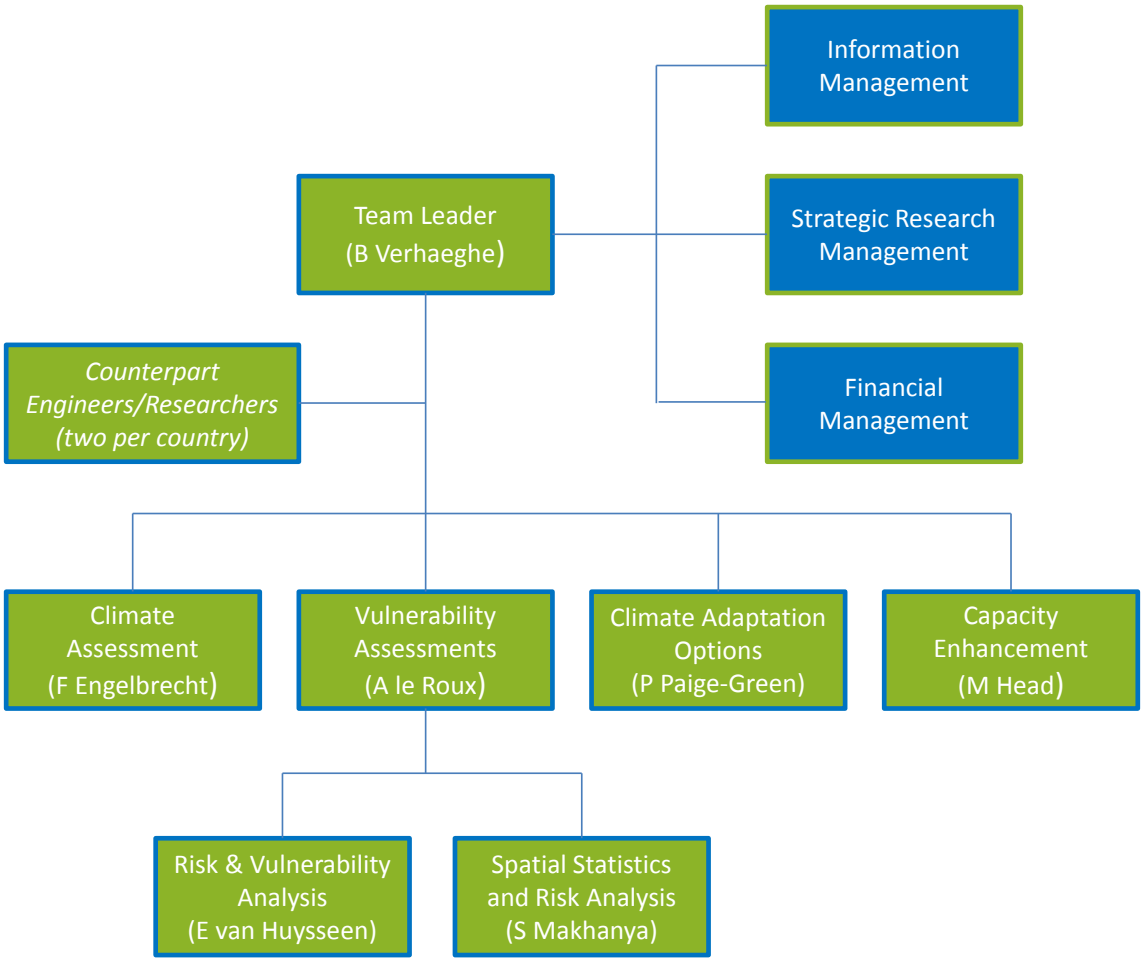


FIGURE 5: Project Organisational Structure

TABLE 2: Professional Inputs for Phase 1

Position Title	Team Members	Actual Inputs vis-à-vis Planned Inputs (in brackets)
Team Leader	Mr Benoît Verhaeghe	126 days (108 days)
Road Engineering Expert	Prof Philip Paige-Green	80 days (95 days)
Climate Expert	Prof Francois Engelbrecht	21 days (25 days)
Capacity Building Specialist	Mr Mike Head	45 days (45 days)
Senior Geo-Informatics Scientist (Vulnerability Assessments)	Mrs Alize le Roux	54 days (63 days)
Spatial Statistics & Risk Analysis Scientist	Mrs Sibusisiwe Makhanya	36 days (28 days)
Spatial Analysis & Profiling Specialist (Risk & Vulnerability Analysis)	Mrs Elsona van Huyssteen	4 days (14 days)
Six Counterpart Engineers/Researchers in three Countries	Ethiopia (ERA): • Ato Alemayehu Endale • Ato Deribachew Mezgebu Ghana (MRH/DFR): • Mrs Efua Akwetea-Mensah • Mr Edmond Balika Mozambique (ANE): • Mrs Raquel Langa • Mr Rogério Simione	Approximately 14 days on average per person (induction to project; site visits; workshops)
Additional resources deployed (CSIR):		
• Urban & Regional Planner	Mr Gerbrand Mans	13 days (-)
• Road Engineering Support	Mr Ashiel Rampersad	3 days (-)
• Strategic Research Manager	Dr Chris Rust	4 days (-)

The roles and responsibilities of the main team members with respect to project management were as follows:

- Benoît Verhaeghe (Team Leader):
  - Overall administration and contract (and subcontract) management
  - Planning and programming of the project
  - Risk identification and response planning
  - Manage and mitigate risk and issues
  - Direct, manage and control project work
  - Perform integrated change control
  - Validate and control scope
  - Control/manage schedule and costs
  - Perform quality assurance and quality control

- Ensure the Project Team's compliance with the quality plan, the risk management plan and the monitoring and evaluation plan
- Manage communication between the Project Team and ReCAP PMU and with relevant stakeholders in the region (particularly those in the three priority countries)
- Management of all Milestone deliverables, as well as newsletters, journal articles, conference papers and workshop reports

- Profs Philip Paige-Green and Francois Engelbrecht, Mrs Alize le Roux and Mr Mike Head (Core Area Leaders), supported by the Team Leader:
  - Maintain an appropriate project plan for each core area, inclusive of work breakdown structure, statement of work, sequence and interdependencies, budget, resource allocation and levelling, duration estimates
  - Establish, implement and maintain all project controls at Core Area level
  - Ensure compliance with project control standards and procedures
  - Report technical and financial progress to Team Leader
  - Identify and highlight variances ('red flags', risk factors) to the Team Leader, as well as propose mitigation actions
  - Perform quality assurance and quality control
  - Adherence to the quality plan, the risk management plan and the monitoring and evaluation plan
  - Ensure the timeous delivery of Milestone deliverables for each Core Area, as well as newsletters, journal articles, conference papers, site visit reports and workshop reports, on brief and on time
  - Contribute to the dissemination of project outputs.

8 Work Plan for Phase 1 – Planned versus Actual

The Work Plan for Phase 1, detailing all Work Packages and associated tasks/activities, is provided in Annex C. It shows the advisory inputs (in red), Milestones (in green), in-country workshops (in blue), in-country activities (in orange) and projects outputs (in grey; Milestone reports and other outputs such as Briefing Notes, workshop training material, journal articles and conference papers).

It also indicates the actual completion dates for each task/activity, which is marked by (**O**), and the additional time require to complete these tasks/activities, which are marked by (>>>).

Whereas the Inception Phase and the deliverables for Work Package A.1 ("climate variability") and WP A.2 ("climate projections") were completed as planned, as well as the Milestone Reports for WP A.3 ("Climate Threats Report" – Version 1) and WP A.4 ("Climate Adaptation Options Report"), delays in the completion of the in-country activities significantly impacted on the programme. These delays were mainly caused by the following, although the availability of some of the team members were a contributing (although lesser) factor:

1. Task A.4.4 ("Engagement with stakeholders in selected AfCAP countries"): Delays were experienced with the scheduling of stakeholder interactions with the three priority countries (Ethiopia, Ghana and Mozambique). In the case of Mozambique, the planned meetings had to be rescheduled twice, which then also impacted on the scheduling of meetings with the other two countries; and in the case of Ghana, the meetings had to be rescheduled in order to enable the project team to obtain their visas (i.e. letters of invitation received too late to process visas). The stakeholder meetings were eventually held on the following dates:
   - Mozambique: 11 July 2016, with follow-up meetings held on 12 July 2016 (*planned for between 10 and 23 June*);

- Ghana: 16 August 2016, with follow-up meetings held on 17 and 18 August 2016 (*planned for between 24 June and 7 July*);
- Ethiopia: 24 August 2016 (*planned for between 8 and 21 July*).

However, despite the delays experienced, all objectives set for this Task were achieved either during or shortly after the meetings held in the three countries.

2. Task A.5.2 ("Engagement with stakeholders in countries to identify and confirm project sites"): The candidate/targeted regions and roads identified by the countries were communicated to the Project Team on the following dates:

   - Ghana: 17 August 2016 (*planned for between 22 July and 4 August*);
   - Mozambique: 23 August 2016 (*planned for between 5 and 18 August*);
   - Ethiopia: 28 September 2016 (*planned for between 19 August and 1 September*).

3. Task A.5.3 ("Road investigations"): Further delays for visiting the identified roads were incurred as a result of: (a) roads becoming inaccessible as a result of flooding (Ghana), and (b) in-country political situation (Ethiopia; cancelling of site investigations while the Project Team was already in the country). As a consequence of the above, the actual site visits were undertaken on the following dates:

   - Mozambique: 12 to 16 September 2016 (*planned for between 22 July and 4 August*);
   - Ghana: 17 to 19 October 2016 (*planned for between 5 and 18 August*);
   - Ethiopia: 8 to 10 November 2016 (*planned for between 19 August and 1 September*).

The above delays have impacted on the drafting of the site visits reports and the submission of the *Recommendations for Phase 2* Milestone Report; the organisation of the in-country workshops and the submission of the Workshops Milestone Report, as well as on the submission of the Final Report.

The planned start dates and completion dates for the Milestone reports and for the other project outputs are shown in the table below:

TABLE 3: Planned and actual delivery dates for Milestone Reports and other project outputs

Main Deliverables	Original Contractual Due Dates	Contract Amendment Dates	Actual Dates
MILESTONE REPORTS:			
Inception Report	29 April 2016	29 April 2016	30 April 2016
Climate Threats Review Report	24 June 2016	24 June 2016	Report versions: 1st: 03 July 2016 2nd: 27 July 2016
Climate Resilience Adaptation Options Report (Guideline)	16 September 2016	16 September 2016	25 September 2016
Recommendations for Phase 2 Report	14 October 2016	18 December 2016	16 December 2016
Training Workshop Summary Report	N/A	17 February 2017	16 February 2017
Final Report	28 October 2016	28 February 2017	28 February 2017

Main Deliverables	Original Contractual Due Dates	Contract Amendment Dates	Actual Dates
OTHER PROJECT OUTPUTS:			
Academic Journal Paper	28 October 2016	28 February 2017	28 February 2017
Peer Reviewed Conference Paper	28 October 2016	28 February 2017	28 February 2017
Training Workshop Summary Report	N/A	17 February 2017	16 February 2017
Briefing Notes (for publishing on website)	N/A	N/A	Four submitted; one after the completion of each Milestone Report

9 Project Outputs

The main outputs produced by the Project Team can be obtained from the following links:

1. **Milestone Reports:**
   - ***Inception Report:*** http://www.research4cap.org/Library/CSIR-2016-ClimateAdaptation-BriefingNote-AFCAP-GEN2014C-v160512.compressed.pdf
   - ***Climate Threats Report:*** http://www.research4cap.org/Library/CSIR-Consortium-2016-ClimateChangeAdaptation-ClimateThreatsReport-AfCAP-GEN2014C-160908.compressed.pdf
   - ***Climate Adaptation Options Report:*** http://www.research4cap.org/Library/CSIR-Consortium_ClimateChangeAdaptation_OptionsReport_AfCAP_GEN2014C_v161027.compressed.pdf
   - ***Recommendations for Phase 2 Report:*** http://www.research4cap.org/Library/CSIR-Consortium-2016-ClimateAdaptation-RecommendationsReport-AfCAP-GEN2014C-v170201.pdf
   - ***Workshops held in Mozambique, Ghana and Ethiopia:*** http://www.research4cap.org/SitePages/Climate%20Adaptation.aspx
   - ***Final Report:*** http://www.research4cap.org/SitePages/Climate%20Adaptation.aspx
2. **Briefing Notes:**
   - ***Briefing Note 1:*** http://www.research4cap.org/Library/CSIR-2016-ClimateAdaptation-BriefingNote-AFCAP-GEN2014C-v160512.compressed.pdf
   - ***Briefing Note 2:*** http://www.research4cap.org/Library/CSIR_2016_ClimateAdaptation_BriefingNote2_AfCAP_GEN2014C_v161101.pdf
   - ***Briefing Note 3:*** http://www.research4cap.org/Library/CSIR-Consortium-ClimateAdaptation-BriefingNote3_AfCAP_GEN2014C_v161010.pdf
   - ***Briefing Note 4:*** http://www.research4cap.org/Library/CSIR-Consortium-ClimateAdaptation-BriefingNote4-AfCAP-GEN2014C-v170125.pdf

3. **Site visit reports (per country; adapted from the *Recommendations for Phase 2 Report*):**
    - ***Mozambique:*** email bverhaeg@csir.co.za
    - ***Ghana:*** email bverhaeg@csir.co.za
    - ***Ethiopia:*** email bverhaeg@csir.co.za
4. **Workshop reports (per country):**
    - ***Mozambique:*** email bverhaeg@csir.co.za
    - ***Ghana:*** email bverhaeg@csir.co.za
    - ***Ethiopia:*** email bverhaeg@csir.co.za
5. **Workshop presentations (customised presentations by country):**
    - ***Mozambique:*** http://www.research4cap.org/SitePages/Climate%20Adaptation.aspx
    - ***Ghana:*** http://www.research4cap.org/SitePages/Climate%20Adaptation.aspx
    - ***Ethiopia:*** http://www.research4cap.org/SitePages/Climate%20Adaptation.aspx

10 Key Results and Feedback from Stakeholders

10.1 ReCAP Log Frame

In the Inception Phase 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 D 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 1 April 2017 for a further 70 to 85 weeks, takes the end of the project target date to July 2018 (covering Milestone 3, or to mid-November (85 weeks) covering 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.

10.2 Workshop feedback

The Workshop held in Mozambique, Ghana and Ethiopia in late January and early February 2017 were considered successful. Overall, approximately 75 delegates participated in the workshops. The overall usefulness of the workshops were rated 78% in Mozambique and 96% in both Ghana and Ethiopia. The average of all evaluation scores were 80% in Mozambique, 84% in Ghana and 86% in Ethiopia. The processed workshop evaluation scores for the three workshops are provided in Annex E.

10.3 Key outcomes and feedback from stakeholders

The following are a list of key outcomes and feedback from stakeholders:

A. *Attention drawn to the challenges of climate threats and adaptation.*
   Phase 1 has successfully drawn attention to major adverse effects of climate to infrastructure and to consequential increased rural access problems. Stakeholders are looking for significant help and assistance in identifying risks and vulnerabilities, and solutions, both engineering and non-engineering, to render their rural road networks more climate resilient.
B. *Agreement that immediate actions are necessary.*
   Backlogs of damages resulting from extreme weather events are growing because of insufficient knowledge, methodologies and funding to address the issues.
C. *Support for receiving and implementing Adaptation Guidelines.*
   Universal and comprehensive guidelines are required on all aspects of climate adaptation, from incorporating climate change considerations in management goals and policies, through the identification of risks and vulnerabilities and the prioritisation of actions, to the adoption of adaptation measures and to monitor and evaluate their effectiveness.
D. *Welcoming of demonstrations to underpin Guidelines in years to come.*
   There is full agreement of long-term usefulness of demonstrations, but eagerness to implement adaptation programmes immediately.
E. *Requests for assistance to improve network resilience.*
   Stakeholders do not have sufficient knowledge and capacity to deal effectively with climate impacts, and are requiring methodologies that are practical and can be implemented almost immediately (also through embedment in asset management systems).
F. *Recognition that capacity to deal with adaptation is very weak.*
   Capacity development is a high priority, and will be a key aspect of Phase 2 focussing on all elements highlighted above. Capacity development should ideally be through the implementation of hands-on techniques (i.e. should try to minimise “classroom” training events).
G. *Need for mentoring as well as training.*
   Long-term technical and mentoring support has been requested. Train-the-trainer programmes should be implemented in Phase 2.

11 Next Steps: Recommendations for Phase 2

11.1 Aims and Objectives

The overall project aim remains unchanged. The aim is to move forward from previous AFCAP research and deliver **sustainable enhancement in the capacity of AFCAP partner countries** to reduce current and future climate impacts on vulnerable rural infrastructure. This is to be achieved through the research, and consequent uptake and embedment, at both policy and practical levels, of pragmatic, cost-beneficial engineering and non-engineering procedures based on the recognition of locally-specific current and future climate threats.

The overall project objectives also remain unchanged. They are as follows (quoted from the project's terms of Reference):

- *The fundamental research objective 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*
- *Capacity Building and Knowledge Exchange. 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.*
- *Uptake and Embedment 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 a solid basis for Phase 2 through research and knowledge exchange. A further aim of Phase 1 was to provide the basis for the implementation of demonstration sections in three countries, namely Ethiopia, Ghana and Mozambique, and to deliberate the guideline documents produced to date, as well as the recommendations for the implementation of demonstration sections, at workshops held in these three countries.

The primary focus of Phase 2 will be on the demonstration of appropriate adaptation methodologies and procedures, capacity building and knowledge exchange, and uptake and embedment of outcomes in especially the three priority countries (Ethiopia, Ghana and Mozambique) but also in the other AfCAP Partner Countries.

11.2 Scope of Phase 2

The following five distinct parts have been adopted for Phase 2, reflecting the programme's aim and objectives:

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.

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.

PART C: sustainable enhancement in the capacity of additional AFCAP partner countries

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

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.

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.

11.3 Methodology and Programme

The methodology for Phase 2 presented hereunder has been based on both the original Terms of Reference for the Project "Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa" and country-specific needs identified at the Workshops held in Ethiopia, Ghana and Mozambique.

The proposed methodology addresses the five Parts listed in Section 11.3. It has been structured as follows:

- **Part A** ("Demonstrators") consists of three Work Packages, one for each of the priority countries (Mozambique, Ghana and Ethiopia), and deals with the physical implementation of demonstration sections as well as "soft" demonstrators linked to vulnerability assessments and road asset management;
- **Part B** ("Capacity Building: three countries) consists of six Work Packages, addressing targeted engagements with the three countries; the development of a Handbook on the climate adaptation of rural access roads and associated training materials; training workshops on the Handbook as well as on-site training linked to the demonstration sections. It also makes provision for the translation of key documents in Portuguese.
- **Part C** ("Capacity Building: other AfCAP Parner Countries") consists of four Work Packages starting off with a situational and needs analysis of the countries and followed up with a series of regional training events (linked to the workshops in Part B), regional stakeholder meetings, participation of the Project Team in regional seminars/conferences, and the continued development of the website and associated discussion forum as a means for wider dissemination of the project's outputs and outcomes.

- **Part D** ("Embedment and Uptake") focusses on addressing the particular needs in both the three priority countries and other AfCAP Partner Countries, with respect to policies, strategies, plans, norms, standards, manuals and guidelines, by the provision of advice and technical assistance.
- **Part E** ("Recommendations for Phase 3") is embedded in the programme component "Inception Phase and Management".

The proposed programme is provided in Annex F (in A3 format). It spans a period of 84 weeks, whereas the original Terms of Reference indicated a duration of approximately 70 weeks. Because of the multitude of activities to be undertaken and complexities associated with those, and also to account for possible delays during the execution of the programme, it is proposed that the programme be extended to 84 weeks.

The programme in Annex F is colour coded as follows:

- Phase 2 Scope Activities
- Extra Over Items (included in budget)
- Deliverables
- Demonstrations
- Prospective funding by World Bank
- Prospective funding by EU/AfDB

The "Phase 2 scope activities" (light blue) as well as the "Demonstrations" (in yellow) are those that are considered to be in line with the original Terms of Reference for the Project. The activities shown in red are in addition to the original scope, but included in the revised scope of the project. The deliverables are shown in black. It is proposed that a significant number of these "reports" be incorporated in the *Quarterly Progress Reports* and *Biannual Country Reports*. Activities shown in green and orange are those that involve, and could potentially be funded by, other Development Partners.

Following discussions held with ReCAP during March 2017, the proposed methodology and programme will form the basis for discussions with the three priority countries and with the other AfCAP Partner Countries in April 2017.

In the sections that follow, an outline of the proposed activities to be undertaken in each of the Parts and associated Work Packages are presented in tabular format.

11.3.1 Inception Phase and Management

1	**Project Initiation communication** Communication with all stakeholders and with the he ReCAP community on the scope and programme of Phase 2 through both direct contact and through a Briefing Note.
2	**Programme and Work Plan development** (to be initiated in April 2017): • Discussions with ReCAP on the proposed scope and methodology • Discussions with Priority Countries to further refine programmes and outputs • Discussions with additional AfCAP country representatives to refine inputs • Discussions with other Development Partners to refine inputs.
3	**Finalisation of programme and plan** To be incorporated into the Inception update.
4	**Inception Update Report** To map out the full programme of activities, inclusive of timelines and deliverables, and to address specific items identified during the Inception period not covered elsewhere.
5	**Progress Reports** To be submitted quarterly and to include additional deliverables identified in the work plan.
6	**Country Reports** Specific reports on progress in the priority countries, submitted biannually.
7	**Contract completion report** Final report, including recommendations for Phase 3.

11.3.2 PART A: Demonstrations

Work Package A.1: Mozambique Demonstration Programme

A.1.1	**Demonstrate appropriate engineering and non-engineering adaptation procedures** • **Gaza Province Demonstrations** – R448: Chokwe to Macarretane. Road is classified as being vulnerable based on the both the AfCAP and World Bank screening tools – Rehabilitation financed by the World Bank – Concept designs completed, contract awarded to contractor – Engagements with ANE and the World Bank to be held in March 2017 (variation orders may be required). • **Zambesi-Nampula District Programme**, linked with EU the 11th European Development Fund (EDF) Programme: – Nametil to Angoche road in Nampula Province – Initial field visit to be undertaken in April/May 2017 – AfCAP's support requested to supplement the Terms of Reference for the design consultants.

A.1.2	**Site investigations and detailed design** Road R448 (Chokwe to Macarretane): – Contractor to complete detail designs by May 2017; establishment on site: March 2017. – Detailed (alternative) designs for climate resilience urgently required. – Detailed site investigation and designs for demonstration sections planned to be completed by May 2017. The following tasks will be performed (R448): – Revisit the road sections identified in Phase 1, apply the ADB adaptation methodology (customised for low-volume access roads), and conduct rigorous site investigations with the objective of gathering sufficient data to produce detailed designs and plans for the implementation of engineering and non-engineering adaptation options. – Support the road authority (and its appointed consulting engineering team), where appropriate), with: (a) Drafting of project specifications for the demonstration sites; (b) Producing bills of quantities, inclusive of an indicative costs, based on item costs derived from projects completed or to be initiated in close vicinity of the planned demonstrations. – A Design Report will be produced (target date: Week 8). The activities on the Nametil to Angoche road in the Nampula Province will be limited to a site investigation (April/May 2017) and a risk and vulnerability assessment during weeks 30 to 36. The objectives of the risk and vulnerability assessment is to understand the differences between the vulnerability ranking/rating done by the World Bank and the approach used by the AfCAP Project Team, and to build capacity within ANE (training in vulnerability assessments and prioritisation). Detailed site investigations and the identification of adaptation options for this road may have to be conducted but these will require further discussion between AfCAP and the EU, also to discuss funding arrangements. The purpose of these investigations and the adaptation design would be to amplify the Terms of Reference for the consulting engineer to be appointed for the design.

A.1.3	**Construction of the demonstration sections**
	
	The following tasks will be performed (R448):
	– Provision of support during construction, including:
	  ○ Meeting with the delivery team (road authority, consulting engineer, contractor, material suppliers) to discuss aspects related to the design, construction and quality assurance of the demonstrations from the perspective of climate resilience.
	  ○ Assist with implementation of quality control and data capturing mechanisms to set a robust baseline that will be used as a reference for future monitoring.
	  ○ Assist with setting up a regime of quality control testing, augmented by quality assurance testing witnessed by the AfCAP Project Team.
	  ○ Technical support to the contractor, consultant and road authority if and when required.
	– Production of an As Built Report (target date: Week 26).

	Although shown on the work plan in Annex F, it is unlikely that construction on the Nametil to Angoche road in Nampula Province will be initiated before the completion of Phase 2 of this project based on the discussions held with the EU.
A.1.4	**Monitoring and evaluation** – A specific monitoring and evaluation plan for the R448 demonstration site will be developed and implemented. – Interactions with local authorities and rural communities prior, during and after the interventions will take place to capture relevant data on the impact of the interventions on their socio-economic well-being, inclusive of changes in traffic patterns (by volume and type).
A.1.5	**Demonstration of appropriate non-engineering adaptation options** 'Soft' demonstration procedures will be developed and implemented to guide practitioners through the processes of, for instance: – identifying vulnerable districts and road links within those, using the vulnerability assessment framework developed in Phase 1 (with the necessary customisation based on World Bank and EU screening tools), and develop local capacity to apply this methodology on a broader scale; and – embedding 'climate adaptation' in road asset management systems so as to support prioritisation and decision-making based on a broader spectrum of attributes, in addition to present road conditions. This will also require road condition assessors to be trained to identify potential environment-related risks and threats within and outside the immediate road environment.

Work Package A.2: Ghana Demonstration Programme

A.2.1	**Demonstrate appropriate engineering and non-engineering adaptation procedures** • **Tamale Demonstrations:** – Identified road: Tampion to Tidjo – Concept designs for entire length of the road completed by DFR – Need discussion between MRH, DFR and AfCAP Project Team on scope and timeline – Construction can only be initiated after rainy season (from September onwards) • **Alternative Surfacings for Steep Hill Sections**, AfCAP funded project in Ghana (GHA2065B): – Need was identified at the Ghanaian Workshop for an additional demonstration section in hilly terrain. – Recommendation was made to use above AfCAP project to implement climate adaptation options for access roads located in hilly terrain. – Road Engineering Specialist of the AfCAP Climate Adaptation project team to interact with team members of the AfCAP Project on Alternative Surfacings for Steep Hill Sections.

A.2.2	**Site investigations and detailed design** Tampion to Tidjo Road (Tamale): – Concept designs for demonstrations sections completed by Project Team. – Detailed (alternative) designs for climate resilience required to support planning. – Detailed site investigation and designs for demonstration sections planned to be initiated in Week 11 with target completion date of Week 18. Tasks to be performed will be similar to those of Activity A.1.2 – A Design Report will be produced (target date: Week 18)
A.2.3	**Construction of the demonstration sections** – Tasks to be performed on the Tampion to Tidjo road will be similar to those described in Activity A.1.3. – Construction of demonstration sections is planned to be initiated in Week 25 with a completion date of Week 44. – An As Built Report will be produced.
A.2.4	**Monitoring and evaluation** – A specific monitoring and evaluation plan for the Tampion to Tidjo demonstration site will be developed and implemented. – Interactions with local authorities and rural communities prior, during and after the interventions will take place to capture relevant data on the impact of the interventions on their socio-economic well-being, inclusive of changes in traffic patterns (by volume and type).
A.2.5	**Demonstration of appropriate non-engineering adaptation options** 'Soft' demonstration procedures will be developed and implemented to guide practitioners through the processes of, for instance: – identifying vulnerable districts and road links within those, using the vulnerability assessment framework developed in Phase 1 (with the necessary customisation based on World Bank and EU screening tools), and develop local capacity to apply this methodology on a broader scale; and – embedding 'climate adaptation' in road asset management systems so as to support prioritisation and decision-making based on a broader spectrum of attributes, in addition to present road conditions. This will also require road condition assessors to be trained to identify potential environment-related risks and threats within and outside the immediate road environment.

Work Package A.3: Ethiopia Demonstration Programme

A.3.1	**Demonstrate appropriate engineering and non-engineering adaptation procedures** • **Tullu Bollo to Kela Road:** – Concept designs for demonstration sections have been completed – Need discussions between ERA and AfCAP Project Team on scope and timeline – Construction can only be initiated after the rainy season (from September)

	• **Retrofitting existing road network (URRAP):** – Discussions required with ERA and World Bank to identify the need for the inclusion of sample roads in the AfCAP project, and on the scope, timeline and cost if sample roads were to be included. • **Somali Region:** – Request that a vulnerable access road from this Region be included in the demonstration programme to represent dessert conditions impacted by flash floods during the rainy season. – Discussions to be held between ERA and the AfCAP Project Team to identify candidate roads in this Region. – Period between Week 18 and Week 24 earmarked for site visits to candidate roads (first-level assessment of problem areas and identification of tentative adaptation measures).
A.3.2	**Site investigations and detailed design** Tullo Bollo to Kela Road: – Concept designs not yet completed for entire road link; – Detailed (alternative) designs for climate resilience required to support planning; – Detailed site investigation and designs for demonstration sections planned to be initiated in Week 13 with target completion date of Week 26. Retrofitting existing road network (URRAP): – Scope to be agreed on between ERA, World Bank and AfCAP, as well as funding arrangements (i.e. not included in current budget of the project); – Period between Week 37 and Week 44 earmarked tentatively for site investigations and the identification of adaptation options, to be followed up with detailed investigations and proposals for retrofitting, and potential implementation, during the period between Week 53 and Week 84. Somali Region: – No demonstration projects have been planned for the Somali region. Tasks to be performed as part of the detailed design will be similar to those of Activity A.1.2, and will include the production of a Design Report for the demonstration projects on the Tullo Bollo to Kela Road (target date: Week 26).
A.3.3	**Construction of the demonstration sections** – Tasks to be performed on the identified demonstration sections (Tullu Bollo to Kela Road, and possibly the URRAP roads) will be similar to those described in Activity A.1.3. – Construction of demonstration sections on the Tullu Bollo to Kela Road planned for Week 25 to Week 44 – As Built Reports will be produced (target date: Week 44).

A.3.4	**Monitoring and evaluation** – A specific monitoring and evaluation plan for the each demonstration site will be developed and implemented. – Interactions with local authorities and rural communities prior, during and after the interventions will take place to capture relevant data on the impact of the interventions on their socio-economic well-being, inclusive of changes in traffic patterns (by volume and type).
A.3.5	**Demonstration of appropriate non-engineering adaptation options** 'Soft' demonstration procedures will be developed and implemented to guide practitioners through the processes of, for instance: – identifying vulnerable districts and road links within those, using the vulnerability assessment framework developed in Phase 1 (with the necessary customisation based on World Bank and EU screening tools), and develop local capacity to apply this methodology on a broader scale; and – embedding 'climate adaptation' in road asset management systems so as to support prioritisation and decision-making based on a broader spectrum of attributes, in addition to present road conditions. This will also require road condition assessors to be trained to identify potential environment-related risks and threats within and outside the immediate road environment.
A.3.6	**Resilience of the Ethiopian Road Network (World Bank)** – The World Bank intends to launch a programme to create awareness on climate vulnerability of roads and integrate climate resilience in road policy. – Many of the elements proposed in this programme overlap with those of the AfCAP programme on climate adaptation (e.g. improvements to current engineering practices, capacity building and development of guidelines – note: World Bank programme caters for all roads). – There is an opportunity for cooperation between the World Bank and AfCAP in order to minimize duplication of effort. – As from 1 April 2017 Phase 2 of the AfCAP programme will work in cooperation with the World Bank to facilitate common goals in climate resilience for the Ethiopian road network.

11.3.3 PART B: Capacity Enhancement (three countries)

WP B.1	**Engagement with Key Stakeholders in the three countries** – AfCAP Partner Countries identified the need for a briefing session at key strategic level to create awareness on the climate vulnerability of their road network and especially their low-volume rural access roads. – Purpose of the briefing sessions is to: o Create awareness on the effects of climate on road infrastructure, and high level impacts thereof on not only rural accessibility, but also on the (recurring) costs of maintenance and reinstatement of access, especially after the occurrence of severe climate events; o Provide information on the scope of the AfCAP study and what it aims to achieve, especially with respect to Phase 2 and the in-country activities planned; o Secure support for the activities to be undertaken in Phase 2. – Interactions with the Key Stakeholders are planned between Week 11 and Week 22. Briefing Notes will be prepared and distributed to the Stakeholders prior to the meeting.
WP B.2	**Generic (Regional) Handbook on Climate Adaptation** – A dedicated Handbook will be developed dealing with all aspect related to "risk management and resilience optimisation for vulnerable road access". – This Handbook could be used as a source document for the training of public and private sector practitioners. – Scoping of the Handbook will be initiated in Week 1, with a first version ready to be used for training purposes by Week 10. – Possibility for the production of the Handbook in **modules** (to assist in updating and augmentation) will be explored. – Further improvements to the Handbook will be done between Week 22 and Week 50, based on feedback received from participants (WP B.3). Also, additional modules covering design and implementation of demonstrations will be completed by Week 30 and Week 50, respectively.
WP B.3	**Training modules and training workshops** – Training material based on the Handbook (WP B.2) will be compiled by Week 10. – Training programmes for the three priority counties will take place from Week 10 to 22 and again from Week 52 to 62. The exact dates and scope of the training workshops will be discussed and agreed with the host countries. However, the following is proposed: o The training programme from Week 10 to 22 will consist of general training aimed at practitioners from both the public and private sector. o The training programme from Week 52 to 62 will be focusing on training the trainers. o Development Partners will be invited to both series of training workshops. – Preparations for the training workshops will be initiated in Week 1.

WP B.4	**Translations of documents and materials** – As per the request of Mozambique, all essential documents, including the Handbook and training material, will be translated in Portuguese. – A provisional amount has been included in the budget for Phase 2.

WP B.5	**On-site training**
	– On-site training will be provided on:
	  ○ Condition and vulnerability assessments, and the selection of appropriate adaptation options; and
	  ○ Implementation of the adaptation measures.
	– The on-site training will coincide with the following activities planned for the demonstrations:
	  ○ Site investigations and detailed design (Activities A.1.2, A.2.2 and A.3.2); and
	  ○ Construction of the demonstration sections (Activities A.1.3, A.2.3 and A.3.3).
	– The training will be aimed at district managers/engineers, but other interested parties (e.g. private sector consultants) would be equally welcome to participate.

WP B.6	**Peer-reviewed journal articles and conference paper submitted** – At least four journal articles or peer-reviewed conference papers are planned for Phase 2. – Peer-reviewed conference papers will be produced for regional conferences (e.g. T^2 Conference).

11.3.4 PART C: Enhancement of capacity in additional AfCAP countries

WP C.1	**Identification of priorities by engagement with AfCAP Partner Countries**
	– Prioritise capacity development needs related to the subject area of this study by means of:
	  ○ Capturing and analysis of information obtained at regional events (i.e. stakeholder meeting to be held in April 2017 and T^2 Conference to be held in May 2017);
	  ○ Analysis of results obtained from a survey directed to main stakeholder(s) in each of the AfCAP Partner Countries.
	– Identify gaps and solutions to bridge these gaps (e.g. as part of the development/improvement of the Handbook and associated training material, the implementation of regional training events, or by other means identified by country stakeholders).
	– The needs identification process will be initiated in Week 1 (Stakeholder Meeting), with regular hold and check points along the 84-week timespan planned for Phase 2 to verify whether expectations are being met.

WP C.2	**Capacity development events**
	– From the perspective of capacity development, AfCAP Partner Countries' participation at events such the ones listed below will be encouraged:
	  ○ Stakeholder meeting to be held in early April 2017;
	  ○ T^2 Conference to be held in May 2017 (and other conferences/ seminars held regionally featuring the project's subject area);
	  ○ Climate Adaptation related training workshops to be held between weeks 12 and 22 (general training workshops), and again between weeks 52 and 62 (train-the-trainer workshops) in Mozambique, Ghana and Ethiopia.
	– An additional Stakeholder Meeting related to the theme of this project is planned for November 2017, while another potential stakeholder meeting could be held around May or June 2018 (to be confirmed).
	– In the AfCAP project's budget allowance has been made for three representatives from each of the AfCAP Partner Countries (apart from the three workshop host countries) to attend one two-day training workshop that is planned to be held between Weeks 11 and 22, as well as a three-day train-the-trainer workshop planned to be held between Week 51 and 62 in the host country that is geographically closest to their country.

WP C.3	**Regional seminars** – Regional seminars/conferences that are aligned with the subject area of this project will be identified. – The organisers of these events will be contacted to explore whether part of the proceedings of the seminar/conference could be devoted to issues related to climate adaptation. – The Project Team will support the organisers and contribute to the programme (e.g. facilitation, presentations).

WP C.4	**ReCAP Website**
	– The Project's webpage on the ReCAP website is an important instrument for disseminating knowledge and sharing information.
	– The project's webpage will be updated on a regular basis with new information, which will include:
	  ○ Handbook and associated training material
	  ○ Project reports;
	  ○ Briefing Notes;
	  ○ Workshop reports, including presentations.
	– The Project team will also manage the discussion forum and user group, and make proposals to improve both the access to and usefulness of the discussion forum (e.g. by introducing a "frequently asked questions" posting on the discussion forum).

11.3.5 PART D: Embedment

WP D.1	**Review of policies, strategies and plans**
	– The objective of this Work Package is to identify those areas where the Project Team can provide optimal support and technical advice to road authorities in order to achieve the necessary uptake and subsequent embedment of climate adaptation in, for instance:
	  o Policies, strategies and plans;
	  o Norms and standards;
	  o Guidelines and manuals.
	– This comprehensive review will be undertaken for each of the targeted countries (Ethiopia, Ghana and Mozambique), whereas a more general review will be undertaken for the other AfCAP Partner Countries in order to identify common threads between these countries.
	– The reviews will be based on the outcomes of the workshops held in Phase 1, the stakeholder meetings, desktop studies and engagement with stakeholders in each of the countries.
	– The outcomes of the above will be synthesised and will inform the scope and nature of technical assistance the countries will require. An action plan, supported by the necessary evidence, will be developed and submitted to ReCAP and country stakeholders for their appraisal and approval.
	– The above activities will be initiated in Week 1, with the aim to have the action plan approved by Week 14. This plan will be reviewed and updated biannually.

WP D.2	**Provision of advice and technical assistance** – The action plan developed in Work Package D.1 will inform the activities to be undertaken to maximise uptake and embedment in particularly the three priority countries but also in the other AfCAP Partner Countries. – The activities will span across a range of levels, from informing national policies, through regional and district planning, down to practical guidance on adaptation delivery at rural road level. – Case studies on 'best practices' will be produced and will be uploaded to the project webpage on the ReCAP website. – Although preliminary work will be done prior to Week 14 (e.g. auctioning some of the recommendations from the workshops held in January/February 2017), formal implementation of the action plan will be initiated in Week 15 and will span across the full duration of the project. – Progress on uptake and embedment will be reported in the quarterly Progress Reports as well as in the Biannual Country Reports.

11.4 Planned deliverables

The planned deliverables for Phase 2 will consist of a series of reports presenting progress towards the realisation of the project objectives and results achieved. The main reports are:

1. Inception Report (Month 1)
2. Quarterly Progress Reports (Months 3, 6, 9, 12 and 15)
3. Biannual Country Reports (Ethiopia, Ghana and Mozambique – Months 6, 12 and 18)
4. Contract Completion Report (Month 19)
5. Design Reports; As Built Reports; and Monitoring and Evaluation Reports – for all the demonstration sections (as per the proposed Work Plan in Annex F)
6. Climate Adaptation Handbook and associated training material (First version by Month 3)
7. At least one Journal Article and one peer-reviewed Conference Paper (but aim for four in total)

All other outputs (e.g. Briefing Notes; workshop/training reports; Action Plans and progress on uptake and embedment; Case Studies) will either be uploaded to the Project's webpage on the ReCAP Website, or embedded in the Progress and Country Reports.

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Annex A: Abstracts of Conference Paper and Journal Article

Conference Paper:

Abstract submitted to the International Conference on Geology, Mining, Mineral and Groundwater Resources of Sub-Saharan Africa: Opportunities and Challenges Ahead & IAEG-Africa Regional Meeting, July 2017, Livingstone, Zambia. Draft paper has been prepared.

Assessment of road Infrastructure for climate adaptation

P Paige-Green

Abstract
The impact of climate change on roads will require that vulnerabilities are identified and adaptations made to minimise the potential damage to the road infrastructure. These climate changes include changes in temperature and precipitation, increased windiness, sea-level fluctuations and the likely occurrence of increased numbers ad frequencies of extreme events. Currently, for road management and maintenance and rehabilitation planning purposes, visual condition assessments of the road network are usually routinely carried out at specified frequencies. These normally look at the road condition, classifying problems such as cracking, deformation, rutting, potholing, etc. by degree and extent to prioritise and budget for follow-up management operations. Generally, only the road carriageway area is assessed. It is, however, necessary to add to this information to provide the required inputs for climate resilience assessments and the implementation of adaptation techniques. This paper describes the nature and collection of this type of data, which is normally not part of the routine data collection. This includes issues such as erosion, problem soils, drainage from the road and its near environment as well as from outside the road reserve, instability of embankments and cuttings, construction issues and maintenance problems. For expedience and to minimise costs, this should be done during the routine visual condition assessments, by the assessment teams or others trained specifically for the purpose. Based on the typical problems expected, the assessments are probably best done by engineering geologists. A standard form for recording the data is provided.

Conference Paper:

Abstract submitted to the International Conference on Geology, Mining, Mineral and Groundwater Resources of Sub-Saharan Africa: Opportunities and Challenges Ahead & IAEG-Africa Regional Meeting, July 2017, Livingstone, Zambia. Paper has not yet been prepared.

The effects of climate change on road infrastructure

P Paige-Green

Abstract:
There is incontrovertible evidence that the earth's climate is changing. This may be for the better in some areas but will mostly be detrimental to low volume rural roads in Africa. These effects will be predominantly related to changes in temperature and precipitation, the influence of greater frequencies and degrees of extreme precipitation events and extended hot and dry periods, potentially longer drought periods with concomitant increases in windiness and wild-fire risks and sea-level rises with larger storm surges. Research into these climatic effects on the existing and proposed road infrastructure is highlighted, identifying the potential problems related to each climate attribute (stressor). Each potential problem will require specific adaptation solutions to increase the resilience of the road network to the climatic changes. Based on several investigations of roads recently damaged by climatic influences in four sub-Saharan countries, numerous necessary adaptation requirements have been identified and measures to construct them proposed. This paper summarises the typical problems expected and highlights some of the proposed appropriate adaptation measures.

Journal Article:

The Journal Article will be submitted to Jàmbá: *Journal of Disaster Risk Studies*[3]. Jàmbá *is an influential, frequently cited, accredited, peer reviewed and Open Access journal published since 2006.* Jàmbá *(meaning disaster in Yoruba) is a journal in the field of disaster reduction, aimed at serving as a platform for discussion and debate in this relatively new field of study.*

A framework for assessing the vulnerability of rural access roads to a changing climate

A le Roux, S Khuluse-Makhanya, P Paige-Green, B Verhaeghe, F Engelbrecht

Abstract
Communities in Africa are worst affected by climate disasters in part due to high socio-economic vulnerability and natural resource dependency. Climate resilient road infrastructure in rural areas will be critical for improving the quality of lives by enabling sustainable enhancement of economic productivity and competitiveness in rural areas through access. A geospatial road infrastructure risk and vulnerability assessment method is developed as a tool to guide the selection of adaptation options for constructing and maintaining rural roads to reduce the impacts of climate variability. The method consists of a data collection and pre-processing phase, an assessment of physical exposure of the road network and an assessment of road criticality as a function of community access. Mozambique was chosen as a study area for applying the method. Currently nearly 70 % of districts in Mozambique are highly vulnerable due to frequent exposure to severe floods and low accessibility due to inadequate road network coverage and poor road conditions. The most vulnerable districts are located in the central, eastern and southern parts of Mozambique. In the future, downscaled climate simulations under a low mitigation scenario indicate that pronounced rainfall increases and cyclone activity in northern Mozambique are more likely while southern region is expected to become drier. Therefore in the future, the vulnerability of low volume access roads to the impacts of a wetter climate will affect the already vulnerable central coastal belt north of Beira and extend to the provinces of Nampula, Zambezia and Cabo Delgado.

[3] Website: http://www.jamba.org.za/index.php/jamba

Annex B: Questionnaire responses

B.1 Botswana

What are the main concerns that your country has about the impacts that current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

Knowledge is key to turning climate change from a challenge into to an opportunity.

From reference in Question 5: Current transport facilities such as storm water drainage systems due to climate change and rainfall trends cannot continue as they pose a threat to sustainable development. Rainfall in Botswana has up surged slightly over the past years and more so in summer than winter. Annual total rainfall has risen by approximately with little change. Palapye is one of the areas in Botswana that has suffered serious impact due to floods and has a great record of floods since 1995, then followed 2000, 2013 and 2016 and these events has resulted to massive destruction of transport facilities such as storm water drainage systems.

Is anything currently being done in your country to assess and/or address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

Research on causes and how to mitigate the effects of climate change are on-going.

If nothing is being done, why not and what have been the consequences up to now?

Not applicable.

If already experienced the consequences, how have these impacted on budget allocations for construction, maintenance and emergency responses?

Some government projects were shelved or adjusted to adapt to change in climate effects

If you are aware of guidelines that have been produced or studies that are currently being conducted/planned in your country (e.g. vulnerability assessments, adaptation studies), can you please list them and provide references as to where more information can be obtained?

Paper by A.S. Oladele, A.F. Faghamighe, T.M. Bafitlhile, "Modelling Climate Change Effects on Sustainable Transport Facilities through Time Series and Rainfall Trend Analysis of Palapye - Botswana".

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

Emerging economies are rapidly increasing research output associated with the development of new technologies in climate change mitigation – such as renewable energy and smart grids.

B.2 Ghana

What are the main concerns that your country has about the impacts that current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

Ministry of Transport:

Economic Impact:

Climate change and Climate variability will directly affect rural road infrastructure and rural accessibility in several ways. High temperatures will cause roads to easily develop cracks within a short period after their construction. Furthermore, higher temperatures combined with increased solar radiation may reduce the life of asphalt road surfaces. Additionally, high precipitation will allow new roads to easily develop potholes while existing potholes will deepen fast. Rising river levels can also flood gravelled and unpaved roads adjacent to the river shore.

Social impact:

Poor roads resulting from huge potholes can lead to road accidents and delay the transport of foodstuffs and other goods across the country. Poor road can also delay in accessing health care which can also result in deaths. Poor roads can lead to more fuel consumption which can result in negative environmental impact (Emissions).

Department of Feeder Roads:

(i) Potential reduction in rural accessibility;

(ii) Destruction of current road drainage assets by floods.

Is anything currently being done in your country to assess and/or address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

None

If nothing is being done, why not and what have been the consequences up to now?

Ministry of Transport:

- High maintenance costs
- Reduction of life span of rural roads
- High cost of living in rural areas

Department of Feeder Roads:

The main reason for our inability to assess and address the consequences is the lack of systems and procedures to estimate and establish the actual impact of changes in the climate on the rural road infrastructure. Budget is also an issue.

If already experienced the consequences, how have these impacted on budget allocations for construction, maintenance and emergency responses?

Ministry of Transport:

The impact has reduced the budget allocation for construction of new roads, shifting attention to maintenance funding.

Department of Feeder Roads:

Although no direct assessment of the impact of climate change has been done, recent effect of severe rainfall patterns on rural roads has impacted highly on the maintenance cost of rural roads. Additionally, the cost and number of emergency road works have increased considerably. The road maintenance budget has however not improved over the years. The good news is that the road fund's major source of funding, i.e. petroleum taxes, has increased and it is hoped that, moving forward, the road Maintenance budget will see some improvement.

If you are aware of guidelines that have been produced or studies that are currently being conducted/planned in your country (e.g. vulnerability assessments, adaptation studies), can you please list them and provide references as to where more information can be obtained?

Ministry of Transport:

No

Department of Feeder Roads:

The Ghana Meteorological Services Department has been contracted by the Ministry of Roads and Highways to update the Rainfall Intensity Duration Curves for the Country with financing by the World Bank. The Project is at the Inception stage.

We are not aware of any additional studies.

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

Ministry of Transport:

In this regard, research questions that arise are:

(a) What is the nexus between climate change and road infrastructure?

(b) What is the economic and social cost of climate change on road infrastructure?

Department of Feeder Roads:

(a) Wash-off of culvert embankments and sometimes a whole culvert is carried away by the flash floods, especially in the Northern part of the country.

(b) A more robust method of flood estimation, taking into consideration, Climate Change has to be established.

B.3 Malawi

What are the main concerns that your country has about the impacts that current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

We have seen over the years an increase in flash flood incidences that have greatly damaged our road infrastructure more especially our rural roads. Most of the rural roads are not properly designed and constructed, and as a result they do not have enough and adequate drainage structures. The damaging effect of flash floods has also been made worse by the deforestation in the country. Deforestation has led to heavy run-off and siltation.

Prolonged dry spells results in loss of moisture on the earth roads and hence during grading and reshaping exercise there is lack of compaction as there is no natural moisture on the road to aid

compaction by passing vehicles hence resulting in having a lot of loose soils, the loose soils create dust pollution on the roads and becomes a health hazard. In order to overcome this problem, grading or reshaping has to be done with mechanized watering and compaction, hence making the whole exercise to be more expensive.

Is anything currently being done in your country to assess and/or address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

The Department of disaster management affairs (DODMA) in the office of the Vice President is currently coming up with guidelines that will lead to design of roads and structures that are disaster resilient especially during periods of floods. This exercise is being done in collaboration with all stakeholders in the construction industry.

If nothing is being done, why not and what have been the consequences up to now?

Not applicable.

If already experienced the consequences, how have these impacted on budget allocations for construction, maintenance and emergency responses?

The country experienced one of its worst floods in recent history in January, 2015, this resulted in loss of a lot of road infrastructure that resulted in road sections and bridges being washed away or partially damaged. This was as a result of the fact that until now our roads and structures have not been built to disaster resilience in mind.

The normal budget could not cover for all the recovery costs, therefore assistance was sought from donors to finance the recovery costs. The major financer was the World Bank which came with a package of $24 million for the rehabilitation of roads and bridges that were affected by the floods.

If you are aware of guidelines that have been produced or studies that are currently being conducted/planned in your country (e.g. vulnerability assessments, adaptation studies), can you please list them and provide references as to where more information can be obtained?

The Department of Disaster Management (DODMA) under the Malawi Flood Emergency Recovery Project (MFERP) is currently producing guidelines for disaster resilient structures. For more information contact Mr James Chiusiwa [chiusiwaj@yahoo.com], Mr Samuel Gama [samuelgama2011@gmail.com], and/or Mr Stern Kita [stenkita@gmail.com] from DODMA. They may have latest information on the current status of the exercise.

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

Climate change will continue to play a big role in terms of accessibility of rural roads. With depleting sources of natural gravel it is important to change how we manage our rural roads. The best alternative though it is expensive is to look at the construction of low volume sealed roads as it provides for all year accessibility and reduces on maintenance costs. Soil stabilization mechanisms should also be explored.

The other critical issue is related to crossing of rivers where channels have been made wider leading to expensive bridges/culverts. There is therefore need to come up with inexpensive/ cheaper but long crossing structures.

B.4 Namibia

What are the main concerns that your country has about the impacts that current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

Namibia is commonly described as the most arid country in Sub-Saharan Africa with a climate that is normally highly variable.

The main concern of the Roads Authority with regard to the impacts that current climate variability and future change may have on rural accessibility and related road infrastructure is the predicted increasingly frequent occurrence of extreme climatic events. Severe floods and their destructive effects on road infrastructure are in this regard the greatest cause for concern.

Namibia's North Central region, an area characterised by a poorly developed drainage system in the form of a huge river delta, experienced heavy flooding in the 1960s and 1970s but for the following decades did not suffer from any abnormal rains or floods. In 2008 floods returned to these areas causing extensive flooding after several consecutive years of drought. Roads crossing streams and oshanas (shallow depressions underlain by an impervious calcrete layer) created backwater effects causing upstream flooding and many of the culverts appeared to be undersized. The floods strongly affected the urban and semi-urban lowland causing extensive damage to buildings and infrastructure. A year later, in 2000, floods were even more devastating.

The floods during 2008 and 2009 caused extensive damage to approximately 600km of road infrastructure in North Central Namibia. Several roads were overtopped, a number of drainage structures and gravel shoulders suffered damages and some road sections were washed away completely.

In 2011 Namibia declared its second national flood emergency in three years (after 2009) following extensive flooding in Namibia's Northern Regions (the North Central Region having been hit the hardest) with reportedly the heaviest rains in 120 years of recorded weather history.

In addition to the North Central Region also the North-Eastern and Southern Regions witnessed extreme rainfall events in recent years which devastated infrastructure and communities. More prominently in 2011 most of the country was affected through major flood damage to infrastructure.

Is anything currently being done in your country to assess and/or address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

The National Policy on Climate Change for Namibia (September 2010) states that in general the recognition of climate change and its associated risks is still fairly new in Namibia and therefore most of the climate change response planning and implementation is primarily reactive rather than proactive in nature.

Though some studies have been carried out in Namibia regarding the general impacts of climate change and possible adaptation measures (see Question 5) very little road accessibility and road infrastructure-related research has been conducted.

The Roads Authority initiated a Study on Flooding of Proclaimed Roads in North Central Namibia (August 2010) after the severe flood of 2008 with the following objectives:

(1) To comprehensively assess all factors that had an influence on the flood of 2008 and in particular the factors influencing the damage caused by it in order to estimate the financial and economic impact the damage had on the proclaimed gravel road infrastructure of the study area;

(2) To develop design and construction guidelines for roads and drainage structures, which could provide long-term solutions to mitigate the impact of flood waters on the gravel road network;

(3) To compile an implementation programme to improve the situation at the gravel road/oshana crossings considering different funding and risk scenarios;

(4) To advise the Roads Authority on aspects pertaining to the legal obligation of the Roads Authority and Ministry of Works and Transport as well as the road user under flood conditions.

If nothing is being done, why not and what have been the consequences up to now?

As indicated in the answer to Question 2, some research has taken place however much more proactive planning is needed with regard to the effects of future climate change and its effects on rural accessibility and road infrastructure.

The Roads Authority conducted the flood study research on the damage caused by the flooding in 2008 however further research has not been conducted on a long-term basis regarding the mitigation measures for extreme weather changes.

The consequences of the current reactive approach is that more money is spent on short-term mitigation measures, such as repair and rehabilitation of roads/drainage structures; as well as money spent by government on relocation and resettlement of flood victims in the area.

If already experienced the consequences, how have these impacted on budget allocations for construction, maintenance and emergency responses?

In response to the findings and recommendations of the Study on Flooding (2010) an Emergency Budget was created under the title "Maintenance of Roads: Flood Damaged Infrastructure Repair" to the amount of approximately N$500 million funder by government. Repair work under this programme is ongoing.

If you are aware of guidelines that have been produced or studies that are currently being conducted/planned in your country (e.g. vulnerability assessments, adaptation studies), can you please list them and provide references as to where more information can be obtained?

Studies include, but are not limited to, the ones listed below:

<u>Rural Accessibility and Road Infrastructure-related Studies</u>:

Study on Flooding of Proclaimed Roads in North Central Namibia, August 2010, Roads Authority (Reference: Ms J Mukuka, Divisional Manager (Acting), Network Planning & Consultation, Roads Authority, Email: mukukaj@ra.org.na, Tel.: +264 61 284 7072).

<u>Other Studies</u>:

Climate Change Vulnerability & Adaptation Assessment Namibia, March 2008, Ministry of Environment and Tourism (Reference: http://www.environment-namibia.net/tl_files/pdf_documents/strategies_actionplans/Climate%20Change%20V%20%26%20A%20Assessment%20Namibia.pdf);

National Policy on Climate Change for Namibia, September 2010, Ministry of Environment and Tourism (Reference: http://www.adaptation-undp.org/sites/default/files/downloads/namibia_nationalclimatechangepolicyfornamib.pdf);

Study on the Effects of Climate Change in the Cuvelai Etoshi Basin and Possible Adaptation Measures, Ministry of Agriculture, Water and Forestry, November 2010 (Reference:

http://www.iwrm-namibia.info.na/downloads/climate20change20in20cuvelai20etosha20basin202.pdf);

Impact of Climate Change in Namibia, M. Wilhelm, October 2012. (Reference: http://ir.polytechnic.edu.na/bitstream/handle/10628/381/Wilhelm.%20Masters.%20Impact%20of%20climate%20change%20in%20Namibia.pdf;jsessionid=74CFB416534503071D259272942E6BD2?sequence=1)

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

As described in the Project Briefing Note No. 1 it is projected that Southern African countries will experience temperature increases of 3 to 4 degrees in the 21st century as a result of climate change. It will therefore be important to establish the effect of the increasing temperatures on the performance of pavements as well as their maintenance. It has to be noted here that many of Namibia's rural access roads in the Northern Regions have been upgraded to bitumen standards in recent years.

B.5 Nigeria

Preamble:

The transport sector contributed about 2.4 % to real GDP in 2004, with road transport alone accounting for nearly 86 % of the transport sector output (World Bank, 2007). Road transportation accounts for more than 90 % of goods, services and passenger movements in Nigeria. This is due to a number of reasons. Firstly, Rail development, which current is around 3,557km in length and links 31 towns and cities, has remained almost stagnant since Nigeria's independence in 1960. Secondly, Nigeria's water transportation consisting of 8,600km of inland waterways in addition to the Atlantic coastline and harbours, has not been appropriately exploited for transportation. Thirdly, Air transportation, which has become popular in recent years, is considered elitist and not affordable by Nigerians. Fourthly, Government investments in transportation over the years have been skewed over the years towards road development with little attention to the development of other transport modes.

Nigeria's transport system consists of 200,000km of roads. This network comprises of a combination of Federal, State and Local Government roads. Out of this, 20 % are paved while 80 % are unpaved. The Federal trunk roads are the principal vectors of the system and have a total length of 34,100 km (17 %). State roads account for 32,900km (16 %) while the Local Government road system, which provides the bulk of rural transportation and accessibility, comprises of approximately 133,100km (68 %). For the Federal Trunk road network, 80 % are paved while 20 % are unpaved. For the State roads, the proportions are 35 % (paved) and 65 % (unpaved). For the Local Government roads, which are essentially rural/feeder roads that account for the bulk of rural transportation, only 2 % are paved while 98 % are unpaved.

Rural transport is important for the transference of farm products and the accessibility to essential services. Improved transportation reduces travel time thereby increasing the time available for economic and social activities while also promoting access to basic facilities. Poor road conditions in rural areas have a negative effect on agricultural activity which is the major source of income of rural communities, thereby increasing the poverty rate. The condition of most rural roads in the country is very poor compared to inter-urban and intra-urban roads. The condition of rural transportation has hampered rural development efforts in the country which has resulted into series of challenges such as: (a) the cutting off of many rural areas from neighbouring larger settlements from which to access

higher order socio-economic services; (b) low productivity; (c) low income and high rate of poverty, and (d) a reduction in the standard of living of rural residents.

Rural Transportation in Nigeria:

Following an end to civil war in 1970 and establishment of an effective central administration, there was an increase in the number of rural footpaths. An important development is the upgrading of footpaths into unpaved roads, which could be used by vehicles much of the time. Rural transportation development in Nigeria is not a function of the increase in the number of villages alone; other important factors are the nature and structural changes in the level of socio-economic activity. For example, the discovery and exploitation of mineral and forest resources such as timber motivated the construction of more rural roads which were initially maintained and used exclusively by those companies which built them and later made available to the general public. (Such rural roads can be taken over by local communities or councils through whom they pass).

Consequently, rural roads and mechanised forms of traffic emerged to cater for the increased demand for rural freight and movement, especially between rural and urban centres. Considering the transport sector as one of the key elements of the country's needs, there has been series of efforts on the provision of rural transportation and rural development in Nigeria. Successive governments have come forth with various rural development strategies. For example, the establishment of the Nigeria Agricultural Cooperative and Rural Development Bank, the various State Agricultural Development Projects, River Basin Development Authorities, Development of Local Government Administrative systems and similar rural development initiatives has been embarked upon by government to facilitate the development of the rural economy. Roads are the country's dominant mode of transport carrying more than 90 % of cargo and passenger traffic (RAMP, 2007). Rural roads constitute the major percentage of Nigerian road system. Realising the importance of the rural transport, in early 2004 the Government launched a policy blueprint through the "National Economic Empowerment and Development Strategy" (NEEDS). The development strategy aimed at interventions in the rural infrastructure, health, housing and employment sectors. Its two key objectives were to improve the transport infrastructure and promote agricultural development. In the road sub-sector, its focus was on the construction and maintenance of road infrastructure to improve accessibility and to facilitate movement of agricultural commodities. As a follow- up on NEEDS, the "State Economic Empowerment and Development Strategy" (SEEDS) was developed at the State level in the 36 State Governments in Nigeria. Furthermore, through the Rural Travel and Transport Programme (RTTP), a National Policy on Rural Travel and Transport (NPRTT) was prepared by the Federal Government. This programme is aimed at improving rural access and mobility. However, despite the above initiatives to address rural transportation problem, little has been achieved due to a lack of political will, frequency of policy somersaults and government instability.

The rural transportation problem in Nigeria relates generally to the provision of access to natural resources like minerals, agriculture, forestry and the provision of access for the rural population so that they can access services at an affordable rate. People in rural areas travel less than their urban counterparts and this is not independent of the absence of reliable and easily affordable means of motorised public transport in those areas. The rural transportation problem is accentuated by the dispersed spatial derivation of traffic; this is conditioned by the nature of rural environment and economy, bulkiness and perishable nature of rural product, imbalance in inflow and outflow, and marked variability in demand for transport.

The performance of rural transportation is not only hinged on cost and quality of construction, frequency of maintenance and effect of climate. The cost of construction of quality rural roads has been known to be high as a result of the deployment of technology often used for the construction of highways. For example, the same heavy equipment used in the construction of highways are usually deployed for the construction of access roads, thereby increasing costs. Community-based

construction technology which employs the use of labour (abundant in rural communities), simple farm implements and roller compactors to construct good quality and cost effective rural/access roads have been advocated by the Nigerian building and Road Research Institute (NBRRI), after a series of successful pilot demonstration programmes. However, these have not yet been adopted nationally. The typical climate variability in Nigeria also has an impact on the performance of rural/access roads. In the coastal and rain forest regions of Southern parts of Nigeria, which are characterised by high rainfall, high humidity, longer rainfall periods, the performance of rural/access roads are adversely affected by these factors, thereby making these roads to have shorter service lives. This underscores the need for quality and appropriate technology for the construction and frequent maintenance of these roads to improve rural transportation.

Questionnaire:

What are the main concerns that your country has about the impacts that current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

a) During the raining season, most rural roads deteriorate and become impassable; this poses a threat to sustainability of rural socio-economic development. The effect is more prominent in the Southern parts of Nigeria where there is heavy precipitation, longer duration of rainfall and high humidity. The frequent occurrence of floods (and flash floods) due to inadequate drainage infrastructures during the peak periods of the rainy season results in road facilities and/or road furniture being washed away, with negative impact on rural transportation and the socio-economic activity of rural communities. The effect is milder in the savannah regions of the northern parts of Nigeria. Thus unchecked climate changes that may result in higher and longer period of precipitation will negatively impact on the performance of rural transportation.
b) Some of the vehicles, mopeds, motorcycles, etc. used as a mode of transport on rural roads are not road-worthy. This makes their services to be slow, irregular, unreliable, inefficient, and even constitute risk to rural commuters. This is exacerbated by the poor state of rural roads arising from the impact of climate, in addition to a poor maintenance culture.
c) Motorized transport cost become very high during rainy season as public transport operators increase their fares because of increased vehicle operating costs, often occasioned by the prevalent very poor road conditions.
d) It has also been observed that, rural travel and transport in most rural areas in Nigeria still take place with great difficulties as a result of flood ravaged rural roads, most of which are devoid of drainage structures, that are poorly maintained, thereby compounding and worsening the problem of rural productivity and rural poverty.
e) There is also issue of desertification in some locations in the Northern part of the country. This extreme condition of lack precipitation over most parts of the year, leads to cracking of the unpaved and paved roads in the rural communities. The issues of dust generation due to the sahel wind either depletes the road structure or covers up rural roads with wind-transported sands.

Is anything currently being done in your country to assess and/or address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

a) There are some measures currently being implemented to address current or future effect of climate change on rural roads. These assume the format of advocacy, campaigns, and public education programmes to sensitise the general population. The impact of these measures has not been significant. It would appear that many people, especially in the rural communities, are yet to come to terms with what climate change is, its impact, and what

they can do to minimise its impact. This may necessitate conducting a study on the assessment of rural community perception and their perceived roles in respect of impact of climate change on their socio-economic order.

b) There is the 'great green wall' project currently being undertaken to address the issue of desertification.
c) Some of the campaigns include 'Tree Planting' especially in Northern Nigeria where the threat of desertification is high. The campaigns do not appear to be conducted frequently.

If nothing is being done, why not and what have been the consequences up to now?

The primary reasons are multifarious and include but are not limited to the following:

a) Inadequate funding provision
b) Lack of political will by Government to effectively address the issue
c) Inadequate advocacy and public awareness. Current efforts do not appear to be sustained.
d) No continuation, re-assessment and strengthening of polices

If already experienced the consequences, how have these impacted on budget allocations for construction, maintenance and emergency responses?

Climate change has resulted into significant and almost periodic flooding issues which have in the past impeded movement of goods and services across the country. A case at hand is the flooding of the middle belt areas of Nigeria some years ago which resulted in rendering many highways linking the northern parts of Nigeria to the southern parts (e.g. Lokoja-Abuja highway, etc.) impassable for several weeks. Significant resources were expended to temporarily address the issue on ad hoc basis until the floods abated.

Budgetary provisions for the construction and maintenance of federal Roads fall under the Federal Government, the state roads under the State Governments and the local government roads under State and Local Governments. Apart from the Federal Government, the State and Local Governments are ill-equipped financially to maintain their existing road network, let alone construct new roads. Even at the Federal Government level, the paucity of funds arising from the economic meltdown and near economic recession has been largely responsible for the inadequate budgetary allocation for road development and maintenance. The existing budgetary provisions appear to be primarily reactive rather than proactive. In other words, it would appear that budgetary funds only become available in case of emergencies.

If you are aware of guidelines that have been produced or studies that are currently being conducted/planned in your country (e.g. vulnerability assessments, adaptation studies), can you please list them and provide references as to where more information can be obtained?

Some examples include:

a) Climate Change and Adaptation Measures in Northern Nigeria: Empirical Situation and Policy Implications. African Technology Policy Studies Network WORKING PAPER SERIES | No. 62.
b) Rural Road Infrastructural Challenges: An Impediment to Health Care Service Delivery in Kabba-Bunu Local Government Area of Kogi State, NigeriaAcademic Journal of Interdisciplinary Studies MCSER Publishing, Rome-Italy, July 2016.
c) Rurality and climate change vulnerability in Nigeria: Assessment towards evidence based even rural development policy; paper presented at the 2016 Berlin Conference on Global Environmental Change Held from 23-24 May 2016 at Freie Universität Berlin.

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

a) Examine and access the level of awareness of climate change impacts in the rural area;
b) Examine and assess the nature of climate change impacts;
c) Identify the different practices that exacerbate the impact of climate change in the area;
d) Identify and describe the indigenous adaptation practices used by farmers in the area;
e) Determine the factors affecting the communities' adoption of various adaptation strategies in the areas;
f) Identify the problems farmers face due to the effects of climate change;
g) Conduct awareness or advocacy programmes for improving the capacity of professionals to adapt to climate change;
h) Conduct studies on the enhancement in the behavioural changes towards climate change adaptation measures by individuals, communities, governments and service providers.

B.6 Tanzania

What are the main concerns that your country has about the impacts that current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

The United Republic of Tanzania has three main concerns about the impacts of current climate variability and future climate change:

(a) Total closure of many rural roads due to damage caused by either excessive rain (more than 95% of rural roads in Tanzania are earth while 3% are gravel roads that both have materials which are more sensitive to changes in moisture content), or excessive dryness in the areas of Ngorongoro and other dry parts of Tanzania, where dust from road soils and loose road soils are turning into deep potholes, leading to road closures.

(b) Failure of Roads Fund Board to meet the current and future demands of rural road maintenance requirements caused by excessive moisture contents (caused by rain) on roads and wash-out of culverts/bridges.

(c) Economic failure and poor socio-economic services in rural areas due to excessive rain or draught. Many socio-economic activities will be suspended or stopped due to lack of transportation services and excessive water or draught where crop growing will become impossible.

Is anything currently being done in your country to assess and/or address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

The United Republic of Tanzania has conducted a number of studies and took measures according to the outcome of the studies conducted. Due to low economic capacity the country has concentrated on National Roads under TANROADS and a little has been done on rural roads:

(a) Removal of identified bottleneck on rural roads (a study conducted by Cardo ITT and funded by DFID). Many identified bottleneck were due to the effects of climate change in Tanzania.

(b) A Climate Adaptation Fund has been requested from DFID to make rural roads more climate resilience.

(c) Review of national standards and specifications to incorporate effects of climate changes so as to preserve our roads.

(d) PO-RALG is collecting data every year and use mathematical models to identify/quantify the effects of climate changes, and report back to, and ask for funding from the Roads Fund Board of Tanzania for maintenance or for mitigating future effect of climate change.

(e) PO-RALG has established a budget item for development activities, inclusive of climate change studies. In the 2016/17 financial year only approximately Tshs 200 million has been allocated for development activities, but it is expected that with time funding will be increased.

If nothing is being done, why not and what have been the consequences up to now?

The United Republic of Tanzania is doing something although not at the required pace due to the following problems:

(a) Low financial capacity;

(b) Lack of climate change expertise in PO-RALG (lack of proper knowledge and understanding);

(c) Lack of general understanding by policy makers;

(d) Use of Specifications and Standards that do not consider existing climate challenges.

If already experienced the consequences, how have these impacted on budget allocations for construction, maintenance and emergency responses?

The rural road construction and maintenance budget has fund allocations for emergency responses. The funds have been used to respond mainly to the effects caused by climate change. At present the Roads Fund Board cannot accommodate the request from various local government authorities due to very high financial requirements that are beyond their capacity. It is now estimated that emergency requirements are absorbing one-half of the total rural roads annual budget.

The maintenance budget has been reduced by 16% in the 2015/16 financial year so as to repair important rural roads that were affected by climate changes. In fact, all maintenance activities are affected country-wide due to effects of climate change.

If you are aware of guidelines that have been produced or studies that are currently being conducted/planned in your country (e.g. vulnerability assessments, adaptation studies), can you please list them and provide references as to where more information can be obtained?

No studies on rural roads. Studies have been conducted on National roads under TANROADS.

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

Tanzania is divided into three climatic zones. The effects of climatic impacts differ from one zone to another but will be combined to simplify the matter:

1) Erodibility of unpaved rural roads requires special skills to understand local and economical treatments that will resist or reduce road soil erodibility;

2) Shifting of river courses every year. Obtain economical solutions that local people can apply to train the seasonal river to maintain their old routes;

3) How to do perform dry compaction in draught-affected areas of Tanzania when constructing/ maintaining roads;

4) How to select/detect/know or obtain cheap and locally available materials that will sustain excessive moisture contents without failure;

5) Knowledge on how to conduct hydrological studies for local engineers at district level. This will help them to understand the magnitude of water and flow requirements for all drainage structure (the EU is conducting this training in Tanzania but needs modification in teaching and applications to suit climate change requirements);

6) Special course on bridge design with consideration to increased water levels and making better choices/estimates to make bridges and roads more resilience to climate change;

7) Special training to PO-RALG staff to help them understanding and increase knowledge on the management of roads in situation where climate change is driving the closure of rural roads.

B.7 Uganda

Background

Climate in Africa is changing and the most immediate impact is from extreme climate events such as drought, floods, storms and cyclones. Knowledge on how this will adversely affect African Governments' roads and transport is weak and there is no common guidance on how to best deal with climate effects at present and in the coming years.

Uganda submitted its intended nationally determined contribution (INDC) in Oct 2015. However, the INDC addresses only agriculture, water energy and health which Uganda considers the most vulnerable to climate risk. Much as it is acknowledged that our transport sector is also affected, it was not discussed even in the Ad hoc Uganda national steering committee on the Paris Agreement. Uganda is a signatory of the Paris Agreement which is built upon the United Nations Framework Convention on Climate Change (UNFCCC).

It is acknowledged that Uganda is very vulnerable to climate change. There is a need to initiate research to understand the extent of this vulnerability, and to identify and/or develop "climate technologies" that are responsive to challenges in the road transport sector occasioned by climate change.

The following questions were answered from the perspective of asset management:

What are the main concerns that Uganda as a country has about the impacts current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

i) The major concern is the disorganized movement of people and goods during inclement weather due to flooding and localized bottlenecks on the network;
ii) The road network drainage is often undermined due to torrential rainfall and resulting in excessive runoff;
iii) Heavy rainfall resulting into perennial ponding of water. This damages the subgrade, subsequently damaging the pavement layers and distorting movement of goods and people.

Is anything currently being done in Uganda to assess and address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

Yes and no. Neither is applicable across the network.

i) **YES**, some mitigation measures are being implemented. In such instances drainage structures are designed with longer recurrent interval;

ii) Most of the swamps situated along roads that undergo upgrading are designed with a drainage blanket.
iii) **NO**, because there are recurrent bottlenecks that have always hindered the movement of road users;
iv) There are many roads with alluvial soils that give way whenever there are heavy rains;
v) Also prolonged drought causes production of dust which is a health and safety hazard to road users.

If nothing is being done why not and what have been the consequences up to now?

Wherever nothing is being done this can largely be attributed to challenges with resources, financial and otherwise. As such we have had part of the road network non-functional, hence affecting the socio-economic development of some areas.

If already experienced the consequences, how have these impacted on the budget allocations for construction, maintenance and emergency response?

i) Damage to the network as a result of floods has caused perpetual deficit in our budget for road maintenance;
ii) Traffic congestion on paved links. Many road links do not attract traffic due to their dusty surface, traffic instead being attracted to paved links and this causes traffic jams. In the long run, this affects road user costs and escalates the maintenance budgets for paved roads;
iii) Larger than designed traffic volumes results into premature failure of paved links of the network.

If you are aware of guidelines that have been produced or studies that are currently being conducted/ planned in Uganda (e.g. vulnerability assessments, adaption studies), can you please list them and provide references as to where more information can be obtained?

Some studies on low cost seals that have been done by TRL and funded by UNRA. However, the recommendations / proposals have yet to be implemented in order to verify field performance. It is believed that low cost seals will mitigate against some climate-induced problems on the network.

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

i) Recalibration of existing, and development of new flood models to reflect the climatic changes in Uganda;
ii) Research and studies to find resilient materials that withstand wet conditions and excessive heat;
iii) Enhancement of hydrological centres to collect and manage hydro-meteorological and climate data;
iv) Capacity building of persons with specialized knowledge and skills such as hydrologists, pavement engineers, drainage specialists, asset managers, researchers, and environmental specialists to handle climatic challenges and develop tailored solutions.

B.8 Zambia

What are the main concerns that your country has about the impacts that current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

Most transport infrastructure works in Zambia have been designed, built and maintained on the premises that future climate conditions across the country will be similar to past conditions. Climate change and climate variability, however, are already a reality in Zambia and climate change impacts on infrastructure are already visible. Zambia's climate insecurity significantly undermines the functionality and accessibility of critical infrastructure, such as roads and bridges. Particularly the rural communities are most affected by the climate related impacts such as floods in roads and bridges which usually disconnect the rural communities from the network.

Is anything currently being done in your country to assess and/or address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

Currently Zambia is planning to undertake a study aimed at revising the transport sector infrastructure standards and codes to ensure that they reflect best practices with regard to climate resilient infrastructure.

If nothing is being done, why not and what have been the consequences up to now?

See answer to Question 2.

If already experienced the consequences, how have these impacted on budget allocations for construction, maintenance and emergency responses?

Eventually the budget for maintenance and emergency responses has increased and in most cases funding has been inadequate to respond to all emergency and maintenance needs. However, no study has been undertaken to establish the impact on the construction, maintenance and emergency response costs.

If you are aware of guidelines that have been produced or studies that are currently being conducted/planned in your country (e.g. vulnerability assessments, adaptation studies), can you please list them and provide references as to where more information can be obtained?

The Government of the Republic of Zambia has received a grant from the Nordic Development Fund (NDF) with the objective to increase the capacity of the Government of the Republic of Zambia to plan for a climate change resilient transport infrastructure.

The project titled "Consulting Services for the Development of Climate Resilient Infrastructure Standards and Codes for the Transport Sector in Zambia" is currently under procurement; further information can be obtained from the Road Development Agency.

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

Building local capacity to incorporate climate change adaptation and resilience considerations throughout the transport infrastructure design and management processes at practical and policy levels are required.

B.9 Zimbabwe

What are the main concerns that your country has about the impacts that current climate variability and future climate change may have on rural accessibility and associated road infrastructure?

(i) To develop a Climate Change Adaptation Training Manual, Training materials and Training Programme:

- Working closely with the PMU, design and develop an Adaptation Training Manual that responds to the identified gaps, needs and opportunities for training;
- Design and develop training materials on how to integrate climate change into development processes at all levels;
- Develop evaluation tools for the training sessions;
- Recommend , source and create a database of other knowledge products according to existing gaps that will help support the integration of climate change and adaptation in national and sector development process;
- Develop a training programme and schedule of training sessions including budget requirements for the training programme.

(ii) Implement a training programme and evaluate impact:

- In line with (i) above, provide training to all identified stakeholders;
- Recommended further training and capacity building priorities if needed;
- Conduct post training evaluation to assess the knowledge, attitudes and practice by trained stakeholders.

(iii) Information Dissemination:

- Working with the PMU, assist in identifying and/or packaging information and disseminating it to different stakeholders in appropriate formats (e.g. policy briefs, research articles, etc.);
- Develop an integrated approach to information analysis and its dissemination to support improved decision and policy making, monitoring and evaluation.

Is anything currently being done in your country to assess and/or address the consequences of current climate variability and future climate change on rural accessibility and associated road infrastructure in order to improve resilience?

The government of Zimbabwe through the environmental Management Agency is implementing a three year UNDP/EMA supported 'Scaling up Adaptation in Zimbabwe through strengthening integrated planning systems project'

If nothing is being done, why not and what have been the consequences up to now?

Contacts for more information: Joy Mlambo <joy.mlambo@undp.org>

If already experienced the consequences, how have these impacted on budget allocations for construction, maintenance and emergency responses?

Since the project is donor funded but the budgets for construction, maintenance and emergency responses to be affected after production of training manuals and donor funded pilot project implementation.

If you are aware of guidelines that have been produced or studies that are currently being conducted/planned in your country (e.g. vulnerability assessments, adaptation studies), can you please list them and provide references as to where more information can be obtained?

No response.

Can you please list rural accessibility and road infrastructure-specific issues related to climate impacts that, in your opinion, require additional knowledge?

- Climate projections;
- Implementation of disaster management in road infrastructure;
- Non-engineering adaptation procedures that may be implemented to strength resilience in rural road access.

Annex C: Work Plan

			Timeframe in weeks																								
WORK PACKAGE		TASKS	1 Apr	15 Apr	29 Apr	13 May	27 May	10 Jun	24 Jun	8 Jul	22 Jul	5 Aug	19 Aug	2 Sep	16 Sep	30 Sep	14 Oct	28 Oct	11 Nov	25 Nov	9 Dec	23 Dec	6 Jan	20 Jan	3 Feb	17 Feb	28 Feb
INCEPTION PHASE AND MANAGEMENT		Inception Phase & Management																									
	1	Project Initiation meetings																									
	2	Program and workplan development																									
	3	Inception workshop																									
	4	Project inception report submitted																									
	5	Phase 1 completion report submitted																>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>		

WORK PACKAGE	TASKS	Timeframe in weeks																								
		1 Apr	15 Apr	29 Apr	13 May	27 May	10 Jun	24 Jun	8 Jul	22 Jul	5 Aug	19 Aug	2 Sep	16 Sep	30 Sep	14 Oct	28 Oct	11 Nov	25 Nov	9 Dec	23 Dec	6 Jan	20 Jan	3 Feb	17 Feb	28 Feb
OBJECTIVE A. CLIMATE TRENDS, VULNERABILITY AND ADAPTATION																										
	Observed Climate Variability																									
	Climate variability in AfCAP areas of interest																									
WP A.1	A.1.1 Characterisation of present-day climate variability																									
	A.1.2 Present-day frequency of occurrence of extreme events																									
	A.1.3 Annual and seasonal average rainfall and temperature trends in recent decades																									
	A.1.4 Extremes of rainfall and temperature trends in recent decades																									
	A.1.5 Capture & analyse local data from historical records or anecdotally from local communities																									
	Climate Change Projections																									
	Climate projections																									
WP A.2	A.2.1 Range of large-scale projected African climate futures																									
	A.2.2 Changes in range of extreme events relevant to road infrastructure (AfCAP areas of																									
	A.2.3 8km resolution projected changes in rainfall rates, extreme rainfall events & run-off																									
	Risk Assessment Methodology and Vulnerability Indices																									
	Analysis of downscaled climate change projections																									
WP A.3	A.3.1 Select & confirm partner countries & review climate threats and vulnerabilities																									
	A.3.2 Climate Threats report submitted								>>>																	
	A.3.3 Create indices & frameworks for assessing exposure and vulnerability																									
	A.3.4 Applying and testing indices and frameworks (Mozambique case study)							>>>																		
	A.3.5 Academic journal paper submitted																>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	
	Engineering and Non-Engineering Adaptation Measures																									
	Adaptation measures																									
WP A.4	A.4.1 Review current status					>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
	A.4.2 Develop questionnaire																									
	A.4.3 Apply and consolidate answers						>>>	>>>	>>>	>>>																
	A.4.4 Engagement with key stakeholders in selected AFCAP countries									>>>	>>>															
	- Mozambique							>>>																		
	- Ghana								>>>	>>>																
	- Ethiopia									>>>	>>>															
	A.4.5 Climate Adaptation Options report submitted																									
	A.4.6 Peer-reviewed conference paper submitted																>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	
	Establishment of Demonstration Programme																									
	Demonstration plan																									
WP A.5	A.5.1 Engagement with key stakeholders to identify and agree on area of interest									>>>	>>>															
	- Mozambique							>>>																		
	- Ghana								>>>	>>>																
	- Ethiopia									>>>	>>>															
	A.5.2 Engagement with stakeholders in countries to identify and confirm project sites												>>>													
	- Ghana																									
	- Mozambique																									
	- Ethiopia												>>>													
	A.5.3 Road investigations (vulnerability assessments)																									
	- Mozambique										>>>	>>>														
	- Ghana											>>>	>>>	>>>	>>>											
	- Ethiopia												>>>	>>>	>>>	>>>	>>>									
	A.5.4 Design of Demonstration Programmes														>>>	>>>	>>>	>>>								
	A.5.5 Drafting of project reports, review by AfCAP PMU and Steering Committee & finalise														>>>	>>>	>>>	>>>	>>>							
	A.5.6 Recommendations for Phase 2 report submitted															>>>	>>>	>>>	>>>							

WORK PACKAGE		TASKS	Timeframe in weeks																								
			1 Apr	15 Apr	29 Apr	13 May	27 May	10 Jun	24 Jun	8 Jul	22 Jul	5 Aug	19 Aug	2 Sep	16 Sep	30 Sep	14 Oct	28 Oct	11 Nov	25 Nov	9 Dec	23 Dec	6 Jan	20 Jan	3 Feb	17 Feb	28 Feb
Objective B: CAPACITY ENHANCEMENT OF AFCAP PARTNER COUNTRIES		**Establishment of website/portal for interaction with AFCAP Partner Countries**																									
	WP B.1	B.1.1 Discussions with ReCAP Knowledge Management & Communications PMU		>>>	>>>	>>>	⊙																				
		B.1.2 Develop and populate website with information																>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>
		B.1.3 Establish user group and discussion forum				>>>	>>>	>>>	>>>	>>>	⊙																
		B.1.4 Produce and publish newsletters (subject to peer-review)			⊙											⊙	⊙	>>>	>>>	>>>	>>>	>>>	>>>	⊙	>>>	>>>	>>>
		Development of training material																									
	WP B.2	B.2.1 Produce training material on current/future climate threats							>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙			
		B.2.2 Produce training material on engineering and non-engineering adaptation options												>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙			
		B.2.3 Produce training material on selection criteria frameworks													>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙			
		Training Workshops																									
	WP B.3	B.3.1 Organise training workshops in three selected AfCAP Partner Countries														>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙				
		B.3.2 Hold 2-day training workshops (inclusive of regional participation by Partner Countries)															>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙		
		- Mozambique (Monday-Tuesday)															>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙			
		- Ghana (Thursday-Friday)															>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙			
		- Ethiopia (Wednesday-Thursday)															>>>	>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙		
		B.3.3 Workshop report submitted																>>>	>>>	>>>	>>>	>>>	>>>	>>>	⊙		

- Advisory Inputs
- Milestones
- Workshops
- In-Country Activities
- Project Outputs
- ⊙ Actual Completion dates

Annex D: 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 2016 to February 2017 and covers Milestone 1 and part of Milestone 2. The Phase 2 option of a further 70 weeks (minimum) takes the end of project target date to July 2018, covering Milestone 3, and is speculative at this stage.

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)		1/4/2016	K=£1,000 C= £0	K=£85,500 C=£200,000	K=£30,000 C=£10,000,000		14 days on average for each of the Counterpart staff - site identification, site visits, workshop organisation & participation 75 workshop participants over two-day period
	2. Concrete examples of change (applied or formally adopted), influenced by ReCAP research that will be allied to #km of road in focus countries.		1/4/2016	0 km	500 km	20,000km		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.		1/4/2016	0	0	8		Journal article and peer-reviewed paper submitted on 28 February 2017
Output 1: RESEARCH and	1.1 LVRR: Number of peer reviewed papers generated from ReCAP supported or related LVRR research	Annex A	1/4/2016	0	2	5		

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
UPTAKE: Generation, 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)	projects made available in open 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.	Annex A	1/4/2016	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.		1/4/2016	0	3	12		Refers to policy and guidelines Targeting all AFCAP partner countries with 3 by end July 2017
	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.	N/A	1/4/2016	N/A	N/A	N/A		N/A
	1.6. LVRR and TS information generated for dissemination, and disseminated, that is not peer	Project Webpage	1/4/2016	4	12	18		Briefing Notes Milestone 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
	reviewed. Total to include research papers, final research reports, workshop reports, manuals and guidelines.							
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.	Team & counter-parts	1/4/2016	6	14	20		Project Team Country Counterpart Team
	2.3. Research projects with female researcher inputs at senior technical level.	Team & counter-parts	1/4/2016	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	PIT mtg & workshops	1/4/2016	-	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.	Project Webpage	1/4/2016	4	10	16		Phase 1: 3 countries Phase 2: 11 countries International, participation, multiple stakeholder groups, multi-topic, multi-country, regional, or local.

Annex E: Workshop Evaluation Scores

MOZAMBIQUE: ANE Conference Room, Maputo, 30-31 January 2017							
Questions		Number of responses					Average
No	Rating score	A=5	B=4	C=3	D=2	E=1	of scores
2	How would you rate the overall usefulness of this workshop?	2	9	3			3.9
3	To what extent did the workshop meet your expectations?	4	6	4			4.0
4	Were you as participant able to effectively contribute to the different sessions of the workshop?	2	4	6	1	1	3.4
5	How do you rate the workshop schedule/timetable?	5	6	3			4.1
6	What was your impression of the logistical organisation and management of the workshop?	6	8				4.4
7	How would you rate the presentations on climate effects and climate adaptation methodologies (Day 1)?	5	7	2			4.2
8	How would you rate the presentations on engineering and non-engineering adaptation options (Day 1)?	4	8	2			4.1
9	How would you rate the presentation on Demonstration Sites Feedback (Day 2)?	2	9	2			4.0
10	How do you rate the presentation and discussion on the recommendations for Phase 2 (Day 2)?	4	7	2			4.2
						AVERAGE OF ALL SCORES:	4.0
1	Three things learned during the Workshop:						
	Awareness about climate change - variability and trends (x7)						
	Issues to be considered in design viz-a-viz climate change impacts (x7)						
	Need for greater preparedness to address climate effects (x4)						
	Importance of non-engineering adaptation options, including policies, strategies and plans (x3)						
	Need for proper coordination in planning/execution across government institutions - multi-disciplinary nature of climate adaptation (x2)						
	Climate adaptation options for rural access roads (x2)						
	Vulnerability and risk assessment, and mapping thereof						
	Regional vulnerability to climate change						
	Impact of climate change on road strategy development						
	Need for incorporating climate change in specifications						
	Recommended adaptations should be done, recognising that different options will have to be applied in different regions/countries						
	More climate-resilient designs can save money in the long term						
	Quantification and prioritisation of risks						
	80% of population live in rural areas						
11	Two and most useful aspects of Workshop:						
	Solutions to be considered for climate resilience of road infrastructure (x8)						
	Awareness about climate change effects and impacts (x4)						
	Need to develop in-country capacity and disseminate knowledge (x2)						
	Vulnerability and risk assessment methodology (x2)						
	Implementation of recommendations is key						
	Need for practical demonstrations						
	Proposed actions for demonstration sections						
	There is a buy-in of the project at all levels - all Mozambican authorities should be involved						
	Research and knowledge sharing						
	Recommendations for Phase 2, including solutions for demonstrators						
	Budget implications						
	Quality communication and feedback by the project team						
12	How could the Workshop have been improved?						
	Some participants may not have been actively involved because of language barrier. Presentations in Portuguese are advisable (x4)						
	Participants to have time to read the material before the workshop (x3)						
	Because of language hurdle, more figures or examples and less text (x2)						
	Hands-on training on site (x2)						
	Other sectors/stakeholders should have been invited to the workshop (x2)						
	Need more demonstrators in other geographical regions						
	Duration of presentations: could be shorter						
	More time spent on climate context						
13	Any other comments or suggestions						
	Include in the team someone with good knowledge of the Portuguese language (x2)						
	Strengthen coordination across institutions, including development partners (x2)						
	Phase 2 needs a greater focus on quality of design and construction - this is a problem in Mozambique						
	Next phase should focus more on hands-on training						
	Excellent sharing of knowledge						
	NB! This project should be linked to the 200km rehabilitation project in Gaza						
	Need to review all road construction material guidelines, structural guidelines and hydraulics manuals (inclusive of return periods)						

GHANA: Ghana Institution of Engineers, Accra, 2-3 February 2017							
Questions		Number of responses					Average of scores
No	Rating score	A=5	B=4	C=3	D=2	E=1	
2	How would you rate the overall usefulness of this workshop?	16	5				4.8
3	To what extent did the workshop meet your expectations?	6	10	5			4.0
4	Were you as participant able to effectively contribute to the different sessions of the workshop?	3	7	8	3		3.5
5	How do you rate the workshop schedule/timetable?	10	8	3			4.3
6	What was your impression of the logistical organisation and management of the workshop?	4	12	5			4.0
7	How would you rate the presentations on climate effects and climate adaptation methodologies (Day 1)?	8	11	2			4.3
8	How would you rate the presentations on engineering and non-engineering adaptation options (Day 1)?	11	7	3			4.4
9	How would you rate the presentation on Demonstration Sites Feedback (Day 2)?	12.5	5.5	2			4.5
10	How do you rate the presentation and discussion on the recommendations for Phase 2 (Day 2)?	7	10	2			4.3
						AVERAGE OF ALL SCORES:	**4.2**
1	**Three things learned during the Workshop:**						
	Awareness about climate change - variability/trends, climate change effects and impacts (x11)						
	Engineering and non-engineering options to identify/manage risk, to drive policy and strategies and to yield sustainable solutions (x9)						
	Importance of climate adaptation in all aspects of road engineering: planning, design, construction, maintenance (x8)						
	Issues to be considered in design viz-a-viz climate change impacts - urgent need to implement climate resilient road designs (x5)						
	Most adaptation solutions are based on 'sound engineering' - proper implementation (good engineering/construction) is key (x4)						
	Climate resilient roads could cost more, but could have lower life-cycle cost (e.g. reduced future maintenance/rehabilitation costs) (x3)						
	Simple and cost-effective engineering methods of adapting roads to become more climate resilient (x3)						
	Vulnerability and risk assessment, and mapping thereof (x2)						
	Climate adaptation methodologies and actions plans (x2)						
	Research, knowledge sharing and capacity building; uptake and embedment of research findings (x2)						
	Climate change is a reality which must be factored into road asset management to minimise its impact (x2)						
	Importance of quality and reliable data as input in decision-making (x2)						
	Importance of monitoring and evaluation						
	Climate change impact progression is of serious concern and must be given the necessary attention						
	Use of cuts and fills, and the risk for downslope failures						
	Broader stakeholder involvement required to tackle the problem of climate change						
	Role of remote sensing and GIS technology in assessing road vulnerability						
11	**Two and most useful aspects of Workshop:**						
	Awareness about climate change - variability/trends, climate change effects, adaptation (x5)						
	Engineering and non-engineering adaptation options to boost adaptation capacity, particularly focussing on rural access (x4)						
	Road asset vulnerability assesment and adaptation methodologies (x3)						
	Engineering adaptation options for different types of roads/structures (x3)						
	Quality communication and feedback by the project team, as well as the discussions (x3)						
	Adoption of 'sound engineering' principles in adaption (incl. simple, low-cost measures) (x2)						
	Need for capacity building and knowledge dissemination (x2)						
	Demonstration site feedback (x2)						
	Demonstrations (trial sections) considered a very important hands-on learning event						
	Cautious use of appropriate construction materials						
	Ability to interact with institutions directly involved within the Ghanaian road system						
	Implementation of appropriate adaptation measures to ensure sustainable access						
12	**How could the Workshop have been improved?**						
	More hands-on training (e.g. on vulnerability assessments) (x6)						
	Field trip and/or field work to be included in future training programmes (x4)						
	Break-out sessions on specific issues to ensure more participation (x3)						
	Participants to have time to read the material before the workshop						
	Workshop could have been extended to a one-week event						
	Broader group of stakeholders could have been invited to the workshop						
	By making it a resident workshop, more time would have been available to discuss/debate issues						
	Larger conference room						
13	**Any other comments or suggestions**						
	Future workshops should be organised close to the demonstration site(s), especially when work is ongoing						
	Capacity building of institutions involved in identifying, implementing and monitoring interventions						
	Consult CERSGIS (University of Ghana) for spatial datasets that will be required for risk assessments in Ghana (www.cersgis.org)						
	Workshop should be extended to other countries to create awareness and plan accordingly						
	Workskop should also be organised for other heads of agencies (decision makers) who couldn't take part in this workshop						

ETHIOPIA: Alemgena Training Centre, Addis Ababa, 8-9 February 2017							
Questions		Number of responses					Average of scores
No	Rating score	A=5	B=4	C=3	D=2	E=1	
2	How would you rate the overall usefulness of this workshop?	12	4				4.8
3	To what extent did the workshop meet your expectations?	5	8	3			4.1
4	Were you as participant able to effectively contribute to the different sessions of the workshop?		9	4	1		3.6
5	How do you rate the workshop schedule/timetable?	8	5	2		1	4.2
6	What was your impression of the logistical organisation and management of the workshop?	7	5	2			4.4
7	How would you rate the presentations on climate effects and climate adaptation methodologies (Day 1)?	9	6	1			4.5
8	How would you rate the presentations on engineering and non-engineering adaptation options (Day 1)?	11	4	1			4.6
9	How would you rate the presentation on Demonstration Sites Feedback (Day 2)?	8.5	5.5	2			4.4
10	How do you rate the presentation and discussion on the recommendations for Phase 2 (Day 2)?	6	8	2			4.3
						AVERAGE OF ALL SCORES:	**4.3**
1	**Three things learned during the Workshop:**						
	Engineering and non-engineering options to drive sustainable solutions (x9)						
	Importance of climate adaptation in all aspects of road engineering: planning, design, construction, maintenance (x6)						
	Importance of climate projections and adaptation strategies to ensure sustainable access (x5)						
	Adaptive capacity will improve by the review of existing policies, engineering practices and manuals (x5)						
	Climate adaptation methodologies and actions plans (e.g. 20 steps) (x4)						
	Issues to be considered in design viz-a-viz climate change impacts - urgent need to implement climate resilient road designs (x3)						
	Climate change effects on low-volume rural roads (x3)						
	How to consider environmental impact in asset management (x2)						
	Awareness about climate change - variability and trends (x2)						
	Different action plans that could be implemented to alleviate problems caused by climate variability and change (x2)						
	Poor road construction renders roads susceptible to climate impacts						
	How environmental changes affect current design assumptions and impact on the economy and development in the future						
	Involvement of other stakeholders to implement resilient solutions to climate change						
	Engineering/technical solutions for high risk areas						
	Overview of the site visits undertaken by project team and adaptation options presented						
	Integration of 'environment' and 'engineering' - impact of environment on roads often neglected						
11	**Two and most useful aspects of Workshop:**						
	Capacity building and dissemination of knowledge, also involving multi-sector participation (x5)						
	Engineering and non-engineering adaptation options to boost adaptation capacity, particularly focussing on rural access (x4)						
	Climate projections and implementation of appropriate adaptation measures to ensure sustainable access (x3)						
	Demonstrations (trial sections) considered a very important hands-on learning event (x3)						
	Overview of the vulnerability assessment and adaptation methodologies (x3)						
	Importance of non-engineering adaptation options, including policies, strategies and plans						
	Balance to be achieved between economically viable, socially acceptable and environmental friendly						
	Current threats associated with climate change						
12	**How could the Workshop have been improved?**						
	Greater involvement of other sectorial stakeholders, as well as service providers associated with ERA (x9)						
	Participants to have time to read the material before the workshop (x2)						
	Duration of workshop too short in view of scope and importance of the issue (x2)						
	Impact of location of workshop (its remoteness) may have impacted on attendance other sectorial stakeholders (x2)						
	Expanding the scope of the study (e.g. high volume roads)						
	ERA administers trunk roads, not local/low-volume roads - more regional road authorities should become involved (focus of project)						
	Engineering options / demonstrators should be broadened to include other regions in Ethiopia						
	Site visits should be included in future workshops						
	Cost-effectiveness of adaptation options should be considered						
	Dissemination to a larger audience - seminar or conference						
	Group discussions						
13	**Any other comments or suggestions**						
	Multi-sector involvement will be required - senior professionals capable of contributing should become involved (x2)						
	Climate resilience aspects of this project are of key importance to Ethiopia to improve road delivery						
	Road sector development plans in Ethiopia and elsewhere should be based on accurate/reliable data on climate						
	Problems and remedial measures presented under "engineering adaptation options" were appreciated						
	Need to brief key stakeholders						
	Capacity building should involve regional research centres, universities and NGOs						
	Local professionals involved in design and construction should be invited to understand their approaches and reason behind those						
	It is pertinent to create awareness among professionals engaged in the road sector, and to build capacity in the process						
	Train-the-trainer programme should be initiated						
	Local partners should be included in the study not only as stakeholders, but fully active and engaged in the entire consulting activity						

Annex F: Work Plan for Phase 2

The Work Plan for Phase 2 is provided on the next page (in A3 format). It spans a period of 84 weeks, whereas the original Terms of Reference indicated a duration of approximately 70 weeks. Because of the multitude of activities to be undertaken and complexities associated with those, and also to account for possible delays during the execution of the programme, it is proposed that the programme be extended to 84 weeks.

The Work Plan is colour coded as follows:

- Phase 2 Scope Activities
- Extra Over Items (included in budget)
- Deliverables
- Demonstrations
- Prospective funding by World Bank
- Prospective funding by EU/AfDB

ANNEX F: WORK PLAN (PHASE 2)

Timeframe in weeks

WORK PACKAGE		TASKS	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
INCEPTION PHASE AND MANAGEMENT		**Inception Phase & Management**																																										
	1	**Project Initiation communication**																																										
	2	**Programme and workplan development**																																										
	3	**Finalisation of programme and plan**																																										
	4	**Inception Update report**																																										
	5	**Progress Reports**																																										
	6	**Country Reports (Ethiopia, Ghana and Mozambique)**																																										
	7	**Recommendations for Phase 3 (PART E)**																																										
	8	**Contract Completion Report**																																										
PART A: DEMONSTRATORS		**Mozambique Demonstration Programme**																																										
	WP A.1	A.1.1 Demonstrate appropriate engineering and non-engineering adaptation options																																										
		Gaza Province: Chokwe-Macarretane Road (R448)																																										
		Districts in Zambesi/Nampula Province, linked with EU																																										
		A.1.2 Site investigations and detailed design																																										
		A.1.3 Construction of demonstration sections																																										
		A.1.4 Monitoring and evaluation																																										
		A.1.5 Demonstrate appropriate non-engineering adaptation options																																										
		Demonstrate methodologies for conducting risk and vulnerability assessments																																										
		Embedment in road asset management systems																																										
		Ghana Demonstration Programme																																										
	WP A.2	A.2.1 Demonstrate appropriate engineering and non-engineering adaptation procedures																																										
		Tamale region: Tampion-Tidjo Road																																										
		Coordination with AfCAP Project "Alternative surfacings for steep hill sections"																																										
		A.2.2 Site investigations and detailed design																																										
		A.2.3 Construction of demonstration sections																																										
		A.2.4 Monitoring and evaluation																																										
		A.2.5 Demonstrate appropriate non-engineering adaptation options																																										
		Data and methodologies to conduct risk and vulnerability assessments																																										
		Embedment in road asset management systems																																										
		Ethiopia Demonstration Programme																																										
	WP A.3	A.3.1 Demonstrate appropriate engineering and non-engineering adaptation procedures																																										
		Tullu Bollo to Kela Road																																										
		Retrofitting existing network (URRAP)																																										
		Somali Region																																										
		A.3.2 Site investigations and detailed design																																										
		A.3.3 Construction of demonstration sections																																										
		A.3.4 Monitoring and evaluation																																										
		A.3.5 Demonstrate appropriate non-engineering adaptation options																																										
		Data and methodologies to conduct risk and vulnerability assessments																																										
		Embedment in road asset management systems																																										
		A.3.6 Adaptation methodology for World Bank (adaptation options for all roads)																																										
PART B: CAPACITY ENHANCEMENT (three countries)		**Capacity Enhancement: Three target countries**																																										
	WP	B.1 Engagement with key stakeholders and Development Partners																																										
		Mozambique																																										
		Ghana																																										
		Ethiopia																																										
		B.2 Generic (Regional) Handbook on Climate Adaptation																																										
		B.3 Training modulus and training workshops based on Handbook																																										
		Mozambique																																										
		Ghana																																										
		Ethiopia																																										
		Development Partners																																										
		B.4 Translations of documents and materials																																										
		B.5 On-site training: condition assessments, adaptation options, implementation																																										
		Mozambique																																										
		Ghana																																										
		Ethiopia																																										
		B.6 Peer-reviewed journal articles and conference papers submitted																																										
PART C: CAPACITY ENHANCEMENT (AfCAP Partner Countries)		**Enhancement of capacity in additional AfCAP countries**																																										
	WP	C.1 Identification of priorities by engagement with AfCAP Partner Countries																																										
		C.2 Capacity development events																																										
		- Regional training workshops (held in three target countries)																																										
		- Stakeholder meeting and PIT meeting																																										
		- Regional seminars																																										
		C.3 Continued development of website for interaction with AfCAP Partner Countries																																										
		- Continued population of website with information																																										
		- Manage user group and discussion forum																																										
		- Produce and publish Briefing Notes																																										
PART D: EMBEDMENT		**Review of policies, strategies and plans**																																										
	WP D.1	D.1.1 Mozambique																																										
		D.1.2 Ghana																																										
		D.1.3 Ethiopia																																										
		D.1.4 Other AfCAP Partner Countries																																										
		D.1.5 Synthesis and formulation of support activities (and revision thereof)																																										
		Provision of advice and technical assistance																																										
	WP D.2	D.2.1 Support embedment in policies, strategies and plans (three target countries)																																										
		D.2.2 Support embedment in norms and standards (three target countries)																																										
		D.2.3 Support embedment in design guidelines and manuals (three target countries)																																										
		D.2.4 Support intersectoral cooperation (environment, land use, etc.)																																										
		D.2.5 Case studies on 'best practices' (for all AfCAP Partner Countries)