The prioritisation and adaptation for climate change resilience of rural access roads

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Synopsis— It has been estimated that by the end of the century, $150 billion will be required to repair and maintain existing roads in Africa, the majority of which will be low volume rural access roads. Research into the prioritisation and adaptation of roads to improve their climate resilience has shown that it is essential to provide good vulnerability assessment information to allow unbiased and equitable prioritisation for the installation of adaptation measures. Such measures will depend on the expected modes of climate change (higher or lower precipitation, higher or lower temperatures, etc) as well as the nature, topography and materials along the road alignment. Most adaptation techniques will rely on existing good engineering principles, although innovative and low cost solutions directly applicable to each situation will be necessary for low volume roads to ensure economic feasibility.

Keywords— roads, infrastructure, climate change, vulnerability assessment

I. Introduction

The fact that the earth's climate is changing is undisputable and there is almost daily evidence in the international news to indicate this. Floods, droughts, cyclones and tornadoes, often more devastating than in past human memory, are regular occurrences. All road networks, but in particular the lower volume road (LVR) networks constructed to slightly lower standards, often using marginal materials and less conservative design assumptions, are highly prone to damage caused by these extreme climatic events.

It has been estimated that by the end of the century, $150 billion will be required to repair and maintain existing roads in Africa [1], the majority of which will be low volume rural access roads. It is thus essential that all new roads are designed considering optimum climate resilience and those existing roads prioritised as important in terms of social, economic or strategic significance are made as climate resilient as possible. It is certainly less costly to incorporate climate resilience into new structures than to try and address resilience problems on existing roads through specific adaptation interventions, unless upgrading and/or retrofitting to climate-resilient standards are embedded in maintenance/rehabilitation strategies. However, most African countries already have maintenance backlogs, and a special effort will need to be made to overcome these problems.

This paper summarises the impact of climate changes on rural low-volume roads, the mechanism for prioritising which roads should include additional adaptation measures and what types of measure should be implemented. This is a significant economic challenge as in most (probably all) African countries, there is currently insufficient funding to even maintain the existing roads at an appropriate level, let alone invest in costly climate resilience adaptation measures. However, the costs of not preparing roads for the future will be significantly higher than the costs of implementing at least basic measures [2].

II. The Project

To help address the significant threat of climate change to Africa's development, the Africa Community Access Partnership (AfCAP), a research programme funded by UKAid, commissioned a project in April 2016 to produce regional guidance on the development of climate-resilient rural access in Africa. The overall project aim was to sustainably enhance the capacity of twelve AfCAP partner countries (but primarily focusing on three AfCAP lead countries namely Ethiopia, Ghana and Mozambique) to reduce current and future climate impacts on vulnerable rural infrastructure. This has been 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 country specific current and future climate threats.

The fundamental (principal) research objectives were to identify, characterise and demonstrate appropriate adaptation procedures at multiple levels from national to local that may be implemented to strengthen the long-term resilience of rural access, based on a logical sequence of guidance covering the following:

- Climate threats – locally-specific
- Climate impacts
- Prioritisation
- Vulnerability to impact (risk)
- Non-engineering adaptations (referred to as Change Management adaptations in this project)
- Engineering adaptations
- Adequacy of funding

The second objective, which focused on capacity building and knowledge exchange within selected countries, was to meaningfully engage with relevant road and transport authorities in a knowledge dissemination and capacity-building programme.

The third objective was to ensure that there was 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 procedures and delivery at rural road level.

Attention was also paid to the management of measures that could be taken in a scenario where budgets are inadequate or absent. Those activities and actions that conventional standard approaches do not cover, were addressed within the adaptation guidelines as well.

The project produced a number of outputs related mostly to African rural roads, but generally applicable to any road, of which the most prominent are the following:

- *Climate Adaptation Handbook*: For managing risks and optimising resilience of vulnerable Low Volume Roads (LVRs); it covers new construction, rehabilitation/retrofitting, maintenance [3].
- *Climate Threats and Vulnerability Assessment Guideline*: It provides a semi-quantitative risk and vulnerability assessment framework [4]
- *Engineering Adaptation Guideline*: It addresses all measures to adapt different low-volume road networks and components to expected local climate changes [5]
- *Change Management Guideline*: It highlights options for: policy, strategy and programme feedback; asset management systems; maintenance planning, early warning and emergencies; augmenting design standards; research priorities; road alignments; user safety provisions; capacity building; how to maximise uptake, embedment of climate adaptation strategies [6]
- *Visual Assessment Manual*: Accompanying document to the *Engineering Adaptation Guideline*s as well as to the *Climate Threats and Vulnerability Assessment Guideline*, and supports the adaptation methodology outlined in the *Climate Adaptation Handbook* [7]

The sections that follow will address some of the aspects of the *Engineering Adaptation Guideline*, with references provided to some of the other documents listed above.

III. CLIMATE CHANGES

Modelling of projected climate changes indicate that they are likely to vary significantly from country to country and even within small areas of certain countries, depending primarily on the topography and geographic location. The effects of these changes on the transportation infrastructure will also vary diversely depending on the age, location and original designs of the infrastructure facilities. Although this paper concentrates on the road infrastructure, other transportation facilities such as railways, airfields and harbours could be equally affected and many of the adaptation techniques are probably relevant to these facilities as well as higher volume roads, where they occur in countries impacted by climate variability and change.

The following primary climate changes are likely to occur to varying degrees in most parts of sub-Saharan Africa (SSA) [8]:

- Increased temperatures (average, maximum and number of extremely hot days (> 35°C) per year)
- Decreased precipitation and longer drier periods

- Increased extreme weather events – violent storms, heavy precipitation, heat waves, etc.
- Rising sea-level
- Northern migration of the tropical cyclone belt in Southern-East Africa
- Increased wind speeds

These will be accompanied by related secondary effects that will affect transport infrastructure and operations:

- Increase/reduction in soil moisture
- Changes in groundwater level
- Changed frequency of extreme storm surges
- Flooding
- Changes in the optimum construction season (possibly timing and length) and conditions due to precipitation and temperature constraints.
- Longer/shorter growing seasons – changes in traffic movement
- Possible changes in crop/vegetation types
- Changes in vegetation density and type and rate of growth
- Changes in ecological equilibrium

Climate changes such as decreased temperatures are unlikely to affect SSA and are not considered in this work. However, there may be localised areas where reduced temperatures occur (e.g. extreme highlands, etc.) and these could have an effect on bitumen properties or working windows, but these are expected to be minimal.

Associated with the main climatic changes and secondary effects, the impacts of, for instance more severe flooding, increased wild-fire hazards, rising sea-levels and lowered groundwater tables on the road infrastructure need to be considered. Other associated influences such as water shortages under increased temperature environments because of higher evaporation could also have an indirect impact on infrastructure provision through limiting construction water availability.

It is anticipated that changes in other climatic parameters (e.g., relative humidity, barometric pressure, presence of fog, ultraviolet radiation, etc.) will have minimal impact on the engineering aspects of the low volume road infrastructure or else be incorporated into the above effects.

Climate modelling is carried out at numerous institutions around the world, using increasingly sophisticated models and improving all of the time as the data inputs necessary are better characterised and quantified. Despite this, modelling at a small scale is still time consuming and expensive. However, as computer power increases (exponentially), the ability to predict climate changes at any particular facility is expected to improve dramatically. This will increase the availability of high-resolution climate maps for use on specific projects, as already identified in some African countries.

IV. PRIORITISATION

With the limited road funding available, the need to ensure that the most “deserving” roads are treated first. The roads in a network (at national, provincial, state or local level) thus need to be classified in terms of various factors. These include whether the roads are considered to be primarily for access or mobility, those roads being used for mobility generally being the higher priority to ensure that they are affected minimally by “shock” climatic effects. However, there is usually a hierarchy of roads at different levels of mobility and access as shown in Figure 1.

Prioritisation of the access roads depends on various factors as follows:

- Potential loss of life
- Availability of alternative routes
- Cost and consequences of closure
- Environmental/sustainability issues (i.e. pollution, aesthetics, etc.)
- Cost of repair
- Available funds
- Accessibility requirements.

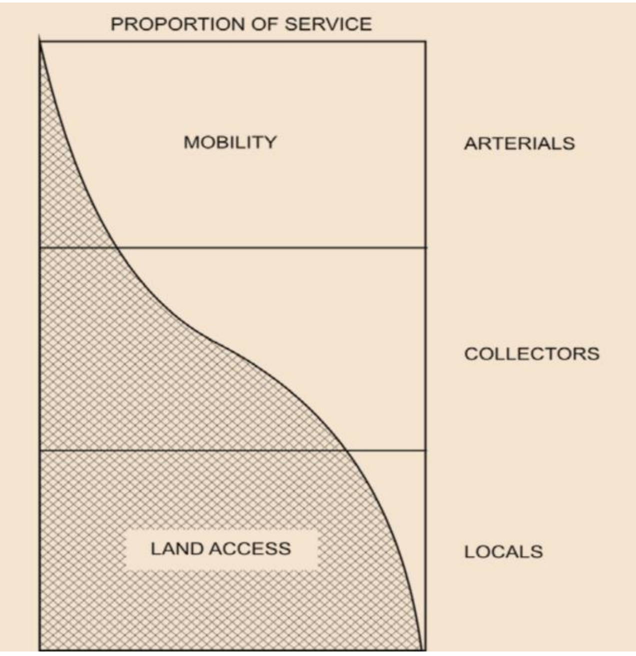

FIG. 1. USE OF DIFFERENT ROAD TYPES IN TERMS OF ACCESSIBILITY AND MOBILITY [9]

Generally, safety (loss of life) considerations will take precedence over the others. However, other than large landslides induced by excavation for roads, the safety implications of climate-related road failures are generally minimal. It should also be borne in mind that it is still more important to ensure that the primary and secondary road networks are maintained in good condition before concentrating on the tertiary or low-volume access road network.

It is essential that all roads are carefully and correctly classified in terms of their required levels of serviceability as a part of the prioritisation process. This serviceability level will be a function of numerous factors, but mostly whether the road is purely an access road (Table 1) or whether it is also used for mobility (Table 2). Various levels of serviceability (LoS) can be defined based on certain variables, for instance, based on whether the road is primarily access or also has an important mobility function and the expected needs of the communities affected (adapted from TRH 20 [10]). Such a classification can be directly related to the required prioritisation as shown in Table 1 for accessibility and in Table 2 for mobility.

TABLE I. GUIDELINES FOR LEVELS OF SERVICEABILITY FOR ACCESSIBILITY

Level of Serviceability	Required standards for accessibility		
	Comfortable driving speed (km/h)	**Impassability**	**Duration of impassability**
6	N/A	> 20 days/yr	> 5 days
5	15	< 20 days/yr	Not more than 5 days
4	20	< 5 days/yr	Not more than 2 days
3	35	Never	None
2	50	Never	None
1	60	Never	None

It should be noted that roads classified as LoS 1 would be those carrying higher traffic, leading to important services and usually not having an alternative route. Roads classifies as LoS 6 on the other hand would serve very small relatively self-sufficient communities, who can handle loss of access for extended periods based on past experience.

TABLE II. GUIDELINES FOR LEVELS OF SERVICEABILITY FOR MOBILITY

Level of Serviceability	Required standards for mobility		
	Max Roughness (IRI units in m/km)	**Impassability**	**Duration of impassability**
5	12	Not more than 4 days/yr	Not more than 1 day
4	9	Never	None
3	8	Never	None
2	7	Never	None
1	6	Never	None

V. HAZARDS, EXPOSURE AND VULNERABILITY

During the design of new infrastructure, climatic impacts should be determined as part of the Environmental Impact Assessment or Strategic Environmental Assessment and should thus be considered in the design, which can incorporate the necessary adaptation measures. However, traditional Environmental Impact Assessments evaluate any new road's impact on the environment, but, the impact of the environment on new roads is not normally considered in a systematic way – a gap that needs to be addressed.

For existing roads, however, during or parallel with the routine visual assessment of roads for input into Pavement Management Systems (PMS), it will be essential to include an assessment of the vulnerability of the road and associated structures (bridges, culverts, embankments, slopes, etc.) to variability and changes in the climate. Potential vulnerabilities and their mitigation will need to be identified. Guidelines for this have been developed [5] and should either be used with the routine visual assessment manuals for the Asset Management System to assist assessors with these decisions or preferably used by teams specifically trained to do climate vulnerability assessments. It should be noted that different experience is required for the two visual assessment programmes with the climate vulnerability requiring more geomorphological and materials experience or training. This information should be used in conjunction with the routine asset management visual assessment as issues such as surfacing condition are not specifically characterised in the vulnerability assessment.

Unlike the prioritisation process, the vulnerability assessment would be a more tactical operation. The climate sensitivity of all components of the road infrastructure needs to be identified in terms of two primary parameters during the visual assessments. These are the potential for:

- *Damage (i.e. physical harm that impairs the value, usefulness or normal function of an asset)* – this can normally be repaired rapidly by local works teams
- *Collapse (i.e. structural failure initiated when the material is stressed beyond its strength limit)* – this is usually costly to repair and involves significant construction and repair works, often by specialised teams requiring a tendering process and can lead to road closures for an extended period.

To minimise the cost of acquiring data on the climate vulnerability of assets, it is essential that vulnerability assessments be carried out as described in the following section and that all necessary data elements are captured. However, the lack of effective asset management in many SSA countries will impact on the availability of historical asset condition data that would inform and support climate vulnerability studies and the identification and prioritisation of adaptation options. To achieve the latter, data will need to be collected directly for each road in the network.

Risk can be defined as a function of hazards, rural access road exposure and vulnerability in terms of rural community access [8]. In particular, 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.

Disaster risk, as illustrated in Figure 2, is determined by the occurrence of a natural hazard (e.g. flood or cyclone), which may impact exposed populations and assets (e.g. rural communities and rural roads located in flood-prone areas). Vulnerability is the characteristic of the population or asset making it particularly susceptible to the damaging effects of the hazard (rural roads in poor condition) and the exposure of the asset or community to the hazard. Poorly planned development, socio-economic vulnerability, environmental degradation and climate change are all drivers that increase the magnitude of these interactions, increasing the risk and effects of large disaster events.

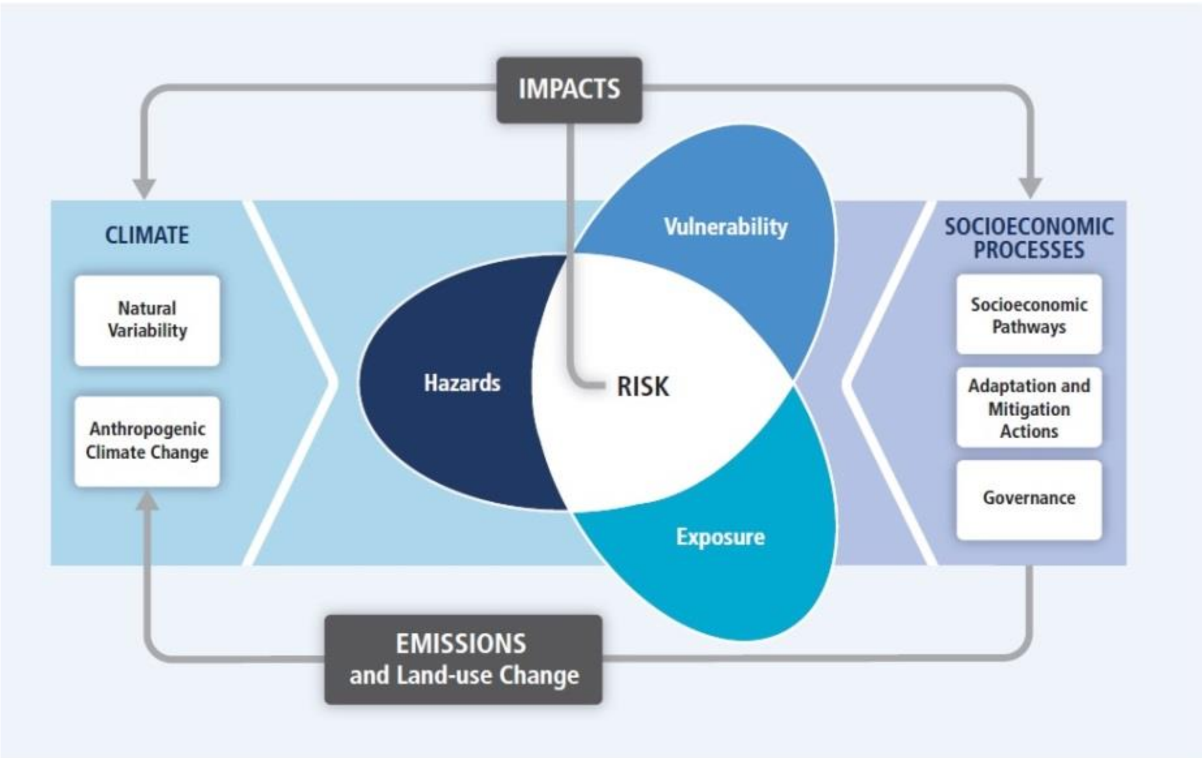

Fig. 2. CONCEPTUAL FRAMEWORK FOR CLIMATE-RELATED RISK AS AN INTERACTION BETWEEN CLIMATE-RELATED HAZARDS, EXPOSURE AND VULNERABILITY OF HUMAN AND NATURAL SYSTEMS [11]

VI. VULNERABILITY ASSESSMENT

The vulnerability is assessed by a walk-over survey of each road during which the hazards and exposure of each of the facilities is assessed. The method of carrying this out and the requirements have been described in [7] and make use of a standard form with an assessment of all the criteria for each 100 m section of road (this could be increased to 500 m for highly uniform environments in flat dry areas) using the degree and extent approach with a 5-point rating scale.

The issues considered during the assessment are directly related to the transport infrastructure affected as described in the following section. They include aspects such as the properties of the materials used in and occurring around the infrastructure, regional and local drainage efficiency, earthwork stability and construction and maintenance issues [5].

A typical example of an assessment exercise over a 2 km section of road is included in Appendix A. By combining the degree and extent of each item assessed with an appropriate weighting value a vulnerability index per section of road can be obtained. Those areas which are shown to be vulnerable should then be addressed first on each specific project being made climate resilient.

VII. Road infrastructure Affected and Adaptation Techniques

The following road infrastructure facilities or issues can be considered vulnerable to climate change and adaptation measures for each of these must be considered.

- Unpaved roads – earth, engineered earth and gravel
- Paved roads – thin bituminous, asphalt and concrete
- Earthworks – embankments and cuttings
- Subgrade soils – particularly problematic soils such as expansive, dispersive, collapsible, saline, and karst areas
- Drainage (water from within road reserve) – road and shoulder surface, side drains, mitre drains, small culverts for cross drainage, etc.
- Drainage (water from outside road reserve) – large culverts and bridges
- Construction
- Maintenance

In several countries, including Ghana, it was concluded that the engineering solutions needed to make a climate-resilient road can to a very large extent be found in the existing design manuals, “from solutions to hydraulic-related problems, such as scour and sedimentation, to problem soils and sub-grade problems as well as slope stability and surface drainage solutions” [5]. The main problem identified is a lack of appropriate and timely maintenance and the inability to identify potential problem areas, which are primarily geological and geomorphology issues. While it is agreed that current designs are probably sufficient if implemented properly and with adequate drainage facilities for extreme events for critical infrastructure, there are several adaptations or specific design decisions that can increase the resilience of roads to climate change.

Most of the problems affecting climate resilience that have been identified are related to excessive precipitation over a short period, either in the direct vicinity of the infrastructure element or resulting from flooding originating from extreme events “upstream” of the facility. Vulnerable areas will usually be known from past experience and older generations in communities can often assist in identifying such problem areas. It must be noted that existing return periods used in design are based on data from extreme events recorded in the historic past. In future, return periods are expected to change significantly as a result of more frequent events with different quanta and durations compared with past events. The main issue is that what was once a 1:50 return period may in future become a 1:10 or 1:15 return period, i.e. extreme storms are likely to become more frequent, but these will need to be quantified based on climate modelling and experience.

As described earlier, adaptation is essentially the implementation of good fundamental road engineering complemented by good construction and maintenance. Innovative and cost-effective techniques are necessary for certain situations but high cost, sophisticated solutions used on high volume roads should be avoided unless absolutely necessary. These include expensive slope stabilisation measures, where bioengineering, slope flattening and gabion retaining walls will often suffice.

In nearly all situations, good collection and control of precipitation and runoff is the most effective solution and no compromises should be made in the provision and maintenance of drainage.

Appropriate adaptation techniques have been summarised in a manual for AfCAP [5] and are widely discussed in the literature. A typical example of this is in National Cooperative Highway Research Programme (NCHRP) report on adaptation techniques specifically for embankments [12], which is a lengthy document of more than 100 pages covering embankment resilience alone.

A. *Unpaved Roads*

These include earth, engineered earth and gravel roads and are probably the most vulnerable roads to excessive precipitation and runoff, where erosion, ponding and structural failures under traffic occur. Un-engineered and engineered earth roads are difficult to adapt to a resilient state and can only be made resilient by being constructed to a full gravel road standard with a good cross-sectional shape and a high-quality gravel wearing course conforming to appropriate specifications. Good surface- and side-drainage is essential for the resilience of any unpaved road.

B. *Paved Roads*

This includes thin bituminous, asphalt and concrete surfaced roads. These are normally resilient to extreme climatic events if properly designed, constructed and maintained. Any deficiencies in these areas will result in problems under excessive moisture conditions, particularly under-compaction and poor finishing off of bituminous surfacings (e.g. streaking, joints, irregular application of binder and aggregates, aggregate loss, etc.). One of the main problems affecting paved roads is erosion of unsealed shoulders and supporting embankments and lower pavement layers during overtopping. Careful design of the horizontal alignment to avoid concentrations of water and turbulent flow across the pavement is necessary in areas prone to this.

C. *Earthworks*

These are related to embankments and cuttings, structures that are strongly affected by excessive moisture in terms of both stability and erosion. This is one area that innovative and creative thinking is necessary in order to minimise earthwork quantities and yet retain adequate carriageway width. Control and drainage of surface water affecting cut slopes is vital in order to minimise subsurface water, which is difficult and expensive to control.

Bioengineering of embankment and cut slopes has been shown to be highly effective in improving the resilience of cut and fill slopes in mountainous areas of the Himalayas and significant experience and expertise has been published on this, some of which is included in the AfCAP Engineering Adaptation Guidelines [5].

D. *Subgrade soils*

Potentially problematic soils such as expansive, dispersive, collapsible and saline soils and karst areas are highly susceptible to fluctuating moisture conditions with potential volumetric movements and even total collapse. Such soils should be identified during the design stage of roads and adaptations made at this stage. Once the road is constructed over problematic materials, it is prohibitively expensive to rectify problems beneath the pavement. In cases where problematic soils are identified after construction, embankment slopes should be flattened with low permeability material, the impermeability of shoulders and pavement surfaces should be ensured and effective side-drains installed to avoid the access of water into the subgrade.

E. *Drainage (water from within road reserve)*

Adequate drainage of water from the road, shoulder and embankments surfaces, into side drains, mitre drains and small culverts for cross drainage, etc., is of critical importance. Conventional drainage structures such as side- and mitre-drains as well as culverts and cross-drains must be designed to handle the expected increased run-off water in the area. Modified return periods should be considered, but if no information in this regard is available, use double the existing return periods for design: i.e. instead of 1:10 or 1:20 return periods, use 1:20 or 1:40, respectively).

It is also essential that head and wing walls are intact and effective and appropriate erosion protection works around these are installed (e.g. mortared stone pitching or gabions founded on concrete beams, etc.).

F. *Drainage (water from outside road reserve)*

Large culverts and bridges that convey water in streams that may originate some distance from the specific roads should be investigated and adapted (if required) in line with future demands. Some of these water courses may originate many hundreds of kilometres away, and even in other countries, such as the Limpopo and Zambezi Rivers in Mozambique. Complicating this problem, is the effect of large dams and water-retaining structures on “international” rivers. These become particularly relevant when overall rainfall is expected to decrease but the frequency and intensity of shock (extreme) events are likely to increase. The effect of low water levels in dams prior to the shock event may result in no impact – however, if the dams are relatively full at the time, they would be overtopped with severe consequences downstream. Design making allowance for such factors is almost impossible, but risk factors should nevertheless be incorporated in design.

In order to cater for future conditions, where large structures are designed to provide a service of 50 or 100 years, there is no doubt that much higher water flows can be periodically anticipated in most rivers. This should be considered by the structural engineers, as well as issues such as the performance of bearings and joint seals, etc. The widespread increase in the number of very hot days (> 35°C) will affect large concrete members which are likely to be subjected to prolonged higher temperatures resulting in larger and more severe thermal gradients and this needs to be considered in their design.

G. Construction

Although quality control and assurance requirements are strictly enforced by clients during the construction of infrastructure, there is no doubt that modern construction practices are not perfect. Any deficiency in construction (layer thicknesses, material quality, compaction, mix design, etc.) will make the facility more susceptible to premature failure, exacerbated by increased moisture and/or temperature regimes. It is thus essential that quality control requirements are rigidly enforced on all projects.

H. Maintenance

One of the biggest problems encountered in road management is the provision of funding for optimum routine and periodic road maintenance, particularly for lower volume roads. It has been stated by numerous authors (e.g. [13], [14], [15]) that the provision of good maintenance alone will increase the resilience of most roads to changing climatic effects.

This is particularly relevant to the cleaning and repair of drainage structures, whether these are unlined side drains or large culverts. Ensuring their effective operation is critical – all drains must allow an unimpeded flow of water to low points where it can be removed from the close vicinity of the road and dispersed or led into a local water-course.

Maintenance of vegetation is also essential. Apart from the effect of excessive vegetation impeding water flow in water courses, it adds mass to unstable slopes, provide debris during flooding and increases pore water pressures in underlying soils. It can also be a significant fire hazard leading to wildfires (particularly with predicted higher wind speed and drier conditions), which can cause damage to roadside appurtenances and even road surfacings (Figure 3).

FIG. 3. DAMAGE TO GUARDRAIL AND BITUMINOUS SURFACING CAUSED BY WILDFIRE

VIII. CONCLUSIONS

It has been estimated that by the end of the century, $150 billion will be required to repair and maintain existing roads in Africa, the majority of which will be low volume rural access roads. Research into the prioritisation and adaptation of roads to improve their climate resilience has shown that it is essential to provide good vulnerability assessment information to allow unbiased and equitable prioritisation for the installation of adaptation measures. Such measures will depend on the expected modes of climate change (higher or lower precipitation, higher or lower temperatures, etc) as well as the nature, topography and materials along the road alignment.

Most adaptation techniques will rely on existing good engineering principles, although innovative and low-cost solutions directly applicable to each situation will be necessary for low volume roads to ensure economic feasibility. Although the scarcity of funding for routine and periodic maintenance is and always will be a problem, regular and high quality maintenance of all transportation infrastructure components will also be essential to ensure climate resilience.

IX. ACKNOWLEDGEMENTS

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APPENDIX A: TYPICAL COMPLETED VULNERABILITY ASSESSMENT FORM

Road Number:	R123	**Date:**	**12/10/2018**	**Assessors:**	XY & ZA	**Weather:**	**S**	**Topography**	**R**

Chainage	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1	0,1	0,2	0,3	0,4	0,5	0,6	0,6	0,7	0,8	0,9	2
Grade	Flat	Flat	Flat	Flat	Medium downhill		" "	" "	"	Flat embankment		"	"	"	" Bridge	Flat	Medium uphill	"	"	"	Gentle uphill
Access to facilities	School	School	School	School	School	School	School	School	School	School	School	School	School	School	School	School	School	School	School	School	School
No. of alternative roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common vehicle types	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC	C&MC
Landcover and use	PU	PU	PU	A	A	A	A	F	F	F	F	F	F	F	F	F	F	F	F	F	F
GPS and photo No	1 33.21467S. 29.01752W		2 (side drains)												33.2145S 29.0199W						
Erodibility																					
Sugbrade	0	0	0	0	0	0	0	0	0	2 5	2 5	2 5	0	0	0	0	0	0	0	0	0
Road surface - unpaved	P	P	2 2	2 2	2 2	2 2	2 3	3 3	3 3	1 2	0	0	0	0	0	0	3 3	3 2	3 1	1 1	0
Side drains - unlined	1 4	1 4	1 4	1 4	0	0	0	3 4	3 4	0	0	0	0	0	0	0	5 3	5 4	5 3	5 3	5 3
Embankment slopes	0	0	0	0	0	0	0	0	0	0	0	3 3	3 3	4 3	0	3 3	0	0	0	0	0
Cut slopes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5 3	5 3	5 4
Subgrade problems																					
Material type	0	0	0	0	0	0	0	0	0	0	0	0	5 5	5 5	0	0	0	0	0	0	0
Moisture	0	0	0	0	0	0	0	0	0	0	3 5	3 5	4 5	4 5	0	0	0	0	0	0	0
Drainage (in reserve)																					
Road shape	2 5	2 5	3 5	3 5	3 5	3 5	3 5	3 5	3 5	4 5	4 5	4 5	4 5	5 5	5 5	5 5	3 5	3 5	3 5	3 5	3 5
Shoulders	2 5	2 5	3 5	3 5	3 5	3 5	3 5	3 5	4 5	4 5	4 5	4 5	4 5	5 5	5 5	5 5	3 5	3 5	3 5	3 5	3 5
Side slopes	0	0	0	0	0	0	0	0	0	0	2 2	2 2	2 2	2 2	2 2	2 2	0	0	0	0	0
Side drains	2 4	2 4	3 4	3 4	2 3	2 3	2 3	2 4	2 4	4 5	4 5	4 5	4 5	4 5	0	4 5	2 1	2 1	2 1	2 1	2 1
Mitre drains	0	0	0	0	0	0	0	5 5	0	0	0	0	0	0	0	0	0	0	0	0	0
Drainage (streams)																					
Structure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 1	0	3 3	0	0	0	0
Approach fills	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Erosion of approach fills	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3 3	0	0	0	0	0	0
Protection works	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5 2	0	4 3	0	0	0	0
Flood plain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slope stability																					
Cut stability	0	0	0	0	0	0	0	0	0	0	0	0	2 1	0	0	0	0	0	0	0	0
Fill stability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4 1	5 3	0
Construction																					
Overall finish	0	0	3 5	3 5	3 5	3 5	3 5	3 5	3 5	0	0	0	0	0	0	0	0	0	0	0	0
Erosion protection works	1 1	0	0	0	0	0	2 1	0	0	0	0	0	0	0	0	0	3 3	0	0	0	0
Maintenance																					
Quantity	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5
Quality	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5	5 5
COMMENTS:																					
										Potholes and ruts							Culvert with broken wing and headwalls				