Improving the resilience and quality of rural road infrastructure through landslide management and optimisation of road reserve use – Phase 1

Inception Report

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Alexander van Oostenrijk

Project No.  UGA 2150A

10 March 2019
Improving the resilience and quality of rural road infrastructure through landslide management and optimisation of road reserve use

The views in this document are those of the authors and do not necessarily reflect the views of the Research for Community Access Partnership (ReCAP), or of Cardno Emerging Markets (UK) Ltd, for whom the document was prepared.

Cover Image: Scenes from the Inception visit

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**ReCAP Report Template**

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<td>End Date</td>
<td>30 June 2019</td>
</tr>
<tr>
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<td>5 February 2019</td>
<td>Date Received</td>
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Abstract

The Research for Community Access Partnership (ReCAP) is funding a research study in Uganda with the following overall objective:

*to improve the climate resilience and quality of road infrastructure through landslide management and optimisation of road reserve use.*

Landslides pose a hazard to infrastructure management and sustainable rural livelihoods in several parts of the country and the Uganda National Roads Authority (UNRA) is concerned about the resilience of its road network and road reserve assets to these hazards.

The research study is divided into three Phases: Phase 1 is a Scoping/Feasibility Study; Phase 2 covers data collection, investigation and analysis; and Phase 3 includes study implementation. As far as landslides are concerned, the objective of Phase 2 is to investigate the development of a cost-effective method for mapping landslides in the country and, from this, develop a landslide vulnerability map for the UNRA road network. As far as road reserve optimum use is concerned, it is agreed that this will focus on the use of bio-engineering and drainage-water management measures for the benefit of a) slope management and b) rural community livelihood sustainability. During Phase 3, a Landslide and Road Reserve Management Toolkit (LRMT) is planned to be developed alongside slope management and landslide mitigation trials and the development of guidelines.

This Inception Report describes the findings of a project Inception visit to Uganda in January 2019. This visit included kick-off meetings, other meetings in Kampala and a visit to Mbale Station in the northeast of the country to observe landslide sources, mechanisms and impacts on the road network. The field visit helped to identify the fact that many of the landslide impacts on the road network in that region are associated with landslides that originate on slopes well outside of the road reserve. Management of slopes from both an engineering and a community livelihood point of view is therefore not confined to the road reserve but should involve consideration and application to the wider road corridor, namely the terrain in which it is constructed.

Other Phase 1 initiatives that have commenced during this Inception period include a desk study of published landslide literature, liaison with other government agencies and university researchers in terms of landslide and relevant geo-environmental datasets, the development of a landslide datasheet to be circulated to UNRA stations for landslide data collection, a review of Ugandan newspaper articles on landslide events and an examination of stereo aerial photographs held in the Bodleian Library, Oxford.

It is concluded that, while Phase 1 should remain fully flexible in terms of project direction, it should focus on the themes outlined above concerning the wider management of land and its stability for both engineering and community benefit.
Key Words
Uganda, landslides, road reserve, slopes, land use, remote sensing; mapping, GIS, database management systems
## Acronyms and Initialisms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AFCAP</td>
<td>Africa Community Access Partnership</td>
</tr>
<tr>
<td>BMS</td>
<td>Bridge Management System</td>
</tr>
<tr>
<td>COTS</td>
<td>Commercial, off-the-shelf (software)</td>
</tr>
<tr>
<td>DEM</td>
<td>Digital Elevation Model</td>
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<tr>
<td>dTIMS</td>
<td>Deighton’s Total Infrastructure Management System</td>
</tr>
<tr>
<td>ESIA</td>
<td>Environmental and Social Impact Assessment</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
</tr>
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<td>HGL</td>
<td>Hearn Geoserve Ltd</td>
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<tr>
<td>HGLC</td>
<td>Hearn Geoserve Ltd Consortium</td>
</tr>
<tr>
<td>LRMT</td>
<td>Landslide and Road Reserve Management Toolkit</td>
</tr>
<tr>
<td>PhD</td>
<td>Doctor of Philosophy degree</td>
</tr>
<tr>
<td>PMU</td>
<td>Project Management Unit</td>
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<tr>
<td>RDMS</td>
<td>Relational Database Management System</td>
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<td>ReCAP</td>
<td>Research for Community Access Partnership</td>
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<tr>
<td>RMS</td>
<td>Road Management System</td>
</tr>
<tr>
<td>SQL</td>
<td>Structured Query Language</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom (of Great Britain and Northern Ireland)</td>
</tr>
<tr>
<td>UNRA</td>
<td>Uganda National Roads Authority</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator (GIS co-ordinate system)</td>
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1 Introduction

1.1 Background to the Project

The Research for Community Access Partnership (ReCAP) is funding a research programme with the objective of i) investigating the susceptibility of the road network of Uganda to landslide hazards, ii) examining and improving the resilience of the road network to these hazards, and iii) identifying ways in which the use of the road reserve can be optimised accordingly. The Africa Community Access Partnership (AfCAP) has funded a considerable amount of research and development in various fields of low volume road sustainability in the Sub-Saharan region, and this Ugandan landslide research is a logical follow-on to some of this work.

Uganda has large areas of hilly and mountainous terrain, experiences very heavy and intense rainfall and is in a seismically active region, due to its proximity to the East African Rift. There have been several landslide events in the country that have caused large loss of life, loss of livelihood and damage to roads and other infrastructure. The Ugandan National Roads Authority (UNRA) is concerned about the hazard posed by landslides to its infrastructure, and the Department of Research and Development within UNRA is responsible for the implementation of this research project.

This project is divided into three Phases. This first phase (Phase 1) is a feasibility study, or scoping exercise, whereby the details and resourcing of following phases can be confirmed. Phase 2 is planned essentially as a data gathering and investigative phase while Phase 3 is intended for implementation. The investigative elements of Phase 2 centre on the assessment of landslide susceptibility and vulnerability of road infrastructure, and the management and optimisation of the road reserve, for example from a rural livelihood and bio-engineering (botanical) viewpoint. The implementation elements of Phase 3 relate to the trialling of bio-engineering techniques of slope and road reserve management and the development of a Landslide and Road Reserve Management Toolkit (LRMT).

1.2 Objective

The overall objective of the research is to improve the climate resilience and quality of road infrastructure through landslide management and optimisation of road reserve use.

The project Terms of Reference describe how the assignment will specifically:

- Analyse landslide and road reserve use problems in Uganda;
- Develop a spatially referenced, web-based system for management of landslides and road reserves;
- Develop guidelines for the use of road reserves to mitigate adverse environmental impacts of road use and maximise their socioeconomic benefits to UNRA and the local communities. This shall include appropriate adaptation measures (engineering solutions) to improve the road infrastructure resilience.
1.3 Approach and Stakeholder Consultation

The approach that has been adopted to fulfil the initial requirements of Phase 1 is to commence consultation as widely as possible with UNRA and other relevant stakeholders concerning the locations, mechanisms and impacts of landslides and the datasets available to examine them. We have also collated a library of relevant publications and we were able to review these before travelling to Uganda for the Kick-off meetings. Furthermore, while Phase 1 is designated essentially as a desk study exercise, we have made provision for short visits to selected areas to help familiarise ourselves with the extent and impact of landslides. We are also carrying out some trials in the use of aerial photographs and satellite imagery for landslide mapping in the Ugandan context.

These activities are outlined in this report. The UNRA staff and other stakeholders we have met with during this Inception period, as well as those we intend to meet during the progress of Phase 1, are listed in Sections 2.3 and 4.1.

1.4 Consultant Team

The expert team assembled to deliver the project outputs is as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Consortium Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gareth Hearn</td>
<td>Team Leader/Geo-Disaster Mitigation Specialist/Geotechnical Engineer</td>
<td>Hearn Geoserve Ltd</td>
</tr>
<tr>
<td>Mark Ruse</td>
<td>GIS Expert</td>
<td>Independent Consultant, engaged through Hearn Geoserve Ltd</td>
</tr>
<tr>
<td>Alexander van Oostenrijk</td>
<td>System Design &amp; Development Expert</td>
<td>Independent Software Ltd</td>
</tr>
<tr>
<td>Rose Mugidde</td>
<td>ESIA Expert</td>
<td>ICS Engineering &amp; Environment Ltd</td>
</tr>
<tr>
<td>John Howell</td>
<td>Botanist</td>
<td>Living Resources Ltd</td>
</tr>
<tr>
<td>Hayley Larkin</td>
<td>Satellite Image Interpretation Specialist</td>
<td>CGG/NPA Satellite Mapping, engaged through Hearn Geoserve Ltd</td>
</tr>
</tbody>
</table>

In addition to the above key expert posts, Ugandan technical staff resources have also been made available through ICS Engineering & Environment Ltd.

1.5 Purpose of this Inception Report

According to the project Terms of Reference, this Inception Report is required to ‘provide a refined approach and methodology to project implementation with specific quality &
performance controls that will be employed during the assignment’. In addition, it is important to summarise the outcome of the Inception Visit to Uganda by members of the project team, undertaken in January 2019, including the kick-off meetings and a short visit to the field.
2 Inception Visit

2.1 Programme

The Inception Visit was carried out between 8 and 13 January 2019. The overall programme of this visit was as follows:

- 8 January kick-off meeting No 1 – between UNRA, the consultant team and ReCAP
- 9 January Kick-off meeting No 2 – between UNRA, the consultant team and ReCAP
- 10 January – 12 January field visit to UNRA Mbale Station and roads around Bududa and Mt Elgon
- 10 January – 12 January meetings with UNRA and with other relevant stakeholders concerning datasets and database system design and development
- 13 January team meetings in Kampala.

2.2 Kick-off Meetings

The Minutes from the main kick-off meeting held on 8 January 2019 are contained in Annex A. The main points of discussion and outcomes of this meeting are summarised below:

- The project history comprised two separate components: landslide activity; road reserve optimisation/commercial management
- The project should commence with a landslide focus and address relevant issues of road reserve management where they overlap
- Commercial use of the road reserve can be addressed at a later stage, either in this project, as an extension or separately
- Land use may contribute to landsliding, whereas optimisation through slope protection and properly-managed community use of the land may improve resilience
- Differentiation would need to be made between earthworks failures and natural slopes failures, including those originating outside the road reserve
- Data sources, stakeholders and contact agencies were discussed with arrangements made to contact them via letters of introduction from UNRA
- There is a need to maintain a flexibility over project objectives which become refined as the project proceeds
- Guidelines on the route selection of new roads will be important
- A second meeting (9 January) is required to clarify project scope further

The Minutes of the second kick-off meeting held on 9 January 2019 are also contained in Annex A. The main points of discussion and outcomes of this meeting are summarised below:

- The project needs reliable data on landslide incidence and impacts on UNRA infrastructure
- The project needs to test the potential contribution of remote sensing (aerial photographs and satellite imagery)
- The project needs to identify vulnerable areas and provide guidelines for slope and road reserve management
Improving the resilience and quality of rural road infrastructure through landslide management and optimisation of road reserve use

- A participatory approach enhancing livelihood sustainability and slope protection would be optimal, combining engineering and community-based slope management
- The project will need to establish a risk register to manage risks associated with data and uncertainty
- It is important to tap into the knowledge held by some of the more senior members of UNRA, who will know about historical landslides on the road network
- The Ministry of Works & Transport has access to ground investigation reports in some areas that could prove useful
- The optimum use of the road reserve will focus on the mitigation of environmental and social impacts of roads through roadside vegetation barriers (bio-engineering) and water harvesting (drainage management and water use)
- Roadside borrow pits and quarries can pose serious issues in terms of health and safety, environmental impact and slope stability. Guidelines on this could be a useful component of the project
- The research outputs should feed into guidelines and policy documents.

2.3 Other Meetings

In addition to the kick-off meetings, discussions were also held with several other staff within UNRA and other agencies. A brief summary is given in the table below of these meetings.

<table>
<thead>
<tr>
<th>Discussion Date</th>
<th>9 January 2019</th>
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<tbody>
<tr>
<td><strong>Participants</strong></td>
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<tr>
<td><strong>Name</strong></td>
<td><strong>Position</strong></td>
</tr>
<tr>
<td>Isaac Wani</td>
<td>Director, Network Planning and Engineering, UNRA</td>
</tr>
<tr>
<td>Mark Henry Rubarenzya</td>
<td>Head, Research &amp; Development, UNRA</td>
</tr>
<tr>
<td>Emma Mbabazi</td>
<td>Project Co-ordinator, UNRA</td>
</tr>
<tr>
<td>Henry Nkwanga</td>
<td>ReCAP PMU</td>
</tr>
<tr>
<td>Gareth Hearn</td>
<td>Team Leader, HGL Consortium</td>
</tr>
<tr>
<td>Alexander Oostenrijk</td>
<td>System Design &amp; Development Specialist, HGL Consortium</td>
</tr>
<tr>
<td>Mark Ruse</td>
<td>GIS Specialist, HGL Consortium</td>
</tr>
</tbody>
</table>

**Main points of discussion**

Mark Henry Rubarenzya introduced the project team to Isaac Wani and provided him with a brief background to the project, setting out the project circumstances and objectives; Isaac Wani welcomed the project team to UNRA and extended his full support and good wishes for the success of the project; Henry Nkwanga provided insight into the overall ReCAP objectives with regard to this project.

<table>
<thead>
<tr>
<th>Discussion Date</th>
<th>9 January 2019</th>
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<tbody>
<tr>
<td><strong>Participants</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Name</strong></td>
<td><strong>Position</strong></td>
</tr>
<tr>
<td>Joseph Otim</td>
<td>Director, Road Maintenance, UNRA</td>
</tr>
<tr>
<td>Emma Mbabazi</td>
<td>Project Co-ordinator, UNRA</td>
</tr>
<tr>
<td>Gareth Hearn</td>
<td>Team Leader, HGL Consortium</td>
</tr>
</tbody>
</table>
Landslide issues pose some of the biggest constraints to effective road management in some areas; Among the greatest challenges are mudflows and debris flows from areas remote from the road (e.g. in Karamoja and Kasese); Landslides are increasing in area and in number; In areas where there were previously no landslides, they have now appeared; Regulations can prevent UNRA staff from carrying out mitigation works outside the road reserve; An holistic, multiple-use approach is needed for landscape management; There needs to be a greater interface between UNRA and Ministries of Agriculture, Environment and Mining; The Director agreed to circulate a landslide data sheet among the various UNRA stations.

**Discussion date** 9 January 2019  
**Participants**  
Name | Position  
--- | ---  
Immaculate Katusi | Senior GIS Officer, UNRA  
Alexander Oostenrijk | System Design & Development Specialist, HGL Consortium  
**Main points of discussion**  
Discussion of datasets and provision of shapefiles and ArcGIS geo-database files.

**Discussion date** 10 January 2019  
**Participants**  
Name | Position  
--- | ---  
Isaac Menya | Manager, Network Planning, UNRA  
Alexander van Oostenrijk | System Design & Development Specialist, HGL Consortium  
**Main points of discussion**  
Introduction to UNRA’s dTIMS (Dayton Total Infrastructure Management System). dTIMS runs on a Microsoft SQL Server database; Introduction to UNRA’s Traffic Information System, Bridge Management System, Pavement Management System and GIS; IM provided 2018 GIS shapefiles of the UNRA road network.

**Discussion date** 10 January 2019  
**Participants**  
Name | Position  
--- | ---  
Moses Musinguzi | Assoc Professor & Dean, School of the Built Environment, Makerere University  
Brian Makabayi | PhD student, School of the Built Environment, Makerere University  
Alexander van Oostenrijk | System Design & Development Specialist, HGL Consortium  
**Main points of discussion**  
Both Mr Musinguzi and Mr Makabayi are willing to share any data they may have that are relevant; The west of Uganda is an area where there are more earthworks failures than landslides per se; Mr Makabayi is working on some of the landslides around Mt Elgon;
Mr Musinguzi is promoting a ‘National Spatial Data Infrastructure’ whereby academic organisations and government departments might share geo-spatial datasets; The subject of landslide datasets and landslide susceptibility maps was briefly discussed. It would be a major exercise to develop a susceptibility map for the entire country, using digital elevation models and land cover maps etc. Land use change would also have to be addressed.
3 Field Visit

3.1 Purpose and Context

Between 10 and 12 January 2019 a visit was made to the UNRA Mbale station in order to observe some of the landslides that have impacted the roads in the Bududa and Mt Elgon regions. There have been several published papers concerning the landslides in this area, as well as the press coverage of the damage and fatalities they have caused. It was felt important to make this field visit in order to gain an understanding of landslide locations and mechanisms and also provide some background to the interpretation of aerial photographs that was planned to be undertaken in the Bodleian Library in Oxford, UK (see Section 4.2.1).

The Terms of Reference refer to the landslide problems in the regions of Rwenzori, Mufumbiro and Mt Elgon. Gareth Hearn has visited the Kabale-Mufumbiro region while examining ‘premature pavement failures’ on behalf of the Transport Research Laboratory, UK, for UNRA and was able to examine several predominantly cut and fill earthworks slope failures. It was important, therefore, to observe some of the natural slope failures in the Bududa-Mt Elgon region. A short visit is also planned to the Rwenzori area later during the progress of Phase 1.

3.2 Field observations

The field visit was attended by the following:

- Henry Nkwanga (ReCAP)
- Catherine Nabanoba (UNRA)
- Angella Lekea (UNRA)
- Gareth Hearn (HGLC)
- Mark Ruse (HGLC)

Mr George Ssonko, the UNRA Mbale Station Manager provided a brief introduction in his office to the landslide problems affecting the road network for which he is responsible. These included the following:

- Bulambuli in 2011-2012
- Bududa in 2013 and 2018
- Sironko in 2017
- Namisindwa in 2018

Mr Ssonko explained how some of these landslides originated on hillslopes far above the road, while others occurred on slopes adjacent to the road. The road was failing as a result of slow-moving landslides in some areas. Land ownership is very complicated, apparently, and cultivation is taking place right up to the edge of the road in places. There are no reports available on these landslide events, i.e. no central records appear to be kept, whereby the location and impact of past landslides are detailed. Mr Ssonko has received no geotechnical assistance in the management of these hazards. The project should be designed to assist with this critical aspect of landslide data collection and management.
The main sites of landslide and slope instability problems observed during the field visit are described and illustrated in Annex B. We would like to thank all those who contributed to the success of this field trip, and especially Mr George Ssonko and his colleagues.

3.3 Conclusions of the Field Visit

Probably the most profound conclusion to be drawn from this very rapid field visit was the fact that, in this part of Uganda at least, most of the problems affecting the road are due to landslide source areas relatively remote from the road reserve, and usually located on the slopes well above. This supports the comments made by Eng. Otim, Director of Road Maintenance, during our meeting on 9 January 2019. The exception to this is the subsiding section of road at Km 14-15 on the Kufu-Magale road where part of a pre-existing large and possibly deep-seated slide has been reactivated, with the road unfortunately constructed across it.

There is a very strong human element to all of these slope failures, in terms of fatalities and ongoing hazard. There is also the strong likelihood that land use is, in some cases, playing an important role in the development of slope instability, though there are insufficient data available at present to confirm this.

The field visit team were left with the strong impression that the most effective way forward would be to focus on the management of slopes outside as well as inside the road reserve, by bringing together community representatives and relevant ministries, including UNRA, to discuss ways in which the hazard and risk posed by future landslides might be managed and reduced through an holistic and integrated approach. Again, this reflects the views expressed by Eng. Otim. Although there are important issues to be addressed regarding the optimisation of land use within the road reserve from a slope management point of view, it does appear to be the case that it is what is happening outside the road reserve that is a) most relevant to UNRA in terms of damage to roads, and b) critical to lives and livelihood sustainability among local communities.

On the basis of this very limited sample of problem areas, it may be the case that there is justification in realigning the priorities away from the road reserve to the wider road corridor. However, the Team Leader’s knowledge of slope problems in Kabale District suggests the opposite. In Kabale the problem appears to relate to earthworks failures plus the use of slopes within the road reserve and outside them for borrow and quarrying. Nevertheless, there are important areas where communities living on slopes above the road reserve are at risk from slope instability, both due to natural causes and the effects of instability originating within the road reserve.

To conclude, therefore, in the overall network there appear to be important issues to address concerning the way in which slopes are managed both within and outside the road reserve, and this concerns both engineering management and the management of the land by rural communities. While this is somewhat different to the focus in the Terms of Reference and indeed during the kick-off meetings, it is our intention to examine this further during the progress of this Phase 1 Feasibility Study. The planned visit by the Team Leader and the Botanist/Bio-engineer to the Rwenzori area in March will help to clarify this.
4 Other Project Activities Ongoing During the Inception Period

4.1 Liaison with project partners and stakeholders
The UNRA project co-ordination team has helped facilitate discussions with key staff members within UNRA and with external agencies during the Inception period. Letters of Introduction are being produced for the following agencies and organisations, and these are currently in the process of being contacted by the engineering staff of ICS Engineering & Environment Ltd, in Kampala.

In progress:
Department of Surveys and Mapping
National Environmental Management Authority
Directorate of Geological Surveys and Mines
Disaster Preparedness and Management, Office of the Prime Minister
National Forest Authority

Planned:
Ministry of Works & Transport/Ugandan Road Fund
National Planning Authority
Ministry of Agriculture, Animal Industry and Fisheries
Uganda Electricity Generating Co Ltd
Ministry of Water and Environment
Ministry of Lands, Housing and Urban Development
Ministry of Energy and Mineral Development
Uganda Electricity Transmission Company
Ministry of Information and Communication Technology
Ministry of Local Government
Uganda National Meteorological Authority

4.2 Trialling of remote sensing data sources

4.2.1 Aerial photographs
The Bodleian Library in Oxford, UK holds a large archive of historical aerial photographs flown by the UK Directorate of Overseas Surveys. These are available for scrutiny at the Library, but they cannot be borrowed. Visits were made in January to examine selected air photographs of the Bududa and Rwenzori areas. This work is ongoing and will be reported on later in Phase 1.

4.2.2 Satellite imagery
The satellite image interpretation specialist has begun to look at options for landslide interpretation, but this activity will not be commenced in earnest until the findings of the air photograph trial are known.
4.3 Database and System Development

4.3.1 Introduction

Phase 1 is intended as a fact-finding exercise for the LRMT work, with the research and development scheduled to take place during Phase 2 and, especially, Phase 3. The information we have ascertained during the Inception period is outlined below.

4.3.2 UNRA’s software-based management systems

The entire software solution UNRA uses to manage roads is known as the Road Management System (RMS). Most of the RMS revolves around dTIMS, as detailed below.

**dTIMS**

For management of its road network, as well as decision-making support, UNRA makes use of dTIMS: Deighton’s Total Infrastructure Management System. Deighton describes dTIMS as a *Commercial Off-the-Shelf (COTS) Asset Management Solution*. The system allows UNRA to manage the inventory, condition, history and usage data related to transportation-related infrastructure assets such as road pavements, bridges and culverts, airports and traffic.

All infrastructure data in dTIMS are stored in an underlying relational database management system (RDBMS) – which is Microsoft SQL Server. Through dTIMS, UNRA defines database tables with identifying keys and typed fields, as required by the RDBMS. Using keys, dTIMS allows one-to-many and many-to-one relationships between tables.

Data Views and queries can be constructed over these tables, which are conceptually similar to SQL Server views and queries. These views allow users to combine and filter data in a desired form. More importantly, data views are dTIMS’s facility for exporting raw data into another application for mass updates, thus forming one way that the LRMT might read road network data from dTIMS.

dTIMS has the ability to import road network structure data from a GIS repository.

**Tables in dTIMS**

UNRA’s dTIMS setup consists of three base tables:

- Base
- Links
- Sections

These entities are related as follows:

---

1 www.deighton.com
In each record, a road, road link or road section is identified by a unique key. An example of a road key is A001, while a link of that road would be identified as A001_LINK01. Where the LRMT is concerned, the dTIMS keys should be considered authoritative definitions.

UNRA’s dTIMS implementation contains several other tables, grouped by purpose:

- Administrative: regions, districts, stations
- Inventory: culverts, line features, nodes, point features
- Condition: roughness, rutting, visuals, pavement strength

**dTIMS ecosystem**

According to the dTIMS user manual for UNRA, several other systems are connected to dTIMS and may contain information that is valuable to the LRMT. The Traffic Information System is implemented as a module within dTIMS, while the Bridge Management System is a separate web application that imports data from dTIMS.

As a web application, the Bridge Management System (BMS) must communicate with dTIMS in the same way that the LRMT would. If the BMS is provided with data regularly through file exports, then communication is trivial. However, if the BMS communicates with dTIMS through a web application, then this would open interesting possibilities for the LRMT to retrieve live data from dTIMS. At a later stage, a further study of the BMS implementation is recommended.
4.3.3 Inter-System Communication

The LRMT must communicate with dTIMS in order to obtain, at least, road network data and possibly data on other infrastructure. It appears there are several ways to do this:

- The LRMT can be provided with datasets exported from dTIMS through a data view. In order to keep the road network up to date, the LRMT would need to obtain these data from dTIMS regularly.
- The LRMT can communicate directly with dTIMS’s underlying SQL Server database as a read-only user, querying the database for the data that it needs. With this approach, the data would always be live.
- dTIMS may have a web endpoint that allows web applications to communicate with it. This may be the strategy employed by the Bridge Management System (to be confirmed). This approach, also, results in live data.

Complex data handling

It would be preferable for the LRMT to query dTIMS for data that it needs as users pan and zoom maps, since the road shapes are quite complex and would need to be simplified for display on Google Maps in a web browser. For display of complex shapes in Google Maps, there are two constraints: bandwidth and polygon complexity, as Google Maps can handle polygons up to a total of around 50,000 points drawn simultaneously on the HTML canvas without slowing down the user’s browser.

There are two strategies that the LRMT can employ to display complex shapes with high point densities. Briefly, these are:

- At low zoom levels, there is no need to display a shape at its highest (native) complexity. Shapes can be compressed using the Douglas-Peucker simplification algorithm, reducing point density considerably while preserving an approximation of the original shape curvature. At higher zoom levels, the shape complexity can be gradually increased until it matches native complexity.
- Shapes that fall outside the bounding box of the map window do not need to be displayed. By preforming pre-calculations that place shapes on an arbitrary grid, only visible shapes can be (downloaded and) shown. By adding more bands to the grid, fewer shapes are downloaded and displayed at the cost of more processing power on the server.

4.4 Development of a landslide datasheet

A landslide datasheet has been developed. The intention is for UNRA to organise the completion of this sheet for each landslide on the road network. The sheet will be completed by a representative from each UNRA Station and will be filled in for past landslides as well as those that occur and recur in the future. The content of the sheet has been discussed and agreed with UNRA and it should be ready for use as a web-based
Improving the resilience and quality of rural road infrastructure through landslide management and optimisation of road reserve use

application in early February 2019. In this regard, it can be considered as the first stage in the development of the LRMT.

4.5 Newspaper sources of landslide data

A review has been undertaken of newspaper publications concerning the incidence of landslides in Uganda. This will be reported during Phase 1.
5 Refined Approach, Methodology and Deliverables

5.1 Refined approach and methodology

One of the outcomes of the kick-off meetings was the need to maintain flexibility in the approach to this research as it develops. Based on the discussions during these meetings and the findings from the initial field visit, the focus is on the optimum management of the road reserve and the slopes within its corridor, i.e. the surrounding terrain, in order to minimise landslide and related slope instability hazards.

The other component of the work, as conceived during the preparation of the Project Concept Note, concerned the commercial use of the road reserve, and it has been agreed with UNRA that this component might form the subject of a later phase or a separately-funded exercise. It will, nevertheless, be examined further during Phase 1 to determine the range of skill-sets and datasets that might be required to implement it.

The table below repeats the activities to be covered under the Phase 1 scoping study in the left-hand column and the work we plan to undertake to address these activities in the right-hand column. It is emphasised that this approach is provisional and may be subject to change as the project progresses and in the light of stakeholder discussion.

<table>
<thead>
<tr>
<th>Phase 1 Scoping Study (from ToR)</th>
<th>Proposed activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Review of general and existing landslide management and road reserve use practice in Uganda, and internationally within ReCAP countries as a minimum, including associated management tools</td>
<td>1.1. Collate available desk study information on landslides and related road reserve slope management in Uganda 1.2. Field visit observations (Mbale &amp; Rwenzori) 1.3. International review based on consultant’s experience of ReCAP countries, any published ReCAP work and other country experience</td>
</tr>
<tr>
<td>2. Research on initiatives to optimise the use of road reserves to mitigate the adverse environmental impacts of road use, as well as maximise the socio-economic benefits of road reserves to UNRA and the local communities</td>
<td>2.1. Review the use of bio-engineering &amp; drainage management practice internationally 2.2. Examine 1.3 and 2.1 in the context of the Ugandan situation 2.3. Consider options for introducing an holistic approach to slope management inside and outside the road reserve, including field studies for Phase 2 and production of training and guidelines for Phase 3</td>
</tr>
<tr>
<td>3. Compilation of existing national data and information on landslides and road reserve use</td>
<td>3.1. Establish which Ugandan agencies have landslide datasets 3.2. Develop a UNRA landslide dataset based on landslide data sheet returns from UNRA Stations 3.3. Compile landslide dataset from published sources (where possible) 3.4. Use information collected during field visits (1.2)</td>
</tr>
</tbody>
</table>
### Phase 1 Scoping Study (from ToR)

<table>
<thead>
<tr>
<th>Proposed activities</th>
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</thead>
<tbody>
<tr>
<td>NOTE: Some of this compilation will continue into Phase 2, especially if existing data proves difficult to obtain and remote sensing proves suitable (4.2)</td>
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</table>

<table>
<thead>
<tr>
<th>4. Identify and assess the availability and cost of relevant aerial photographs, satellite imagery, and remote sensing data required to undertake all project phases</th>
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<tbody>
<tr>
<td>4.1. Discuss availability and cost of available aerial photography with Survey and Mapping Dept &amp; National Forest Authority</td>
</tr>
<tr>
<td>4.2. Determine during Phase 1 the potential contribution that remote sensing might make to landslide and related geo-environmental data collection for use in Phase 2</td>
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<thead>
<tr>
<th>5. Based on a desk study, propose a suitable methodology for cost-effectively locating landslides and developing vulnerability maps using a combination of suitable remote sensing and appropriate validation in field visits</th>
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<tbody>
<tr>
<td>5.1. This will stem from 3.1-3.4 and 4.1 &amp; 4.2.</td>
</tr>
<tr>
<td>5.2. A general landslide vulnerability (susceptibility) map might be produced for the country, and could be field tested (Phase 2)</td>
</tr>
<tr>
<td>5.3. More detailed assessments could be undertaken for specific areas combining a range of desk study and field-based observations (Phase 2)</td>
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<tr>
<th>6. Comment, and make recommendations on, the appropriateness of a combined or separately focussed landslide-and road reserve use initiative within the available budgets and timescales, and the proposed actions and deliverables listed under Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1. Consider the preferred structure and functionality of a landslide database</td>
</tr>
<tr>
<td>6.2. Assess how GIS geo-environmental layers for the wider terrain might be interfaced and analysed in conjunction with this landslide database</td>
</tr>
<tr>
<td>6.3. Suggest how land use might be interfaced with 6.1 &amp; 6.2</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Identify suitable sites for validation of the proposed methodology</th>
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<tbody>
<tr>
<td>7.1. These will be areas for implementing 5.3</td>
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<tr>
<td>7.2. They may also be areas for investigating approaches to holistic land management</td>
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<tr>
<th>8. Stakeholder workshop to agree the way forward for Phase 2</th>
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<tbody>
<tr>
<td>8.1. No elaboration required</td>
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<tr>
<th>9. Prepare an action plan for Phase 2 and outline plans for Phase 3 based on the findings from the activities above, within the agreed budget, for approval by the PMU and UNRA.</th>
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</thead>
<tbody>
<tr>
<td>9.1. No elaboration required, but Phase 3 will be heavily dependent on what is achievable in Phase 2</td>
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</tbody>
</table>
5.2 Deliverables

The following are the project deliverables and the required dates of receipt.

- Inception Report (this report) – 5 February 2019
- Landslide Review Report – 5 March 2019
- Phase 1 Draft Report – 2 April 2019
- Stakeholder Workshop Report – 14 May 2019
- Phase 1 Final Report – 11 June 2019

Should it be considered advantageous, it might be possible to shorten this overall timetable by perhaps 1 month, and we welcome the opportunity to discuss this with our project partners.

5.3 Quality and performance controls

Quality control takes place by internal peer review. The consultant team will be in continuous liaison to discuss methods and approaches, sources of data and how best to examine and review them.
Annex A. Kick-off meetings in Uganda

UGA2150A
AfCAP Improving Resilience and Quality of Road Infrastructure through Landslide Management and Optimisation of Road Reserve Use
Kick-off Meeting Minutes

<table>
<thead>
<tr>
<th>Date and Time:</th>
<th>January 8, 2019, 10:00 - 16:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
<td>UNRA Kyambogo Offices</td>
</tr>
<tr>
<td>Facilitator:</td>
<td>Dr Emmerentian Mbabazi</td>
</tr>
</tbody>
</table>

**Attending:**

- Hearn Geoserve Ltd Consortium (HGLC):
  - Rose Mugidde
  - Bryan Kwesiga
  - Alexander van Oostenrijk
  - Mark Ewart Ruse
  - Andrew Kasekende
  - Gareth James Hearn.

- Ugandan National Roads Authority
  - Emmerentian Mbabazi
  - Catherine Nabanoba
  - Angella Lekea
  - Wilber Lukwago
  - Rosemary Kisembo
  - Immaculate Katutsi
  - Rodgers Mugume
  - Mark Henry Rubarenzya

- Research for Community Access Partnership
  - Henry Nkwanga

**Apologies:**

- John Howell (HGLC)

### AGENDA TOPIC #1: Introduction
Emmerentian Mbabazi (EM) convened the meeting and asked for introductions.

**AGENDA TOPIC #2: Administrative Issues**

- This meeting is confirmed as the formal project start point in terms of deliverables.
- EM was confirmed as UNRA’s Key Contact for day-to-day project management. She noted that UNRA expect the project to be sustainable after the Consulting team left country, with knowledge transfer.
- HN was confirmed as ReCAP’s project contact.
- MER noted an HGSL field trip to Mt Elgon and a potential trip to Rwenzori, including John Howell.

**Action Items:**

- UNRA to provide HGLC with an Introductory letter to support the field visit

**AGENDA TOPIC #3: Web-based Dataset**

- AvO introduced his ability to manage the project outputs and need to know what the UNRA set-up and expectations are.
- RK – Head IT UNRA: UNRA have no current vision of what software or data management framework should be used. Noting that the project addresses Landslides (LS) and Road Reserve (RR), would they be one or two separate systems? How would the output integrate with other existing Road Management Systems (Bridge, Pavement and Traffic Management)? IT is also concerned with security issues involved with the introduction of a new software application.

**AGENDA TOPIC ACTIONS:**

- EM
• HN: There could be one or two systems, as appropriate for ongoing UNRA use of the data. [Later comment: from experience working with other local authorities that previously operated numerous standalone road management systems but later opted for integrating them as far as practicable, may be it is best to combine both the LS and RR management systems. This is a task for the Consultant to investigate and propose a way forward.

• HN: The Terms of Reference (ToR) are purposely modular, in which the external specialists start with a scoping phase (Phase 1) with literature review and recommendations. This would encourage the Project Management Team to review their own information base and expectations, to appraise what will be proposed for taking forward under the current modest budget; ReCAP could consider funding, or additional projects to address the components that will emerge to be outside the scope of this project. ReCAP is scheduled to end in July 2020, but funding may become available for extension; the present project is expected to evolve into other ongoing works.

• [Point raised later in meeting] AvC: Is the Management System Output to be used for predicting?

• HN: Most likely, depending on consultant’s recommendations, but expectation is that the system can help with designing/specifying stakeholder intervention measures rather than just a data storage space. This will not just be a 2 year programme, but iterative. As before, Phase 1 recommendations can suggest tasks be recommended for future additional works rather than everything being done now under this project.

• [Point raised later in meeting] RK: Appreciate request to be open at present. Will the result be web- based or mobile? Referring to a previous project that included developing a management system, the mobile component was found to be out of scope. Will it be a data exchange or a fused system, with shared data or shared functionality?

• HN: Agree that it would be a system that allows sharing of information across government agencies rather than shared functionality of systems.

• MER: While field data is generally best created in an offline system, the project requires web-based output.

**Agenda Topic #4: Road Reserve Component**

• HN: Continuing from discussion of Terms of Reference, the project history was of two separate components, addressing landslide activity and road reserve management. ReCAP and UNRA saw an opportunity to explore synergies between the two components: the current Phase 1 is a time for the Consultant to discuss how these issues overlap, and recommend ways that the project might advance in Phase 2.

• WL (Senior Environment Officer) noted that there is a Road Reserve Policy Document that addresses the entire road reserve, away from landsliding areas. Problems of encroachment would be increasing RR vulnerability. The project might need a sociologist for the RR component.

• MER: Landslide hazard, from the road margins or upslope, intersects with the vulnerable facilities of the RR (downslope) to produce risk. There is a strong logic in focusing on RR issues at this intersection between LS and RR. Previous studies for road asset management (eg Hong Kong) have taken years of registration work, and this would be impossible under the present Terms of Reference. What is known of RR landuse? Is there a dataset or register that can be readily used in Phase 2? If any extra personnel such as a sociologist is identified as necessary during the scoping study, it will be incorporated into the phase 2 proposal.

• EM: There is value in starting the project by addressing locations where landsliding is known. The scope can be addressed by starting with LS areas, the relevant RR areas potentially affected, and the economic value arises from protecting assets and any benefits to local communities.

• WL introduced a ten year programme to optimize RR use (“Green Right of Way-GROW”); where do LS issues sit within that?

• HN said Phase 1 of the current work is intending to capture how things are, to propose if LS/RR issues are one or two management systems, and address the issue of distance from the road centerline to be considered for LS vulnerability.

• [Later in meeting] CN (Geotechnical Engineer- UNRA): Is the Road Reserve only addressing landslides? There are many other issues relating to RR.
**Agenda Topic #4: Landslide Vulnerability**
- HN: Terms of Reference shows how the study will address the Road Reserve in the Phase 3 report. The aim is to extend beyond landsliding over time, but the project may not even get past Phase 2, or UNRA may take the project on. The terms are not overly fixed on RR.
- RM: Keep in mind how to scope the RR component. We need to focus on everything related to the road infrastructure only, and the road reserves. Even if we wanted to intervene to avoid landslides, we cannot plant vegetation on land we do not own.
- HN: Optimisation of RR needs government guidelines, not available for the 95% of network that is rural, so agreed that correct focus is needed.

**Agenda Topic #5: Assistance with Obtaining Data**
- MER: We have prepared a list of possible datasets required and institutions that may hold such datasets. We would like all attending to provide information or contacts on possible source datasets for HGLC to pursue.
- HN: Perhaps EM could start a circular e-mail for all attending? The consultants are supposed to find all required data, by identifying the agencies where data can be found and then sourcing it. UNRA has a supporting role only.
- MER: Other sources? Immaculate as UNRA GIS specialist? Other pursuit of data to come from HGLC’s local partner ICS. Request Ministry of Works Road Design Guidelines, UNRA Draft Design Guidelines (prepared 6 years ago by an external consultant?)
- HN/RM: Discussion of best documents: MoW Trunk and Rural Roads. Special Specifications of UNRA. MER to request by e-mail
### Agenda Topic #6: Executive Director, UNRA visit and Introduction of Afternoon Session
- **MHR**: General introduction of Research and Development Department, and to Executive Director Allen Kagina.
- **EM**: Introduction of the project aims, of the coming together of LS and RR issues to promote road network resilience, currently through data mining for Phase 1 Scoping works.
- **HN**: Introduction of position as DFID representative, Regional Manager for East and Southern Africa. Very good project prospects, hoping to do well and replicate elsewhere: a flagship project.
- **GJH**: Wide ranging project: Phase 1 direction is issue of addressing earthworks failure and/or off-RR landslides that may impact road: two different processes. Must be based on generating facts and good basic knowledge first; many studies do not get to the heart of the problem. Is land-use, for example, the real driver of most slope problems affecting the road reserve? Need to maintain a scientific approach.
- **Allen Kagina (ACK)**: Research Unit must be a key part of UNRA, providing more current solutions than simply generic concepts. Examples of impact: landslide hitting a hospital lead to deaths. Must remain open minded to solutions. Concerning the RR, UNRA is the largest land-owner in Uganda, RR is to expand from 15 m to 40 m from the centre line: how can the road reserve be managed to be of benefit to all concerned?

### Agenda Topic #7: Issues of Scope
- **MER**: Summary of morning’s discussion for benefit of new arrivals
- **HN**: Must clearly stipulate how to pursue the overlapping issues of landslides and road reserve management. What can we reasonably address?
- **RM**: Perhaps focus on UNRA jurisdiction; mindful of budget constraints we need to focus on UNRA’S road reserve
- **GJH**: What is UNRA most interested in? Is it landslide susceptibility maps, is it guidelines for road reserve slope management or is it the need to integrate road reserve and landslide management with the wider issues concerning land use and the community?
- **HN**: There are clear objectives in the Terms of Reference (ToR), which can be redefined as we go along; the phased approach of the project ToR allows us to appraise what we are doing as we progress. ReCAP does not expect a complete solution, there may be scaling back in some areas and extensions in others
- **GJH**: ReCAP, UNRA and HGLC need to maintain communication and agree on the way forward: this is not a standard consultancy.

### Agenda Topic #8: Summary of Project Aims
- **GJH**: What are UNRA’s main concerns regarding landsliding? What does UNRA specifically require from the project? Is it the distribution, cause and mechanism of landslides and earthworks failures with regard to their impact on roads?
- **GJH**: In Phase 1 HGLC intends to confirm the main issues, commence data collection (for example using UNRA road maintenance records) and recommend and define the detailed way forward for Phases 1 and 2. Whatever work is to be done is constrained by the availability and coverage of data. We need to identify potential sources of data, what datasets are routinely collected and whatever else can be obtained, e.g. by remote sensing and field visits. Then move to Phase 2 with a vulnerability model, a viable predictive tool, but should this be a blanket approach for the country or focused on key areas? Susceptibility models need good data and we may need to develop pilot areas in order to maximise it. HGLC will investigate the use of remote sensing and other sources of data.
- **RM**: We do not appreciate the difference between a landslide and an earthworks failure. We hope the project can clarify the difference. **HN**: Agreed that initially the scope’s focal point is the UNRA highway.
- **HN**: Could the output be useful for route selection?
- **GJH**: Yes, guidelines can be provided as part of the Phase 3 deliverables
- **MHR**: Management wants to know about the vulnerability of the UNRA network, focusing on landslide management as water engineers focus on catchments. Focus on real landslides, not newspaper views of landslides. As the road network expands, we need to avoid vulnerable areas. Use lessons from the past to
assisting with future planning. Decouple optimized road reserve (RR) management from landslide management.

Note it is research, so start in the right direction and move ahead: how to optimize road services. We can avoid landslide damage through route selection.

- GJH: Concerning route selection, it will probably be the case that we will not be able to provide ‘go’ and ‘no-go’ areas but rather guidelines on how to identify areas that could become problematic as far as slope stability is concerned. Concerning landslide data and susceptibility points, do we all agree with this approach?
- GJH: We should consider how the road reserve is managed in the context of landslides and slope stability and the interface with adjacent communities and their use of the land. At this feasibility stage, we can review the literature on Uganda and other regional examples, and conduct a field visit.

[MHR had to leave this meeting to conduct other business.]

### Agenda Topic #9: Immediate Action - Field Visit
- General discussion: Contact George Ssonko of Mbale District (EM will organize, including letter of introduction). HN to join imminent HGLC field visit to Mbale.

### Agenda Topic #10: Immediate Action - Obtaining Data
- General discussion: contact Director of Road Maintenance. There are 5 regional managers, 26 station managers that might be able to provide landslide data. Aerial photographs from UNRA?
- AvO: Intends to discuss information systems and data availability with RK and IK, and to explore the likely web-based output. There are many options to explore and these depend on UNRA’s likely intention for use.

### Agenda Topic #11: Immediate Action – Clarify Scope
- HN: Schedule meeting with MHR to ensure convergence of intention with regard to addressing the Road Reserve (ie, at the interplay between landsliding/slope issues and road reserve management). Ensure there is awareness of what can be achieved within the current project budget.
- AK: Can we clarify what the purpose was of the ToR reference to socio-economic issues?
- HN: There were two separate project concepts, addressing the LS and the RR, and these concepts were amalgamated; much has been done on the RR within UNRA, but not yet implemented (HN can provide information relating to the original intention of this LS/RR interaction.) Thus Phase 1 of this project is to determine the relative priority or direction of LS/RR investigation prior to the start of Phase 2.
- HN: Is there data available about the economic use of the RoW?
- EM: Not currently known of; thus, probably not.

### Summary of Action Items:
- EM to provide letter of introduction “To whom it may concern” and set up meeting for tomorrow am. with MHR
- EM to help establish contacts for imminent fieldtrip (especially Mbale Station Manager)
- HGLC to provide list of datasets required
- HGLC to provide list of institutions that may hold such data
- Introduction letters to specific departments
- AoV to have further discussions with RK and IK for GIS data and system discussion
- MER to request Design Guideline Documents.
**AGENDA TOPIC #1: Introductions**

- **MHR** provided an introduction to the project for **TM** benefit
- **GJH** provided a summary of the key project elements, as follows:
  - It was important to fully understand and discuss **UNRA**’s concerns with respect to landslide hazards affecting the road reserve
  - Reliable data on landslides incidence was critical to assessing the distribution of landslide hazards affecting the road network. This includes landslides occurring within the road reserve, and those outside of it that impact the road reserve, ie, on slopes above or below the road reserve.
  - Our aim is to gather all existing data, including examining what information can be obtained from aerial photographs and satellite imagery
  - In the assessment of road reserve vulnerability to landslides it is important to develop outputs of practical use to **UNRA**. This will involve the identification of vulnerable areas and the development of guidelines for road reserve management and land use management in the context of slope stability
  - Participatory management of the road reserve is important, allowing communities to use the road reserve for livelihood sustainability while also encouraging slope stability, erosion control and drainage control
  - It is important to focus on holistic slope management from an engineering and community-based point of view, i.e. all stakeholders are engaged so that the realization of stability of the road reserve and the adjacent slopes can be maximized

**AGENDA TOPIC #2: Assumptions, Risks and Budget**

- **MHR**: Can the consultant list their assumptions and perceived risks at this stage?
- **GJH**: Our technical proposal contained a tabulated list of potential sources of risk that were identified at that time, and these were mostly concerned with data availability. The table outlined what measures might be taken to combat these risks
- **MHR**: Has the consultant budgeted for purchasing data?
- **GJH**: This is the scoping phase, there is no requirement for budgeting
- **HN**: a budget of £10,000 has been set aside for the acquisition of satellite imagery. It may be possible to use some of this if required at this initial stage for other miscellaneous costs. If not, additional requirements can be reviewed by **ReCAP**
- **MER**: We are drawing up a list of potential data sources and Emma will organise introductions to agencies that might have this data. With specific data requests it will be possible to determine what costs might be incurred in obtaining this data
- **[Raised Later in Meeting]** **HN**: Does the project need a risk register? Usually you would establish a basic risk register to begin with and then progress it as the project proceeds. This would lead to the timely redirection of focus, if required.
- **GJH**: We identified potential risks in the technical proposal and a draft register can be produced for the Phase 1 report
- **MHR**: A risk register is very important for project management
### Agenda Topic #3: Data Mining
- MHR: UNRA is 10 years old and R&D has been established for 3 years. The Ministry has a longer history with information that extends back further before the establishment of UNRA. Older staff members will be a great source of information on landslides on the road network.
- TM: The Ministry has information on soils and geotechnical ground conditions contained in various reports prepared for projects over the years. The Ministry could make this information available if required. The Ministry would like to see clear guidance coming out of the outputs. The research should feed into policy documents.
- MER: This would be interesting and we might be able to use some of the MoW information in selected areas to help make the geomorphological assessments more rigorous.
- GJH repeated the point raised earlier that it was important to focus on UNRA’s concerns relating to landsliding.
- MHR: Yes, but also it is important not to become biased, or pre-conceived i.e. the consultant should decide how best to go about the research and of course consult with R&D as the project progresses in terms of direction and focus.

### Agenda Topic #4: Road Reserve Component of Project Scope
- HN circulated the original project Concept Note for information. He referred to a specific section that stated the aim of developing ‘… a plan for the use of the road reserve to mitigate environmental and social impacts of roads through roadside vegetation barriers and water harvesting…’ This should be the focus of the road reserve optimisation study.
- GJH: it is clear in the ToR that this is the case, and this is reflected in the team composition and in the consultant’s Methodology.
- HN: We need a phased approach and to understand that all aspirations cannot be fulfilled due to limited resources, including both finances and time frame. We need to focus on what we are discussing here and we may find that other related elements of work might have to be funded separately.
- GJH: the optimum use of the road reserve is intended to focus on holistic road reserve management. This results in the livelihoods of rural communities that cultivate roadside slopes (within and outside of the road reserve) being maintained while at the same time promoting soil conservation, drainage control and slope stability. This can be of economic benefit to UNRA if these communities engage in sustainable slope management that ultimately reduces slope maintenance costs. DFID has undertaken this work in other countries, especially Nepal, where ReCAP has an ongoing project on participatory roadside slope management. Our project botanist has extensive experience in this field and can develop guidelines specific to the problems faced in parts of the UNRA road reserve. The ESIA specialist has the environmental and social development experience of Uganda to support this. Trials are to be scheduled during Phase 3 for this work.
- MHR: I now understand the direction that you are going in.
- There was general discussion on the Grow programme and the work Wilber is doing in terms of the demarcation of the road reserve, its ‘beautification’ and environmental impact mitigation.
- GJH: There is also the issue of legal/illegal roadside borrow pit excavation and quarrying activities. As well as posing health and safety concerns, there are cases he had seen where uncontrolled roadside excavation had resulted in slope failure with boulders landing on the road.
- MHR: this is a good point. It is important to provide guidelines so that these activities can be better managed.
- RM: The problem often arises when the local communities say that this is our land, we can do what we like with it.
- GJH: all the more reason for the optimum use guidelines to include these issues as well.

### Agenda Topic #5: Any Other Business
- MHR: The R&D department has qualified geotechnical engineers who are well aware of landslide problems. They understand the problems very well. Are there any points raised in the ToR that require clarification?
- GJH: Paragraph 5 in Section 1.2.2 of the consultant’s technical proposal states ‘One issue that will need to be defined at the commencement of the project is the manner in which UNRA expects to derive socio-economic benefit from the enhanced management of the road reserve.’ It had now been made clear by HN that this relates to the extract from the Concept Note (‘… a plan for the use of the road reserve to mitigate environmental and social impacts of roads through roadside vegetation barriers and water harvesting…’), i.e. the interaction between roadside community use of the land and the need to manage slope stability through bio-engineering, community participation and effective drainage control. So, this is now clarified.
- MHR: I appreciate the direction in which you are going. I have not read the technical proposal, can I have a copy?
- HN: We will need to consult ReCAP procurement over this request.

### Action Items:
- EM produced a general letter of introduction for the consultant to use, i.e. ‘to whom it may concern’ but more specific details will be required from the consultant to go into individual letters. MER to provide a list and the details required.
- MHR: Should we have regular catch-ups via Skype or similar?
- It was agreed that regular interaction by all parties will be necessary.
- MER and TM to meet about MoW data.
- GJH to meet Director, Road Maintenance.

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Annex B. Notes from field inspections in the Bududa and Mt Elgon areas

Km 14+200 Kufu-Magale Road (UTM 36N 651376/98906)
In May 2018 the road subsided here over a length of approximately 1.2 km. Movements appear to be planar and are occurring on an 8–10° slope in clayey soils, though there are rotated blocks occupying intermediate scarps. Standing water was observed 0.5m below ground level. The subsidence appears to be associated with the reactivation of a much older, probably pre-historic landslide. Local residents suggest that ground movements also occurred 20-30 years ago, though there is some uncertainty over the reliability of this information. The morphological evidence suggests that a reactivated movement has taken place some time in the recent past, and that the road is now affected by further reactivations. Sections of road appear to be moving faster than others, and neighbouring houses have collapsed or been abandoned. Nevertheless, many families still remain, living on and continuing to cultivate the slopes. Mr Ssonko reported that local accounts suggested that the diversion of stream water for irrigation purposes on the slopes some distance above the road might have been a contributory factor to the reactivation of ground movements.

Top left: horizontal and vertical deflection to the road
Top right: rotated block (with reverse slope) in intermediate scarp
Bottom left: horizontal displacement to the road. Buildings in distance have been abandoned
Bottom right: roadside dwelling abandoned due to excess ground movements
Improving the resilience and quality of rural road infrastructure through landslide management and optimisation of road reserve use

Km 12+670 Bubulo-Bududa Road (UTM 36N 649250/113824)
The road was blocked here for 2-3 days following the deposition of a debris flow fan across the road in 2010. The debris flow originated from a landslide source several hundreds of metres above causing approximately 365 fatalities. A similar landslide was deposited on the road at 14+080 at approximately the same time, blocking the road for a week and contributing to the number of fatalities.

Km 5 Namagumba-Budadiri Road (UTM 36N 637057/127146)
This is the start of an 8 km length of road where the approx. 2m high cut slope has failed into the side ditch, impeding drainage and causing gradual retrogression (sliding extension) in an upslope direction. The soil is a fissured silty clay and in places has developed on colluvial soils (derived from previous landslide activity). Banana plantations are common alongside the road and the limited width of the road reserve prevents the implementation of any remedial works. In places, some low-cost solutions, including earthworks and bio-engineering, could assist in encouraging stabilisation but this would require land acquisition.

One of the villages in this section is called Nagulutri which apparently is the local word for ‘landslide’. Landslide activity seems to have been going on for a long time, certainly at least 50 years, according to an elderly resident.

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Km 6 Nalugugu-Elgon Road (UTM 36N 644519/139579)
In 2018 rocks fell into the road at this location and the carriageway is now narrow as a result. There is also a 40m long section of road that appears to be subsiding.
In 2011 a mudflow blocked the road at this location which took 2 weeks to clear. Approximately 12 people lost their lives in the neighbouring village. The road and the villages in this area appear to have been constructed on colluvial aprons overlying completely weathered tuff. The weathered tuff comprises what appears on visual inspection to be a plastic clay. There is a cliff-line approximately 200m above (to the southwest of) the village. A large spring emerges from the toe of this cliff and there is evidence of other springs and sources of surface water runoff that must seep into the slope above the village. There is also an indication that this spring water is diverted onto the slope that failed in 2011, though the local farmer was adamant that this irrigation does not take place in the wet season. On the basis of the morphological evidence, the volume of the slope failure that gave rise to the mudflow was 7,000m³.
Improving the resilience and quality of rural road infrastructure through landslide management and optimisation of road reserve use

Pre-mudflow Google Earth image showing cultivated slope between spring and village

Post-mudflow (current) Google Earth image showing grassed over landslide scar (centre of image) between spring and village
Improving resilience and quality of rural road infrastructure through landslide management and optimisation of road reserve use

Top left: slide scarp below two villages
Top right: view up the failed slope towards the cliff-line
Bottom left: excavation of completely weathered tuff for plastering village house walls
Bottom right: pointing towards the location where the copious spring emerges from toe of cliff (NB spring water not visible)

**Km 8 Bulegani-Bullago Road (UTM 36N 648718/140874)**

In 2011 a mudflow with an approximate volume of 20,000m³ blocked the road for 3 weeks or longer. There were also several fatalities according to local residents. The mechanism of failure appears to be broadly planar, though there may have been an element of rotation as well. The angle of the pre-failure slope appears to have been 8-15°, and movement was presumably triggered by a high water table in completely weathered tuff. The presence of relatively fresh tension cracks/scarps towards the top of the slope suggest that it is still potentially unstable.
Improving the resilience and quality of rural road infrastructure through landslide management and optimisation of road reserve use

Left: failed slope with side scarp in background
Right: tension crack/scarp at the top of the slide area

Km 8+600 Bulegani-Bullago Road (UTM 36N 649074/140232)
An approximate 1,000m$^3$ rock topple occurred from the cliff above the road in 2018. Fortunately, the debris did not reach the road and the road was unaffected. The debris still poses a potential hazard, as does the potential for further rock falls from the cliff.

Rock fall scar above the road, road runs along base of pine trees

The final location the team visited was to the site of a major rock fall from a cliff that killed 7 people in August 2018. The location is far from the road, but the mechanism and location
are probably indicative of the potential for rock falls from other sections of near-vertical cliff in the region. The cliffs appear to be formed in volcanic agglomerate rock and is inclined at 60° or steeper. It is very difficult to estimate the volume of this rock fall, but it could have been of the order of 6,000-10,000m³. The rock fall appears to have occurred as a result of sliding along a stress-release joint in the rock mass. There remains a further mass of rock, also defined by this steeply-sloping joint, that could also fail in the near future. The volume of this mass could be of the order of 3,000-4,000m³. Other scars on the cliff are indicative of previous rock failures and, according to local residents, the boulders that litter the slopes below the cliffs, i.e. above the main village area, are the result of individual rock falls that occur each year.