PROJECT: ROAD MATERIALS AND AGGREGATE INVENTORY DATABASE – PHASE 1

Inception Report

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Orion Consulting Associates (OCA) in association with Link Asea

RAF2101A

June 2017
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Cover Photo: Jan Bijl

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AfCAP Inception Report Template

AfCAP Database Details: RAF2101A Road Materials and Aggregate Inventory Database

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Abstract

This report covers the inception period of the project Road Materials and Aggregate Inventory Database Phase 1. The project has three phases: Phase 1 – Scoping study to identify a suitable architecture for a materials database, Phase 2 – Development of the database and partial population for beta-testing, and Phase 3 – Rollout to partner countries, including training. The project will be implemented in close collaboration with the 12 AfCAP partner countries in Africa, namely Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Liberia, Malawi, Mozambique, Sierra Leone, South Sudan, Tanzania, Uganda and Zambia.

During the Inception stage, a desk review and stakeholder survey was carried out to assess the current institutional framework for materials information management in the partner countries as well as their current materials database systems and needs. Of those who responded, only one (1) partner (Ethiopia) has only recently developed a materials database, which is currently being trialled.

The main priority of the stakeholders is to have a materials database with a mapping tool showing borrow pits and quarries, their typical properties and potential use in road works. Based on the stakeholder feedback, the proposed countries to be visited during Task 2 (fieldwork consultations) for problem analysis, conceptualising the database model and defining the system requirements are Ghana, Ethiopia and Mozambique. In addition, the Consultant proposes to visit Namibia to review their well-tested materials database system.

Key words

Acknowledgements

We would like to acknowledge the contribution of the AfCAP partner countries; in particular staff involved in completing the stakeholder survey and supplying us with information about materials information management in their country, the Africa Community Access Partnership (AfCAP), Project Management Unit (PMU), staff from the Namibia Roads Authority (NRA), Department of Roads in Botswana and the Zimbabwe National Road Administration (ZINARA), staff from Transport Research Laboratory (TRL) and other key informants and materials experts who have shared information with us and facilitated networking with other countries.

Acronyms, Units and Currencies

$     USA Dollar (US$ 1.00 ≈ 23.04ETB, 61.86MZM, 4.24GHS, 2235TZS, 108.65 SSP)
ADB   Asian Development Bank
AfCAP  Africa Community Access Partnership
ARTReF  African Road and Transport Research Forum
AsCAP  Asia Community Access Partnership
BPIIM  Borrow Pit Information Module
CBR    California Bearing Ratio
DMS    Data Management Specialist
DRC    Democratic Republic of Congo
ERM    Entity Relationship Model
GDP    Gross Domestic Product
GIS    Geographical Information System
GMS    Gravel Management System
GNI    Gross National Income
GPS    Global Positioning System
HVR    High Volume Roads
HWSD   Harmonized World Soil Database
ISRIC  International Soil Reference and Information Centre
IT     Information Technology
LVR    Low Volume Roads
LVSR   Low Volume Sealed Roads
MDIS   Materials Database and Inventory System
MI     Materials Inventories
MIM    Materials Information Management
MRD    Ministry of Rural Development
NRMD   National Road Materials Database
NRA    Namibia Roads Authority
NRMS   National Road Materials Information System
NRMS   Namibia Road Management System
OCA    Orion Consulting Associates
PMU    Project Management Unit
PO-RLA/  President's Office – Regional Administration and Local Government
PRMD   Pilot Road Materials Database
RECAP  Research for Community Access Partnership
SADC   Southern African Development Committee
TL     Team Leader
TOR    Terms of Reference
TRH    Technical Recommendations for Highways
TRL    Transport Research Laboratory
UAV    Unmanned Aircraft Vehicles
UK     United Kingdom (of Great Britain and Northern Ireland)
AFRICA COMMUNITY ACCESS PARTNERSHIP (AfCAP)

Safe and sustainable transport for rural communities

AfCAP is a research programme, funded by UK Aid, with the aim of promoting safe and sustainable transport for rural communities in Africa. The AfCAP partnership supports knowledge sharing between participating countries in order to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources. The programme follows on from the AfCAP1 programme that ran from 2008 to 2014. AfCAP is brought together with the Asia Community Access Partnership (AsCAP) under the Research for Community Access Partnership (ReCAP), managed by Cardno Emerging Markets (UK) Ltd.

See www.research4cap.org
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Executive Summary

Information on the availability of suitable materials for road construction and maintenance is being collected but usually contained in site-specific project reports and not readily accessible. The development of a generic database linked to a mapping tool providing a detailed inventory of available road materials has been identified as one of the priorities by many AfCAP partner countries and some AsCAP countries have also expressed an interest.

The project will be implemented in close collaboration with the 12 AfCAP partner countries, namely Democratic Republic of Congo (DRC), Ethiopia, Ghana, Kenya, Liberia, Malawi, Mozambique, Sierra Leone, South Sudan, Tanzania, Uganda and Zambia.

The project has three phases: Phase 1 – Scoping study to identify a suitable architecture for a materials database, Phase 2 – Development of the database and partial population for beta-testing and Phase 3 – Rollout to partner countries, including training. This report covers the inception stage of Phase 1, which was commissioned to Orion Consulting Associates in association with Link Asea. The scoping team consist of Jan Bijl (Team Leader) and Ravindra Corea (Data Management Specialist).

This main objective of the scoping study is to identify the needs and architecture for a materials and aggregate inventory database that can be implemented by the partner countries for improved management of materials for the improvement and maintenance of roads, in particular Low Volume Roads (LVR). The scoping study will also provide a detailed plan and budget for the development and testing of the database (Phase 2) and actions for training and rollout to partner countries (Phase 3).

The scoping study will be carried out from April to August 2017. A regional stakeholder workshop, to present and discuss the draft database report and recommendations, is planned in the beginning of August 2017 at a venue yet to be decided.

The desk review and stakeholder consultations during the inception showed that:

- Very few AfCAP partner countries have an operational materials database in place. Of those who responded to the stakeholder survey (seven countries), only Ethiopia has recently completed the development of a materials database;
- Elsewhere in Africa, middle income countries such as South Africa (e.g. Western Cape Province), Namibia and Botswana have a roads materials database in place which according to key informants are well established and good examples to be followed;
- Outside Africa, under the South East Asia Community Access Program (SEACAP) a materials database was piloted in 2 provinces in Cambodia but never implemented by the host institution, the Ministry of Rural Development. A materials database was developed under joint DfID-World Bank funding for the Ministry of Public Works in Indonesia (1989 – 1997), but its current status is uncertain;
- Although private laboratories have emerged, in most countries the responsibility for road materials testing and data management lies with the National Road Authority or the Ministry responsible for roads, typically through the materials and research division and a Central Materials Laboratory;
- Materials information management is generally under resourced in terms of budget, staffing and equipment. This is one of the key challenges that will not only affect the development of the database but also its operation and sustainability;
The main priority of the stakeholders is to have a materials database system showing locations of existing borrow pits and quarries, the material properties, available quantities and their potential use and cost in road pavement and surface layers;

The desk review of literature has revealed how various indicators (remote sensing, botanical and landform indicators among others), have been used for prospecting of unexplored materials sources.

The development of a generic materials database system provides an opportunity to use materials prospecting tools (such as materials indicators) as part of a Geographical Information System (GIS) or other suitable mapping tool.

Based on a desk review of relevant literature and initial consultations, the Consultant proposes to conduct the stakeholder field consultations in Ghana (western Africa), Ethiopia (eastern Africa) and Mozambique (southern Africa). This would refine the problem analysis, define the user needs, conceptualise the database model and functional requirements.

In addition, the Consultant proposes to visit Namibia or Botswana to review the experience and lessons learned of an established and, reportedly successful, Materials Information System.

In line with the priority of the stakeholders and their resource availability, the basic requirements of the generic materials database have been explored and the inception stage conclusions include:

- The database should at least cover existing material sources, their properties, quantities and potential use in road pavement layers;
- The database should include the capability to interface directly to a mapping tool;
- The database should benefit all roads, low and high volume;
- The database should be simple to use and easily accessible (e.g. web based) for road industry professionals;
- The database should be flexible enough to accommodate country specific requirements (including, where feasible, interface with existing road asset management systems) and its implementation should be based on a pragmatic, staged development process.
1 Introduction

1.1 Africa Community Access Partnership

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

The second phase started in August 2014, runs for 6 years and is managed by Cardno Emerging Markets (UK) Ltd. The aim of the second phase, under the overall Research for Community Access Partnership (ReCAP) umbrella, is to build on the high-quality research established under AfCAP phase 1 and take this forward to a sustainable future in which the results of the research are adopted in practice and influence future policy making in the rural road sector.

The AfCAP partner countries and their income status are shown in Figure 1.

![AfCAP Partner Countries](image)

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<th>Partner countries</th>
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Figure 1: AfCAP partner countries and their income status

The majority of AfCAP partner countries are low-income economies with a Gross National Income (GNI) of less than US$ 1,025 per capita\(^1\). Only Ghana, Kenya and Zambia have a lower middle-income status with a GNI of between US$ 1,026 and US$ 4,035 per capita. In comparison, middle-income countries like South Africa, Botswana and Namibia, have a GNI in order of US$ 5,000 – 6,000 per capita.

A country’s income status is an important (not the only) indicator to explain road sector performance. A study by the World Bank in 2008\(^{[25]}\) concluded that half of the countries in Sub Saharan Africa are not allocating adequate resources to road maintenance. Of those, half cannot even meet their routine maintenance needs. Under spending on maintenance is evident in all low-income countries, whereas middle-income countries do better and spend above the maintenance norm.

A study\(^{[25]}\) also concluded that road construction and maintenance costs are rising and road design standards should be cost-effective. On average 30% of the road network was found to be over-engineered for the traffic carried. Road design standards should be adapted to the local the conditions and available materials to avoid excessive costs in road construction and maintenance.

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\(^1\) World Bank Atlas method
maintenance, in particular for low volume roads. This requires a good knowledge about the locally available materials as an input to the road design process.

### 1.2 Rationale of road materials and aggregate inventory database

Acceptable quality road construction material sources are becoming increasingly scarce in many Sub-Saharan countries. Uncertainty regarding the availability of road construction materials gives rise to delays in the planning and design of road construction and maintenance projects. Although information on materials used for construction and maintenance of roads is being collected, it is usually contained in site-specific project reports and therefore not readily accessible to the community of practitioners.

The development of a generic database that is linked to a mapping platform providing detailed inventory of materials in terms of location, properties, quantities, their previous use and performance in road construction and maintenance has been identified as one of the priorities by many AfCAP partner countries. To prevent duplication of effort, it is intended that this project will scope the general requirements and architecture of a generic materials database that can be used by interested AfCAP partner countries for a more efficient and effective planning and costing of road works.

Although the main focus of the project relates to materials sources for Low Volume Roads (LVR), typically defined as those carrying less than 1 Million Equivalent Standard Axles in one direction and less than 300 vehicles per day, it is difficult to make a clear distinction between materials information management for LVR and High Volume Roads (HVR). In practice, borrow pits and quarries are not exclusively used by one category of road projects. Moreover, institutional responsibilities for road asset management, including materials information management, are assigned according to the administrative and/or functional classification of roads, not by their level of traffic (e.g. LVR or HVR).

### 1.3 Project scope

#### 1.3.1 Objectives of the project

The ultimate objective is a generic road materials database with a mapping tool showing the borrow pits and quarries with their typical properties and potential use, that is made available for population and use by partner countries. Capacity building, uptake and embedment is an integral part of the project but more relevant towards the later stages of the project (Phases 2 and 3).

#### 1.3.2 Project phases

The project has three phases:
- Phase 1 – Scoping study to identify a suitable architecture for a materials database;
- Phase 2 – Development of the database and partial population for beta-testing;
- Phase 3 – Rollout to partner countries, including training.

Phase 1 of the project has been awarded to Orion Consulting Associates (OCA) in association with Link Asea. The team consists of:
- Jan Bijl (TL), Orion Consulting Associates, bijl@orion-associates.com
- Ravindra Corea (DMS), Link Asea, rcorea@linkasea.com

#### 1.3.3 Objective of Phase 1

Phase 1 is to identify the needs and architecture of a natural construction materials and aggregate inventory database that can be implemented at national level for improved management of
materials for the various categories of roads, in particular LVR. The scoping study will also provide a
detailed plan and budget for the development of the database (Phase 2) and actions for training and
rollout (Phase 3).

1.3.4 Tasks of Phase 1

Phase 1 of the project (April – August 2017) has four distinct tasks:

- Task 1: Inception and desk review of current database\textsuperscript{2} systems;
- Task 2: Problem analysis, conceptualise database model and system requirements through
  fieldwork consultations in three selected countries;
- Task 3: Regional stakeholder workshop to present findings and recommendations;
- Task 4: Finalization of the conceptual database model.

1.3.5 Deliverables Phase 1

The deliverables for Phase 1, the Scoping Study of the project, are:

- Inception report
- Draft database report for presentation at the regional workshop
- Regional stakeholder workshop to present and discuss findings and recommendations
- Final database report with a work plan and budget for Phase 2 and Phase 3

1.4 Inception and desk study report

The inception stage provides an initial indication of the basic information requirements, which will
then be refined during the following tasks. Through the literature review and consultations, the
Consultant will review lessons learned from other materials database systems established and also
assess how remote sensing and material indicators (e.g. botanical species) could be used to enhance
the effectiveness of road materials prospecting.

After the introduction in Chapter 1, this inception and desk study report describes the activities
undertaken during the inception phase (Chapters 2 - 4), the initial findings, considerations and
recommendations in respect of the materials database development (Chapter 5) and the work
ahead (Chapter 6):

- Chapter 2: Sets out the basic systems development considerations that would apply to this
  project, based on current best practice, in the context of the initial information obtained
  through the country surveys and desk review of literature;
- Chapter 3: Presents the results of a survey among AfCAP partner countries, designed to
  identify the stakeholders’ institutional framework, current database systems in use, and
  their needs and expectations;
- Chapter 4: Describes a desk review of literature and key informant consultations to review
  existing materials database systems in use and lessons learned, assess how materials
  indicators have been used for locating unexplored material sources and identify any
  synergies with AfCAP and other regional initiatives;
- Chapter 5: Initial findings, considerations and recommendations for further work;
- Chapter 6: Planning the work ahead.

Annex A presents a list of all documents reviewed as part of the inception stage.
Annex B includes a list of all persons and stakeholder institutions consulted during the inception stage.

\textsuperscript{2} The term “database” is used in a general sense throughout much of this report, to mean an information system
consisting of a database and suitable applications software providing one or more user interfaces.
2 System development

The proposed Road Materials and Aggregate Inventory Database may, in technical terms, be viewed in terms of two main components: a “database” – i.e. a repository of data organised in such a way as to support certain types of queries and views of the data; and a set of “applications software” that provide users with convenient means of accessing the data for analysis, viewing, updating, maintenance or download. The two components, collectively referred to as a “system”, here, would usually be supported by different technologies: a database management system for the database and a wide range of software development and deployment technologies for the applications.

2.1 Critical Success Factors in System Development

The development processes applicable to the design and development of a system such as this are well established in Software Engineering. However, it is useful to link these general principles to the specifics of this initiative from the outset, setting out a basic set of guidelines to frame subsequent analysis and design activities.

The project may be viewed in terms of two primary perspectives: The user perspective (or user domain), which is concerned with how such a database would be used by the respective countries in their road construction and maintenance works; and The systems development perspective, which is concerned with the challenges of building and implementing a system that supports user needs effectively.

1. The user perspective. How will the materials database be used by the respective countries?
   This relates primarily to the type of information that would need to be available and updated in the database, and the various systems and processes surrounding its use and maintenance. This would largely be driven by generally applicable road engineering processes, as well as the policies and procedures of the roads sector, in particular, materials information management, in each country. In this project, the user perspective may be further sub-divided into:

   a. The management of materials source data (borrow pits, quarries) obtained through conventional testing methods for which results may already be available in paper or spreadsheets format, but not well collated or easily accessible to others. Such data need to be renewed or updated from time to time as new sources are identified and additional testing data becomes available.

   b. Information on how and where such materials have been used in road maintenance and improvement projects (selected fill, pavement layer, wearing course), the workmanship testing during construction and in-situ performance during service life. Related to this, guidance may also be provided on how such materials can be used for future projects, in particular relevant for low volume roads.

   c. New ways of prospecting potentially suitable (but unexplored) materials and their locations, taking advantage of remote sensing technology and other material indicators (see also Chapter 4). These methods can be used for initial screening of material sources and can save on costly and time-consuming field investigations.

2. The systems development perspective. The success of failure of any systems development enterprise, especially its sustained use and maintenance, depends on attention to certain basic aspects of systems development that apply regardless of the user domain. Importantly,
the critical success factors are not typically technological, but are related to how well the system integrates with the users’ domain. The following are perhaps most relevant in this project:

a. **Ownership.** At partner country level, there needs to be an entity that “owns” the initiative and has a vision for its long-term use and development. It must also have the authority to implement any policy, regulatory and/or procedure changes that may be required for implementation. This needs to be established at the outset as it sets quite firm practical boundaries on the policies and processes surrounding the system and therefore its functional design.

b. **Completeness and integrity of data.** How well have user requirements been examined and reflected in the system? For example, the planned users may be government engineers, consultants and contractors preparing designs and bids. If the database lacks important information, it would require either revisiting former project documents or conducting new tests, potentially making the database redundant. The same would happen if the integrity (accuracy and consistency) of the stored data were questionable, either undermining the use of data as an input to the road design process, or if such were to be used, raising liability issues.

c. **Integration within regular operational processes of the users.** Information systems that depend on a separate set of activities to maintain the accuracy and currency of data, are difficult to sustain over time, as the key process of maintaining it is viewed as being secondary to the main business of users. However, if the system can be integrated within the primary work processes of the institution, with points of intersection strategically identified at an early stage, update of information occurs almost as a by-product of regular work. An example is the update of sales, and stock information, automatically, in a retail enterprise, simply by deploying electronic point of sale systems at checkouts. A similar focus at the design stage, on integration with road maintenance and construction processes or research activities, could greatly improve the chance of success.

d. **Excessively ambitious scope.** Possibly one of the key causes of failure of information systems projects is the attempt to design and build systems that comprehensively cover all identifiable aspects of the user domain in one or two large steps. Such projects tend to be expensive, take too long to develop, and often discover that business conditions have changed during the development so that requirements identified at the outset are no longer valid. The current popularity of Agile methodologies was motivated by the observation that projects designed to deliver the first set of useable outputs within a short time, followed by several more development and implementation phases, showed greater success rates. Agile processes are typically based on a series of very short development cycles (often of just a few weeks duration) that each deliver a useful functioning output.

e. **Designing for future needs.** In order to proceed in a series of small but useful and logical stages as discussed in “d.” above, it is necessary to ensure that the overall structure of the design is based on a thorough understanding of the user domain and is designed to support future needs to the best degree possible. The conceptual technological split between database and applications software discussed above is especially relevant here. The database design, which is based on an “enterprise data model”, needs to be as comprehensive as possible. This is feasible because it is based on the characteristics of the domain (road construction and maintenance in this case), which is not expected to change fundamentally. However, a great deal of flexibility is available in terms of the applications software, both technologically and
in terms of how the data is used, so that it may be developed in small stages, redeveloped (for web-access, for example) and maintained independently.

2.2 The Development Process

The conventional software development process is viewed as a series of sequential tasks that make up the development life cycle. The "Waterfall" method was a widely used example of this approach. Modern practice (such as the "Agile" method) favours a process based on short development cycles, where many of the same tasks are required albeit in a compressed and sometimes less formal style, applied through many iterations. The use of documentation to express requirements and specifications is also replaced, in many modern methodologies, with prototypes and other models.

The typical steps in systems development include:

- Identification of user requirements, through consultation with stakeholders as well as mapping and modelling of current processes and data requirements.
- Analysis of the user requirements to produce a system specification, which may separately identify Functional specifications and Technical specifications.
- Detailed System design.
- Software development, which includes programming and unit (module) testing.
- Implementation, which covers deployment on the appropriate hardware, linkage of the relevant components and upload of initial data
- System testing and user acceptance testing
- Maintenance.

In this project, the process is less straightforward, due to the fact that many countries are involved and it is still unclear whether a generic design is feasible. Based on an initial review of the information available, it is likely that differences in process and user needs across countries will require the final steps of software design and development to be addressed individually. This does not, however, preclude the development of a generic model, especially at database level, and even choices of technology that maybe reviewed and refined for implementation in each country, as needed.

This scoping study will therefore focus on:

1. Identification and analysis of user requirements at generic level to produce a set of high-level functional requirements. Wherever possible, this will include high-level models of key processes and points of integration with existing work processes.
2. Analysis of the user domain to produce a high-level enterprise data model, expressed as an Entity-Relationship Model (ERM).
3. Identification of recommended stages for systems development, including suggested scope and timescales for those stages.
4. Production of Terms of Reference for software developers, which would include reference to these high-level design decisions and to a recommended process.
5. Recommendations on technical choices, with a view to long-term costs and maintainability, including interfaces to other systems and technologies.

While these outputs will not be at a level of detail sufficient to proceed directly to software development in most cases, it is anticipated that they will be robust enough to provide a strong framework on which to base subsequent development.
3 Stakeholders survey: institutional framework, current systems and needs

3.1 Survey design

One of the tasks of the inception phase was to conduct a stakeholder survey among AfCAP partner countries to establish:

1. What systems are currently in use by partner countries?
2. What data is available?
3. How user-friendly are these systems?
4. Are they suitable for possible customization and use in other countries?
5. What are the expectations and data requirements of the potential users of the database?
6. What is the computer literacy of the end users?

This would give a first good indication of the minimum requirements for the database system to be developed. After analysis, it was concluded that some of these questions were too complicated for a questionnaire and better discussed during Task 2, the stakeholder fieldwork consultations. The survey was therefore designed around three main topics:

- Part A: Current institutional framework for road materials data management
- Part B: Current road materials information management systems
- Part C: Requirements and expectations for improved road materials data management

The survey form (questionnaire) is attached in Annex C of the report. The survey was sent out on Monday 24 April to all partner countries. Respondents were given 2 weeks (until Friday 5 May) to complete and return the questionnaire. Another reminder was sent on Monday 1 May.

The questionnaire was sent to the institution (department) responsible for materials testing and information management. The feedback therefore reflects the materials information management perspective (client view) and does not necessarily reflect the views of other potential users (government engineers, consultants, contractors, researchers).

3.2 Stakeholder’s level of response

Out of the 12 AfCAP partner countries, 7 completed and returned the questionnaire. The other 5 partner countries did not return the questionnaire. **Table 1** summarizes the response.

<table>
<thead>
<tr>
<th>Partner country</th>
<th>Questionnaire completed and returned</th>
<th>Questionnaire not returned on time</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRC</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Ghana</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Liberia</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Malawi</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Mozambique</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>South Sudan</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

3 The partner from Liberia confirmed that currently no materials database is in place.
Table 1: Stakeholder Survey Response

<table>
<thead>
<tr>
<th>Partner country</th>
<th>Questionaire completed and returned</th>
<th>Questionaire not returned on time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Zambia</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Sections 3.3 – 3.5 provide a summary of the feedback obtained from the respondents. More details are presented in Annex D.

3.3 Institutional framework for materials information management

The Institutional framework would determine both “ownership”, as described in Chapter 2, and capacity for implementation of a materials information management system in the partner country.

Several aspects are relevant, of which the following are among the most prominent:

- **Policy decisions or plans.** If, for example, the institution responsible for road materials management in the country has already identified the need for a database, or has begun initiatives to establish both data collection and management processes, one of the foundations for successful implementation would already be in place. Establishing priorities for what types of data are required based on detailed knowledge of the anticipated use (e.g. road design, tendering, research, etc.), will be an important next step and the extent to which such prioritisation has already been done will enhance prospects for success. Most of the respondents to the survey appeared to have identified priorities, at least in terms of high-level requirements. Specifying the priority areas of application of the database, and the specific information needs of those use cases, will be a key focus of consultations with participating institutions and this will also provide the basis for establishing the order of implementation of software modules.

- **Integration with work processes.** The opportunities for data collection and the availability of data, even in paper based files, often depend on a range of factors, including whether works are executed directly by government agencies or outsourced to private sector entities. In the former case, materials information could well be available in one place and the task of converting and maintaining information in electronic format would be simpler. If works are typically outsourced, the procedures for contracting and whether they are amenable to adjustment, to ensure for example that data collected under each contract is made available to the client agency in a specified format, could be a key factor in maintaining the currency of data in the future. Identifying such opportunities for integration with mainstream work processes would be an important platform for a successful system. Formal policy decisions may be required to implement and consolidate changes to processes.

- **Facilities and resources available** for road materials management. This may include the resources available for identifying and testing materials and updating that information on a systematic and regular basis so that users may rely on the completeness and accuracy of the database. The linkage with other systems, such as road asset management systems may also be relevant. In addition to expertise and capacity in materials management, access to a certain minimum level of Information Technology (IT) capacity, whether in house or outsourced, will also be an important factor.

Accordingly, the initial survey and desk review explored some of these areas. Some important findings are discussed below.
The institutional responsibility for road materials information management in most partner countries lies with the national road administration or authority, which would typically have a designated section for materials and research, with staff numbers ranging from 6 (Mozambique) to as many as 26 (Uganda) and several laboratories, typically one central materials laboratory and various regional or provincial laboratories (Sierra Leone, Tanzania, Mozambique and Ghana). On an increasing scale, privately operated laboratories (ranging from 1 in Sierra Leone to 15 in Tanzania) are emerging in the materials testing market. This is an important development; ideally all road materials testing data in the country should be collected, not just those from public institutions. However, private laboratories are running a business model and will have different views on sharing information.

In most partner countries the management of rural roads is delegated to a feeder roads department, local government ministry or district councils (in the case of Kenya, to the Kenya Rural Roads Authority). These institutions typically have a lower resource base and rely on the national road administration or authority for materials information management and testing facilities. Considering the budget constraints in the road sector (see section 1.1, most countries struggle to keep their road network under regular maintenance), parallel structures for materials information management should be avoided at all cost. In most countries, it would appear sensible to work with the national road agencies and closely involve other institutions managing lower classes of roads.

The majority of partners have IT and GIS specialists in their institution that would be available to support the materials database development, except South Sudan and the President’s Office – Regional Administration and Local Government (PO-RALG) in Tanzania. GIS software is generally available and mostly used for mapping purposes and to support road network planning and design.

Table 2 shows the staffing and budget allocation for materials information management and materials testing.

<table>
<thead>
<tr>
<th>Materials Database Modules</th>
<th>Staffing</th>
<th>Budget (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Academic</td>
<td>Technician</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Mozambique</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>South Sudan</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Tanzania (PO-RALG)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Uganda</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2: Local resource availability

Table 2 shows a significant variation in the availability of resources between some of the countries, which in part can be explained because of the difference in road network responsibilities. Data received from Ghana (staff and budget) and Sierra Leone (budget) seemed disproportionately high and has therefore not been included in the table. These figures will be reconfirmed and presented in the next report. Between the other 5 countries, Mozambique and Uganda have the highest budget allocations for materials information management and testing.

A clear institutional ownership, sufficient resource availability and strong management support systems (e.g. IT) are pre-requisites for a successful development and sustainment of materials database systems.
3.4 Current materials database systems in place

In terms of materials information management, only Ethiopia confirmed to have developed a road materials database system, which is currently being trialled. This was only recently developed in a Microsoft Access database. It mainly contains materials testing data from road design reports: material properties (grading, Atterberg limits, material strength, etc.), source location, estimated quantity and a description of the material. The database was developed with support from an external service provider. It is not yet linked to a GIS but ambitions exist to do so.

The other six respondents confirmed that they do not have a database system in place although in some countries (e.g. Mozambique and South Sudan) materials testing data (borrow pit and quarry location and materials description) is stored electronically in excel files but this is not easily accessible and data cannot be queried. Of the 5 countries that did not respond, secondary sources of information suggest that Malawi may have (had) a materials database in place but its current status is unknown.

The survey response creates the impression that materials information is predominantly used by in-house staff of the road agencies and less so by external partners (consultants, contractors, researchers). This could well be explained by the fact that for major works on HVR, engineering consultants and contractors bear a contractual liability for materials testing and have the means to carry out materials and aggregate prospecting and materials testing thus relying less on existing information about sources and test results. Whereas for the case of LVRs, government engineers or agency staff do most of the road design work in-house and they have to rely more on existing materials sources and test results (there is a lack of resources for materials investigations as an input to project design and supervision). This is a fundamental difference that needs to be better understood and will be further explored during the consultations with government engineers, consultants and contractors as part of Task 2.

The survey feedback also shows that improved materials information management is seen as a priority by the client institutions in the road sector.

3.5 Stakeholders’ needs and expectations

With respect to stakeholders needs and expectations (mainly from the client perspective), the main challenge of road materials information management is an obvious one; most countries do not have a road materials database in place and information on the location, availability and properties of road materials is not readily accessible. This uncertainty affects the planning, design and costing of road maintenance and improvement works. The reason why such databases have not emerged is frequently quoted as financial constraints to support extensive data collection and data processing exercises.

But there could be another factor that was not explicitly mentioned. Most of the central materials laboratories and materials information systems (see also chapter 4) originate from an era where road works were designed and constructed by force account operations (good examples are Zimbabwe and Tanzania). Information fed into the database was fully controlled by the materials engineers of the ministry responsible for roads whilst the main users of the database were government project engineers. There was full control over data collection, materials testing procedures, quality assurance and data storage. As a result of the commercialization (and privatisation) of the road sector in most African countries, most of the works are now designed by consultants (in particular for HVR, less so for LVR) and contracted out to private contractors.
With contractual liabilities passed on to consultants and contractors, both the demand and the supply side of materials information and testing data have changed significantly.

The recent trend to let out long term performance based maintenance contracts is also particularly relevant in this context. Under performance-based contracts, contractual risks are passed on to the bidder/contractor who need objective and reliable data on the availability of road materials, the materials used in the pavement layers and historical data on pavement performance.

The stakeholder survey also inquired about the importance of different type of materials information. Table 3 shows that the highest priority (number 1 showing the highest priority and number 7 the lowest priority) from the respondents is information about material properties of soil samples and aggregate products obtained from existing sources.

<table>
<thead>
<tr>
<th>Materials Database Modules</th>
<th>Ethiopia</th>
<th>Ghana</th>
<th>Mozambique</th>
<th>South Sudan</th>
<th>Tanzania</th>
<th>Uganda</th>
<th>Sierra Leone</th>
<th>Final Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials properties of existing quarries and borrow areas</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1 (14)</td>
</tr>
<tr>
<td>Geotechnical investigations</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2 (19)</td>
</tr>
<tr>
<td>Materials and workmanship testing of road works</td>
<td>-</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>4 (19)</td>
</tr>
<tr>
<td>Location mapping of quarries and borrow areas</td>
<td>-</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3 (21)</td>
</tr>
<tr>
<td>Road pavement evaluation and performance data</td>
<td>-</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5 (28)</td>
</tr>
<tr>
<td>Prospecting tools for locating unexplored materials sources</td>
<td>-</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>6 (30)</td>
</tr>
<tr>
<td>Road alignment (subgrade) testing</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>7 (35)</td>
</tr>
</tbody>
</table>

Table 3: Materials Database Modules and their priorities

This priority setting will be reconfirmed during Task 2 when there is an opportunity to also discuss this with a wider group of stakeholders, most importantly, consultants and contractors.

Training needs identified for road materials inventory and information management include various aspects of database management, materials testing techniques and the use of topographic maps and satellite images as an indicator for materials location and prospecting.
4 Desk review and key informant consultations

The purpose of the literature desk review (see Annex A) and key informant consultation (see Annex B) was to answer the following questions:

- What materials database initiatives have taken place in low and middle-income countries, and what lessons can be learned from them (Section 4.1)?
- Could the database make use of materials indicators (other than field work and sample testing) for prospecting of unexplored road materials (Section 4.2)?
- Are there any potential synergies with other AfCAP regional projects (Section 4.3)?

4.1 Road materials database development: initiatives and lessons learned

The TL participated in the ReCAP regional stakeholder workshop on 5 and 6 April 2017 in Tanzania where the Development of Guidelines and Specifications for Low Volume Sealed Roads through Back Analysis (RAF 2069A), carried out by TRL, was discussed. This workshop provided a good opportunity to present the objectives of the project and get initial feedback from the participants, mostly representatives from the AfCAP partner countries, on the following issues:

- Which of the AfCAP partner countries has an operational materials and aggregate database in place?
- Do you know of any low-income country that has successfully established a materials database and managed to keep it operational?

With respect to question 1, the majority of partner countries indicated that they did not have an operational materials database system in place other than a paper-based archive. Ethiopia mentioned that they have (only recently) established a materials database. With respect to question 2, the feedback from participants pointed towards some interesting developments in Africa and South East Asia:

- Indonesia, the Indonesian Construction Materials Information System (ICMIS);
- Cambodia, the Pilot Materials Database for the Ministry of Rural Development;
- South Africa, Western Cape Province, Borrow Pit Information Module (BPIM);
- Namibia, the Materials Information Management (MIM);
- Botswana, the Materials Database and Inventory System (MDIS);
- Zimbabwe and Malawi, Materials Inventories (MI).

The consultant has reviewed documents and contacted key informants to better understand how these databases function and what their current status is. In some cases, information on the operational status of the materials database was not received in time for the submission of this Inception Report. Any additional information obtained will therefore be included in the next report.

The outcome of the desk review and consultations is briefly described in sections 4.1.1 – 4.1.6.

4.1.1 Indonesia, the Indonesian Construction Materials Information System

The Indonesian Construction Materials Information System (ICMIS) was developed with support from DFID and World Bank (1988 to 1997). ICMIS \[^{26}\] includes materials data in terms of their location, quality and quantity from all 26 provinces of Indonesia.
Major factors contributing to the development of ICMIS were: i) the absence of an existing materials database, ii) the identified need within the Indonesian Ministry of Works (MOW) to have a centralised materials information system, iii) an existing road research institute that could host the database, iv) recently completed terrain evaluation and topographic maps, and v) existing materials data from the provincial administrations.

ICMIS was developed over a number of years through various trials, data collection, training and mainstreaming phases:

- Phase 1 Background and Research: review of existing systems and identification of key data sets (3 months)
- Phase 2 System Set Up and Trials: Design of Database files systems, data collection forms and output procedures. Trials in one province (9 months)
- Phase 3 Nation Wide System Set Up: National input of provincial data sets and refinement of database design.
- Phase 4 Mainstreaming: roll out of provincial level data collection (and updates) and reporting procedures through training programmes and workshops.

Key aspects in the design and implementation ICMIS were:

- The use of standard relational database software
- Collection, storage and manipulation of data in separate but related files
- The use of coded data to simplify information entry and manipulation in the database
- The use of standard data collection sheets
- Standardised laboratory testing programmes
- Procedures for data reliability and quality checking
- Standardise output forms
- A programme training workshops

ICMIS was taken over by the Indonesian MOW and used for locating materials sources for national and provincial road projects and costing of materials use in national and provincial road programmes. It also provided inputs to land use planning and was a starting point for road materials research. The current status of ICMIS is unknown. Any additional information obtained on its current status and use, will be included in successive reports.

4.1.2 Cambodia, the Pilot Materials Database for the Ministry of Rural Development

The pilot materials database was developed by TRL in association with local consultants KACE during 2007-2009 for the Ministry of Rural Development (MRD) with support from the DFID funded SEACAP [2]. The pilot was developed in two regions using sample data of the location and properties of road materials sources.

The database, which had a GIS capacity linked to local maps, contained six main tables:

- Location: quarry’s location, utilities, processing capabilities, accessibility and environment
- Material: available materials at the quarry sites
- Product: quarry products derived from the available materials
- Samples: materials samples taken for testing
- Test results of soils: materials tests on soil samples
- Test results of aggregate: materials tests on aggregate samples
After the pilot, it was anticipated that the Pilot Road Materials Database (PRMD) would be expanded, firstly, into a National Road Materials Database (NRMD) and subsequently into a wider National Road Materials Information System (NRMIS) through the inclusion of road materials testing information from existing roads and road pavement performance data.

These ambitions never materialised. Reportedly, the material database was developed near the end of the SEACAP program. The time only allowed for population of the database with typical data sets of operational quarries, gravel deposits and road alignment subgrades after which the database was handed to the client. The database was never institutionalised and rolled out nationwide, let alone upgraded to the NRMD and NRMIS. The lack of local ownership may have been another key factor.

4.1.3 South Africa, Western Cape Province, Gravel Management System (GMS)

The Gravel Management System (GMS) forms part of a suite of software applications to assist the Western Cape, Department of Transport and Public Works, in the strategic and operational management of the provincial road network [23,24]. The GMS also assists the district and municipality managers and consulting engineers with the operations of gravel road improvements and maintenance activities, as illustrated in Figure 2, including materials testing and design approval.

![Figure 2: Relationship of GMS to other management systems](Source: 22)

The purpose of the Borrow Pit Information Module (BPIM) is to capture all information related to existing borrow pits including location, ownership, material properties, materials quantities and their suitability for different layers in the pavement. Materials testing results are recorded for each separate investigation (see Figure 3) carried out for that particular borrow pit and as such provides a timeline of the materials’ properties sampled. The BPIM forms part of the project cycle where samples submitted by consultants are approved or rejected by the client as part of road design and contract supervision quality assurance procedures. The person who registers soil samples (usually consultants) receives a notification through email about the results and the outcome of the investigation. All borrow pits are uniquely referenced using road name, chainage (km) and location.
The gravel testing results include among others: grading analysis, Atterberg limits, California Bearing Ratio (CBR) / density relationship, moisture content, TRH-14 classification (relevant if the material is used for pavement layers) and TRH-20 classification (relevant if the materials is used as a wearing course).

The Consultant has requested more information about the current status of the database and how it is being used in practice but this information was not received. Through secondary sources, it is understood that the GMS is fully operational and forms part of the gravel road management system.

### 4.1.4 Namibia, Materials Information Management (MIM)

The Namibian, Materials Information Management (MIM) is an integral part of the Namibia Road Management System (NRMS) of the Namibia Roads Authority (NRA). The users of the database are mainly in-house staff from the NRA construction materials sub-division.

The MIM includes a mapping tool of borrow pits and quarries, but is not yet fully populated because there is a shortage of staff to import materials testing data. The programming language of the database is out-dated and the ambition of NRA is to re-write on the open source Postgres platform. The laboratory system also needs to be integrated with the MIS but will only become a priority once the NRMS modules have been re-written.

The Consultant has requested more information from the NRA but this was not received in time for this Inception Report. It is proposed to pay a short visit to Namibia as part of Task 2 to witness the actual performance of the MIM and discuss experiences and lessons learned in more detail.

### 4.1.5 Botswana, Materials Database and Inventory System

Like in many other African countries, finding suitable material for road construction and maintenance has become increasingly difficult in Botswana. With conventional road materials becoming scarcer, the Materials and Research division of the Roads Department at the Ministry of Works and Transport decided in 2007 to develop a materials database to better manage the use of road materials.

TRL was commissioned to design and implement a Materials Database and Inventory System (MDIS). The system includes a list of materials sources (borrow pits, quarries and associated test data), quality control testing data of “as-build” pavements and pavement performance evaluation tests [24].

The MDIS is operational and reportedly a successful materials inventory. The Consultant has requested more information from the Materials and Research division but this was not received in time for the Inception Report. If not possible to visit Namibia (see section 4.1.4), the Consultant proposes to visit Botswana instead.
4.1.6 Zimbabwe and Malawi, Materials Inventories (MI).

As part of the DFID funded Collaborative Research Program on Highway Engineering Materials in the Southern African Development Committee (SADC) Region [1], TRL supported the Departments of Roads in Zimbabwe and Malawi to establish an Information System for Managing Road Construction Material Resources.

The objective of the project was to have a repository in which data on the location and use of road materials would be centrally accessible. Zimbabwe and Malawi were selected because significant amount of materials data was already available in these countries.

In Zimbabwe, the Materials Inventory (MI) module was part of a larger road asset management system. The MI comprised 9 separate database files including borrow pit location and material properties, road centreline soil testing and road pavement description and testing. The amount of historical data at the Central Roads Laboratory was so much that it took 4 staff members 3 years to enter data. The database contained 65,000 records and 2.25 million data items by the end of the project in 1999. Interestingly, the project in Zimbabwe also piloted the use of GIS by showing the digitised road network, location of borrow pits and a summary of their properties.

In Malawi, the MI had a different feature covering test data for road specific borrow pit and quarry testing as well as road alignment soil investigations. The amount of data was considerably less (4,300 records and 116,000 data items) than in Zimbabwe but it still took 2 staff members, 2.5 years to enter data.

Although both inventories were developed under the same project, separate databases had to be developed because both countries used different standards for materials testing and different templates for data collection.

More information has been requested about the current status of these database systems but this was not received in time for the Inception Report.

4.1.7 Some additional remarks about existing materials databases

A key factor in ensuring that a new system is properly embedded and sustained long-term, is to identify and implement specific points of integration with existing work processes. A general policy decision, for example, recommending, “the use of the materials database in design work wherever possible” is often insufficient. A more specific direction that requires all materials testing results to be in a specific electronic format, and to be accepted only after entry in the database verified by some formal output from the system, for example, is more likely to ensure currency and accuracy of the data.

In this respect, the BPIM implemented by the Western Cape Province, South Africa, provides a good example. The literature available and feedback obtained from the other initiatives does not (yet) provide adequate detail on this aspect, but it will be a key focus of investigation in Task 2 in respect of both successful and unsuccessful examples.

4.2 The use of indicators for road materials prospecting

With available road materials becoming scarcer, a structured approach to materials prospecting can be important tool for materials prospectors and road engineers. Through literature review [4,7,16,19], an overview is given of how different indicators are used for unexplored road materials prospecting. It is important to mention that the soil forming process is complex and dependent on many different, time and place related, variables. Although indicators mentioned below are useful as an
initial screening tool to further reduce the search area for further field investigations, sample testing is always required to confirm the physical and engineering properties of road materials, as well as the quantity of the available material.

4.2.1 Geological information and climate
Most of the road materials are derived from weathered rock. The parent rock material is therefore an important factor influencing its physical and engineering properties. Over time, parent rock undergoes a series of geomorphological processes, a combination of chemical and mechanical weathering, erosion, transportation and deposition forming different soil-rock profile. Temperature, pressure and exposure to water (rainfall, groundwater), play an important role in the weathering and soil forming process.

In Sub Saharan Africa the Weinert n-Value \[^{[5]}\] is used to classify wet \((n < 2)\), moderate \((2 < n < 5)\) and dry regions \((n > 5)\). By combining geological and climate maps (Weinert), to some extent soil-forming processes can be predicted and used as a first indicator for materials prospecting. Most of these maps are can be geo-referenced and uploaded to a GIS and used in combination with other relevant data sources.

4.2.2 Soil information
Soils maps of the AfCAP partner countries are readily available (see Figure 4), usually through the responsible Ministry overseeing agriculture. They are mostly prepared to guide agriculture and food production but also provide important clues to engineers with respect to soil origin, soil properties, drainage capacity and their texture. One challenge is that they are often only available as paper copies. If they are to be effectively used as a road materials indicator in combination with other data sources as part of a multi-layered GIS they require geo-referencing. This can be a challenging task for staff inexperienced working with GIS and may require specific training.

![Soil types](image1) ![Soil maps](image2)

Figure 4: Example of Soils Maps from Mozambique and Tanzania

Where local soils maps are not easily available, another useful open data source is the Africa Soils Atlas \[^{[18]}\], a collaborative initiative of the European Union (EU), the African Union (AU) and the Food and Agriculture Organization (FAO) to support the sustainable use of soil resources in Africa. The soil maps presented in the atlas are derived from the Harmonized World Soil Database (HWSD) \[^{[17]}\].

The HWSD soil data is derived from a number of existing regional and national sources of soil information similar to those presented in Figure 4. The scale of the input data varies from 1 in 1 Million (for Eastern and Southern Africa) to 1 in 5 Million (the Sahara, West Africa and most of Central Africa).
The World Reference Base (WRB) categorises soils within 32 main groups, of which some are of particular interest to road engineers and material prospectors, e.g. lithosols ([4] some contain ferricrete), luvisols ([4], some contain good gravels), calcisols (some contain nodular calcrete), plinthosols (some contain laterite) and arenosols.

All the maps contained in the atlas (geological, soils, climate) have been produced for use in GIS (as a shape file) or Google Earth (as keyhole markup zipped file) and can be easily uploaded with other data layers (e.g. the road network).

Besides soil classification the atlas also provides useful geo-referenced information (albeit at a large scale) of indicative particle size distribution, climate zones, annual precipitation, mean annual temperature, soil moisture regime and estimated depth of the groundwater.

The atlas further provides a detailed description of key characteristics of each soil type, a typical profile (e.g. a photo of the soil horizon), their associated landscape and a broad distribution across Africa. It should be noted however that a particular type of soil is not limited to the areas shown on the map, i.e. on a local scale, other soil types and local variations may be present and more significant.

4.2.3 Land form information

Land classification recognises distinctive patterns of landscape (land forms), which have been created by interaction of different components of the natural environment (mainly rock, soil, topography, vegetation and climate). The underlying concept of landform observation and terrain classification is that where these components have the same character and operate in a similar manner, the physical form of the landscape will essentially be of an identical nature [16]. Geologists’ awareness of this repetitive nature can recognise associations between certain rock types, hill shapes, soils and vegetation. The same principle can guide road engineers and materials prospectors in locating good road building materials.

The shape of the land surface, see figure 5, is an important soil-forming factor due to its influence on local climate, vegetation, water tables and the movement of water (the slope of the terrain controls drainage and movement of material due to gravitational forces). Even small changes in elevation or minor gradients can be important especially in flat lands. River terraces for example or small depressions (e.g. salt pans) can lead to localised improved drainage or waterlogging respectively.
In Botswana [4] and South Africa [19], clear guidance is provided to recognise particular landforms associated with gravel indicators in sandy and rocky areas, see Figure 6 and 7 respectively.

The examples provided in Figure 6 and 7 are equally applicable to other countries although some are more relevant to the very dry regions of South Africa, Botswana and Namibia. Elsewhere, other specific landforms may be associated with the presence of road building material, for example in

Figure 5: The influence of landform on soil forming process and horizon [Source: 18]

Figure 6: Typical gravel landforms in sandy regions [Source: 19]

Figure 7: Typical gravel landforms in rocky regions [Source: 19]
Ethiopia along the rift valley cone shaped landforms associated with the presence of cinder gravels (scoria that erupted from volcanoes) can be identified in a radius along the crater [3]. In Mozambique, location of calcrete was associated with a number of distinct landform features i.e. pans, depressions, hollows in between dunes and old river channels [6].

Landforms can be identified from aerial photos, satellite images, topo maps and from a field reconnaissance survey. The skill required to identify landforms from images and maps is not difficult and can be acquired through practice. However, to fully understand the correlation between certain landforms and the presence of specific road materials (e.g. gravels) requires an expert interpretation and a good understanding of soil forming processes.

4.2.4 Other indicators (plants, animal and human activity)

Other indicators of possible road building materials are the presence of plants that depend upon the properties of the soils on which they are growing, the temperature and rainfall. Again, this is only indicative; the presence or absence or certain presence of species does not necessarily mean that materials are available or absent (plants also adapt to their environment). Human activity, bush fires and overgrazing may also eliminate indigenous vegetation and therefore reduce the usefulness of this indicator.

Figure 8 illustrates an example from Botswana [4] showing botanical species that can be used as an indicator for the presence of pedogenic road materials (e.g. ferricretes, calcretes and silcretes). Their presence is not limited to Botswana; some are spread throughout southern Africa.

<table>
<thead>
<tr>
<th>Material type</th>
<th>Botanical name</th>
<th>Common name</th>
<th>Local name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcrete</td>
<td>Acacia feroxii</td>
<td>Blade thorn</td>
<td>Mokala/Mohau</td>
</tr>
<tr>
<td></td>
<td>Acacia mellifera</td>
<td>Hook thorn</td>
<td>Mongana</td>
</tr>
<tr>
<td></td>
<td>Acacia nitida</td>
<td>Water acacia</td>
<td>Crupungiywa</td>
</tr>
<tr>
<td></td>
<td>Acacia nilotica</td>
<td>False umbrella thorn</td>
<td>Opungiywa</td>
</tr>
<tr>
<td></td>
<td>Capparaceae lebeo</td>
<td>Trumpet thorn</td>
<td>Cunupungiywa</td>
</tr>
<tr>
<td></td>
<td>Combretum imbondo</td>
<td>Leadwood</td>
<td>Lewis</td>
</tr>
<tr>
<td></td>
<td>Dichrostachys citer</td>
<td>Sickie bush</td>
<td>Mogwana</td>
</tr>
<tr>
<td></td>
<td>Dichrostachys citer</td>
<td>Snowbush</td>
<td>Moratlwa</td>
</tr>
<tr>
<td></td>
<td>Euclea senegalensis</td>
<td>False brandybush</td>
<td>Mokgamphathwa</td>
</tr>
<tr>
<td></td>
<td>Ficus macroglossa</td>
<td>Brandybush</td>
<td>Motlomo</td>
</tr>
<tr>
<td></td>
<td>Hyparrheis campilostachya</td>
<td>Donkeybearb</td>
<td>Mogalansetsi/Mokuti</td>
</tr>
<tr>
<td></td>
<td>Terminalia prunoides</td>
<td>Contrell tree</td>
<td>Mohatha</td>
</tr>
<tr>
<td></td>
<td>Terminalia prunoides</td>
<td>Bitterm bush</td>
<td>Moteisa</td>
</tr>
<tr>
<td>Ferricrete</td>
<td>Andropogon eucosma</td>
<td>Snowflake grass</td>
<td>Mohutiri</td>
</tr>
<tr>
<td></td>
<td>Combretum apiculatum</td>
<td>Red bushwil</td>
<td>Bankokuthi</td>
</tr>
<tr>
<td>Deep sand (indicate absence of gravels)</td>
<td>Acacia haematoxylon</td>
<td>Grey camel thorn</td>
<td>Mokholo</td>
</tr>
<tr>
<td></td>
<td>Baphia massaleris</td>
<td>Sand carrwood</td>
<td>Monato</td>
</tr>
<tr>
<td></td>
<td>Burkina africana</td>
<td>Red syringa</td>
<td>Megenoro</td>
</tr>
<tr>
<td></td>
<td>Terminalia senescia</td>
<td>Silver terminalia</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8: Plant indicators for pedogenic gravels in Botswana

Similar lists of botanical indicators may be available, or could be elaborated, for western and eastern African countries with the help of local botanical experts and experienced material prospectors. In Mozambique, calcrete was located using associated with the presence of the snowbush, a woody shrub 0.5 to 1 m high [6]. It needs to be noted that the correct identification of botanical species requires training. Landform features are therefore considered more appropriate for materials location than plant species.

Activities resulting from fauna (insects), in particular those resulting in gravel particles, soil or stones being brought to the surface can also help to identify subsurface soil types. Termites plough the
subsurface soils to considerable depth and in doing so bring up samples of minerals to the surface that can be inspected for presence of useful road building materials.

### 4.2.5 Remote sensing and multi spectral reflectance

Remote sensing is the science to obtain information about objects or areas on the earth’s surface from a distance, typically from aircraft and satellites. Aerial photographs and satellite images are valuable sources of information for engineers, showing relief and landform, vegetation cover and drainage patterns. As shown in section 4.2.3, they can also be used to identify landform.

With commercial satellites and UAVs (Unmanned Aircraft Vehicles), aerial photography and high-resolution satellite images have become more accessible and affordable. For the purpose of road materials location, existing maps, aerial photos and low-resolution satellite images are sufficiently detailed to identify landforms typically associated with the presence of gravel materials. Most of the Ministries and Road Authorities have an archive of aerial photographs obtained from previous project studies. Satellite images are publicly accessible through Google Earth up to a resolution of about 30 m.

A more sophisticated high-tech application using remote sensing (high resolution satellite images) is the use of spectral reflectance to help identify different materials. The technology works by measuring reflected or emitted radiation. Different soils reflect or absorb radiation from the sun in a different way. The soil reflectance property is specific for that material and referred to as its “reflectance signature”. The interpretation of multi spectral images requires highly specialised skills and knowledge about the materials’ “signature”. The technology has been used in some African countries, e.g. Botswana [16], especially where finding good road materials can be extremely difficult with conventional technologies and where soils are not covered by (dense) vegetation. The cost of high-resolution multispectral satellite images is USD 10-20/km2 (from archive) or USD 20-30/km2 if specifically ordered [8,9,10,11]. Due to the cost involved and the skills required for image interpretation, there does not seem to be an immediate scope to apply this on a large scale as part of the materials database development project. However, in places where finding suitable road materials can be extremely challenging (e.g. coastal areas in southern Mozambique), the use of high-tech solutions, with a focus on satellite imagery, could be considered (see also section 4.3.2).

### 4.2.6 Local consultations

Making use of local knowledge still remains one of the most effective and affordable tools available to road engineers and material prospectors. Most people in rural Africa are engaged in farming and local building. An indigenous knowledge about local building materials has passed on from generation to generation. Local consultations showing typical samples of road building materials can quickly point towards areas where road-building materials are abundant. District extension workers and staff working for building contractors often draw on local knowledge of existing and potential material sources and how materials from various sources have performed.

### 4.2.7 Linkage with a Materials Database System

Although technological approaches are advancing (e.g. remote sensing technologies) material prospecting remains a skill that depends on the knowledge, practical experience and expert interpretation of the prospector. Various indicators are being used to identify potential sources of road materials and reduce the area for further field investigations, sampling and materials testing.

These methods are not new but the potential of using a GIS to guide the prospecting of new sources of road materials by combining various multi-layered geo-referenced data sources (soil maps, climate, topography, geological maps, satellite images) can provide a powerful tool in materials prospecting. If different sources of information are combined in a GIS or other mapping tool, this
could assist less experienced road engineers with materials prospecting and save time and effort in finding new sources.

### 4.3 Potential synergies with related AfCAP projects

During the inception phase the consultant reviewed project documents and established contact with key informants of related on-going AfCAP projects to explore if there are any synergies and to obtain their views on the materials database development project.

- **Asset Management Project (GEN2081C):** piloted in Sierra Leone, Uganda and Zambia;
- **Satellite Imagery (GEN2070A):** piloted Ghana, Kenya, Uganda, Zambia and possible Tanzania;
- **Back Analysis (RAF2069A),** piloted in Ethiopia and Mozambique:

The results of the document review and consultations are briefly described below.

#### 4.3.1 Asset Management project (GEN2018C)

The project formulation [15] and Inception Report [14] reveal that this project (July 2016 – December 2018) provides technical assistance to selected partner countries (Zambia, Sierra Leone and Uganda) to achieve improvements in rural road asset management at a very practical level and measure performance of rural roads in terms of condition and their impact on the local economy.

In terms of geographical coverage, there is no overlap with the materials database development. There could be potential synergies if road condition performance monitoring was linked to the materials sources of the pavement layers, wearing course and surfacing. In doing so, the evaluation of pavement performance could feed back into the road materials database. This will only work if a unique materials source-referencing system exists and where “as built” data is available with information of the materials (and their source) used in the pavement. That is, unfortunately, rarely the case on LVR.

There are no apparent synergies between the two projects.

#### 4.3.2 The use of high-tech solutions for road network and condition analysis, with a focus on satellite imagery (GEN2070A)

The project inception [9] and progress reports [8,10,11] indicate that this project (April 2016 – May 2017) is piloting the use of high-resolution satellite images to undertake road condition surveys through remote sensing technology including a training component to transfer skills in satellite image interpretation and calibration (ground truthing). The selected partner countries are Uganda, Zambia, Ghana and Kenya (and possibly Tanzania).

In terms of geographical coverage, there is overlap in Ghana. There could be potential synergies because both projects make use of satellite images and GIS albeit for different purposes. The Consultant has contacted the TRL project manager to inquire about the use of high-resolution satellite images and spectral reflectance in locating road-building materials. There is some experience in Africa, including work carried out by TRL on locating calcrete, cinder gravels and laterites. Some of these leads have been followed through and information obtained has been used in this Inception Report.

#### 4.3.3 Development of Guidelines and Specifications for Low Volume Sealed Roads through Back Analysis (RAF2069A)

The purpose of this Africa regional project is to develop guidelines and specifications for low volume sealed roads through ‘back analysis’, i.e. analyse historic performance data of various trial projects
which were built over the past four decades in Sub-Saharan Africa \cite{13,14} using non-conventional design standards and materials.

The knowledge obtained will be captured in a regional database that is publicly accessible.

The TL participated in the AfCAP regional workshop in Dar es Salaam, which included a presentation and demonstration of the first prototype regional database covering data from 40 projects. The database and user interface have been developed as a web-based tool and is freely accessible after registration. No specific software is required for the users other than an Internet connection and web-browser and any updates to the software can be rolled out from one central location.

The database tool has been developed in Visual Basic.NET and the platform it runs on is SQL Server (a freely available version, SQL Server Express, is available without licensing cost, but has some restrictions on the maximum size of the database). Both the software and the database are temporarily residing on a server hosted by TRL until a suitable host is found.

The database works through a series of filters (data source, country, road section, material, layer, property) from which report tables can be generated and exported as excel or csv files, see Figure 9

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|}
\hline
Source Name & Section & Country & Tool Type & Result Type & Result & Result Layer & Site Info Type & Info & Static Info Layer & Author/ Contact & Page Year & Data Source Type & Link & LWP Published \\
\hline
\hline
\hline
\hline
\hline
Analysis of South African Pavement Monitoring Sector & MANA 1 & Botswana & Strength (200x) & SAR @ 100% M&O & 62 & Base & Material & Calcium & Base & F & Page-Grimes & 2010 & Paper & Yes & Yes \\
\hline
Analysis of South African Pavement Monitoring Sector & MANA 1 & Botswana & Strength (200x) & SAR @ 100% M&O & 64 & Sub-base & Material & Calcium & Base & F & Page-Grimes & 2010 & Paper & Yes & Yes \\
\hline
Analysis of South African Pavement Monitoring Sector & MANA 1 & Botswana & Strength (200x) & SAR @ 100% M&O & 41 & Sub-grade & Material & Calcium & Base & F & Page-Grimes & 2010 & Paper & Yes & Yes \\
\hline
\hline
\hline
\hline
\hline
\hline
\hline
\hline
\hline
\hline
\hline
\end{tabular}
\caption{Report table [Source: TRL http://www.lvroadsdata.com]}
\end{table}

The database does not link pavement performance with the materials source (this information was often not available or not clearly referenced in the original data source). An interactive mapping tool showing the location of the road and test sections is not yet available but the intention is to include this in the next database version.

There are obvious synergies with the materials database in terms of type of data stored (materials testing, road pavement performance) and the database development process. Close contact will be maintained with the project team for information and experience sharing.

4.4 Potential synergies with regional initiatives

4.4.1 The African Road and Transport Research Forum (ARTReF)

The African Road and Transport Research Forum (ARTReF), recently established with support from AfCAP, aims to promote research and innovation in the road transport sector beyond the life of AfCAP. The members of ARTReF are national road transport research entities representing Botswana, DRC, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Namibia, Nigeria, Sierra Leone, South Africa, South Sudan, Tanzania, Zambia and Zimbabwe.

One of ARTReF’s specific objectives is to lobby for regional harmonization and identification of strategic road research needs including the development and management of knowledge management systems. At present, ARTReF is coordinated by an Executive Committee supported by a
Secretariat, which, for the time being, is hosted by CSIR in South Africa. The intention is to move the secretariat to the Ethiopian Roads Authority in the very near future.

Once fully operational, ARTReF could play a pivotal role in the development and roll out of a generic materials database system across AfCAP partner countries.

### 4.4.2 Association of Southern African Road Agencies (ASANRA)

The Association of Southern Africa National Road Agencies (ASANRA) is a forum for networking of on policy formulation and technical exchange among industry and professionals in the road transport sector in the SADC region, share innovative ideas and best practice. One of its six standing committees covers materials and design standards to promote regional best practice and consistency in road and bridge design and materials testing.

One of the proposed projects is to prepare a harmonized manual for road materials laboratory and field-testing. Consultations with ASANRA revealed that after review of various testing practices and manuals from member countries, it was decided to test the manual developed in Namibia for one year and then obtain comments from the other member countries. A decision will then be made if and how to adopt the manual or what amendments to make.

A copy of the Materials Manual from Namibia[^20], first edition 2014 has been obtained in order to assess its relevance for the materials database development. However, the main emphasis is on harmonization of testing methods and not on materials information management and data storage.
5 Preliminary findings, considerations and recommendations

5.1 Findings

5.1.1 Existing materials databases in AfCAP countries and elsewhere

While existing materials databases in AfCAP partner countries are few (Ethiopia having just established one), the reports of successful implementation in other African countries (South Africa, Namibia, Botswana) provide important examples to be studied in further depth. Even if the specific institutional, policy or resource considerations may differ significantly, it is likely that these initiatives will yield both implementation lessons and, potentially, examples of technology and processes that may be broadly applicable at a generic level.

The information currently available seems to indicate that several countries implemented materials databases, some with quite comprehensive data sources (Zimbabwe, Malawi), and others only reaching pilot stage (Cambodia). Despite sustained efforts, some did not survive the test of time. The precise reasons are yet to be identified but they do clearly demonstrate that the technological challenge of building and populating an information system is not the most challenging. Identifying, committing to and embedding the policies, procedures and work processes that are fundamental to implementing such systems are more difficult than they may initially appear.

5.1.2 Institutional framework and resource availability

The survey responses in most cases report the availability of staffing resources both in the area of materials and in IT support. Although resources are clearly limited, this need not be viewed as a barrier to success, but rather as a constraint that would need to be taken into account in the development of the road materials database. For example, an initiative with initially modest ambitions (and therefore requiring less resources) which is nonetheless successful in its outcomes (e.g. demand driven by satisfying user needs) is likely to generate further resource commitments for subsequent phases.

The implementation approach can also strive to leverage the skills and capacity available to the best degree possible, rather than emphasise the ideal-case approach. The choice of technologies (for example, open source versus proprietary) may also determine the long-term resource demands and should therefore be made with these constraints in mind.

The extent to which the solutions and developments of other countries may be adapted and re-used will also impact resource needs significantly. These considerations will be highlighted in the forthcoming activities in Task 2 and 3.

5.1.3 Stakeholders’ needs and expectations

The information currently available indicates that stakeholder needs are largely consistent. Knowledge about material sources, their location, properties and quantities, for example are among the highest priorities of the majority of respondents. Except for very specific local conditions, it is applicable to all countries and driven as much by engineering considerations as by institutional needs. This provides a good basis for attempting to identify a generic model, at least at a high-level, which provides the maximum opportunity for sharing of knowledge, solutions and resources.

5.2 Considerations

These considerations on the minimum functional requirements of the materials database are initial thoughts of the Consultant based on a desk review and stakeholder consultations. They will be
worked out in more detail and presented as firm recommendations after the fieldwork (Task 2) as part of the database report.

5.2.1 Scope of the materials database

The development of a generic materials database should not be viewed as a purely technology driven initiative. Its success relies on several closely interrelated factors that need to be in place including institutional ownership with assigned responsibilities for materials information management, strong management support with clear systems and procedures for laboratory management and field testing practice, dedicated staff and financial resources.

The materials database will need to interact with other systems and processes including road asset management and related work flows. In most partner countries, private companies (consultants and contractors) are responsible for designing and implementing works on HVR. For LVR, design and supervision is mostly done in-house. It is also important to recognise that having a materials and aggregate inventory database, is not a substitute for undertaking materials prospecting and testing. It should rather be seen as a screening tool to quickly identify potential sources of materials that are appropriate for the type of works and the class of road to be maintained or improved.

The literature review and stakeholder consultations lead to the conclusion that the materials database must be kept simple, initially. Stakeholders should not be tempted to include the totality of materials data and information available in the road sector but rather consider the actual need for materials information required by road engineers, private and public.

Based on the review of various materials database initiatives in Africa and elsewhere, and the survey responses obtained, the following components have been identified as being typically part of a materials database:

- Material sources location, properties and quantities;
- Geotechnical investigations for structures and road alignment studies (subgrade testing);
- Materials and workmanship testing for roadwork contracts;
- Location mapping of quarries and borrow areas;
- Road performance evaluation testing data;
- Screening tools for identifying unexplored sources of road materials.

Institutions responsible for materials information management in the AfCAP partner countries indicated that the main priority is to have a good inventory of existing road materials sources. During fieldwork consultations, there will be another opportunity to reconfirm this prioritisation by also incorporating the views of consultants and contractors.

Given the limited resources available, a focussed approach is required in order to effectively manage materials information gathering and collation procedures and to limit its scope to an affordable, sustainable level.

As part of Task 2 of the scoping, and after more in-depth consultations, further guidance will be provided on the scope of the materials database and what information it should cover.

5.2.2 Development through several small stages of pragmatic scope

Development methodologies that proceed in small stages, each producing a planned, useable output, are well established in modern software engineering practice. In the case of AfCAP partner countries, however, the issues of modest capacity and resources that have already been highlighted make it even more important that implementation is carefully staged and that the scope of each
stage reflects the prevailing conditions, both constraints and opportunities of each country and the region.

It is noted that implementation of such a process may require some adjustments to Phases 2 & 3. As currently proposed, Phase 2 will focus on design and development while Phase 3 will roll out the database to participating countries. If a more iterative development process is adopted, as recommended, the two phases may need to run concurrently.

5.2.3 Flexibility to allow for country specific requirements

The similarities in environment between countries offer potential for development of a generic model with a number of attendant advantages (e.g. cost efficiency). However, it is also important to take account of the differences that inevitably exist in the institutional arrangements, materials testing procedures, skills and capacity across partner countries. Therefore, any generic model needs to be flexible enough to absorb country specific requirements.

This includes not only the functionality of the system and the structure of its underlying database, but impacts also on the implementation plan and the scope of the various stages. It may also further require significant adjustments to the functional details of the application software, especially if procedures differ significantly and points of integration with those procedures differ as a consequence. It is therefore likely that the implementation plan will include, as a first step, a detailed review of that country’s needs vis-à-vis the generic model, followed by identification of design amendments if needed, and implementation of those changes.

5.2.4 Low volume roads versus high volume roads

Although the main focus of the project is to establish better management of road materials for LVR, in practice it would be difficult to distinguish between LVR and HVR. The need for better materials information management exists for all categories of roads independent of their function, class or use (traffic).

Having a web-enabled platform allowing all stakeholders to benefit from this information may therefore be more important than the question of who should host the materials database or to which category of roads the database should apply.

Different institutions in the partner countries are responsible for the management of national, rural and urban roads. The initial consultations demonstrate that the institutions that are currently tasked with road materials testing and information management are probably in the best position to host the database simply because of the management support systems already in place. However, it is important to recognise that some locally available materials that do not meet traditional specifications for HVR are eminently suitable for LVRs but often not used. These sources (including some industrial by products that could potentially be used in road pavement layers) need to be captured and classified for potential use in the various road categories, both HVRs and LVRs.

5.2.5 Promote public access to materials information

The policy of UK Aid is to promote open access to data for its supported projects. In this particular case the database is being developed for use by the partner countries. In some countries current policy and regulations may restrict public access to road materials information. This will be confirmed during Task 2; there may be a scope to differentiate between the open source access of the database system and the confidentiality of some of the data contained in it.

It is not very clear yet how road materials information in each of the partner countries is being managed. The general impression is that data is not publically accessible but professionals from the
industry can submit a request to the responsible institution to obtain specific information (presumably free of charge). Following the main principle of AfCAP, which is to make LVR research available to the wider community of practitioners, open access to information is a prerequisite. As part of Task 2 of the scoping, further guidance will be given on this issue of public access to materials information.

5.3 Recommendations

It is still too early to come up with specific recommendations hence the preference to refer to considerations on the way forward as explained in section 5.2. The only firm recommendation presented in this Inception Report relates to the country selection for the stakeholder consultations (Task 2).

Three (3) countries will be visited during the fieldwork consultations (Task 2) for a more in-depth investigation into the current status of materials information management, the challenges, ambitions and needs of the stakeholders.

The selection of the three countries is based on the following criteria:

- The selected countries have completed and returned the stakeholder questionnaire (as an indicator of interest, commitment and to allow the consultant to prepare for field work and follow up on information provided);
- The selection should have a good geographical spread, preferably one country from western, one from eastern and one from southern Africa;
- If possible, the selection should represent a range of different maturity levels in terms of their income status (see Figure 1) and available resources for materials information management (staffing, budget, GIS/IT capabilities, etc.).

The following 3 countries are selected and approved by the AfCAP Steering Committee:

- **Ghana**, western Africa, being a lower middle-income country, with no materials database in place but strong management support systems and resource availability;
- **Ethiopia**, eastern Africa, being a low-income country, having recently established a materials database system with ambitions to link this to a GIS;
- **Mozambique**, southern Africa, being a low-income country with some evidence of electronic storage testing data storage.

It needs to be stressed that the aforementioned selection has no implication for the final selection of countries to be included as pilots for Phase 2 (database development and beta testing). Other criteria may be required for this purpose, including the countries availability to support the materials database development.

Because the proposed inclusion of Mozambique does not require any travelling (the TL is based in Maputo), the Consultant’s travel budget can accommodate the inclusion of Namibia (or alternatively, Botswana subject to approval by the host institutions) as part of the fieldwork.

Namibia and Botswana have both established materials information systems, which are considered “good practice” by some key informants consulted. The visit would allow a better understanding of what they have done; discuss their experiences and lessons learned.
6 The work ahead

6.1 Additional comments on the Terms of Reference

Our comments on the TOR remain as those presented in the technical proposal.

6.2 Revised work and staff plan

The updated Work Plan and Staffing Schedule is presented in Figure 10 (next page) and also included (enlarged) in Annex E. The assignment started 2 months later than the anticipated with the kick off meeting on Thursday 6 April in presence of the PMU and TL. The delayed start of the assignment has been reflected in the revised work plan. With a 20-week duration, the assignment will be completed by Friday 18 August 2017 with the submission of the final report. Sufficient time (2 weeks) has been allowed for stakeholders to comment on the various draft reports.

The staffing inputs are shown in the bottom 2 rows of the work plan. Their planned time input is presented against the 4 main tasks of the assignment. In line with the TOR, the methodology consists of four (4) distinct tasks:

- Task 1: Inception and desk review (output: Inception Report);
- Task 2: Problem analysis, conceptualise database model and system requirements through fieldwork consultations (output: Database Report and recommendations for presentation at the workshop);
- Task 3: Regional stakeholder workshop to present and test findings (output: Workshop Report including workshop resolutions);
- Task 4: Finalization of the database architecture and system requirements (output: Final Report).

The division of responsibilities between the 2 key experts is summarised below:

- The TL (OCA) will be responsible for project management including the planning, budgeting and progress reporting and interaction with the client. As LVR engineer and materials expert he will also be responsible to guide fieldwork consultations to specify the problem, review current systems / procedures for materials information management, define user needs, analyse resource availability and specify functional requirements of the materials database;

- The DMS (Link Asea) will review what current database systems are in use by the partner countries, assess resource availability and support systems. Based on the problem analysis, user needs and resource availability, he will then translate this into the concept database design and a high level set of functional requirements for the software, which would feed into the TOR for the database developer.

The TOR proposed a separation of fieldwork responsibilities between TL and DMS, the latter assumed to be operating predominantly home based. The Consultant considers it more effective if both experts operate side-by-side during fieldwork to translate engineering information needs into database functional requirements (see work plan Figure 10).
Figure 10: Updated work and staff plan

6.3 Technical inputs, payment schedule and budget

6.3.1 Technical inputs

Table 4 shows the distribution of workdays for both experts and for each task of the project. There are no major changes compared to the technical proposal. Some days earmarked for home-based work during Task 2 and 3 have been moved to field based work, again because it is considered more effective if both experts work together on site to prepare for the draft database report and stakeholder workshop. These changes have no budget implications.

Table 4: Inputs of Key Experts by Task, Home and Field

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Key Experts</th>
<th>Planned versus Actual</th>
<th>Task 1: Inception and Desk Review</th>
<th>Task 2: Field Work, Database Report</th>
<th>Task 3: Prepare and Conduct Workshop</th>
<th>Task 4: Final Reporting</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Field</td>
<td>Home</td>
<td>Sub-total</td>
<td>Field</td>
<td>Home</td>
</tr>
<tr>
<td>TL</td>
<td>Original</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>18</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Revised</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>19</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>DMS</td>
<td>Original</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>17</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Revised</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>17</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>Original</td>
<td>0</td>
<td>11</td>
<td>11</td>
<td>35</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Revised</td>
<td>0</td>
<td>11</td>
<td>11</td>
<td>35</td>
<td>0</td>
<td>38</td>
</tr>
</tbody>
</table>

6.3.2 Payment schedule

The project deliverables with milestones and the payment schedule are presented in Table 5. There are no chances compared to the technical proposal.
### Task Summary

<table>
<thead>
<tr>
<th>Task</th>
<th>Milestone</th>
<th>Timing (weeks from start)</th>
<th>Total Input days</th>
<th>Expert</th>
<th>Input Days</th>
<th>Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Database Report</td>
<td>12</td>
<td>38</td>
<td>JB/TL</td>
<td>20</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Draft Recommendations for presentation at Regional Workshop Action Plan and Budget for Phase 2 and 3 of the Project</td>
<td></td>
<td></td>
<td>RC/DMS</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Conduct Regional Stakeholder Workshop Regional Workshop Report</td>
<td>16</td>
<td>10</td>
<td>JB/TL</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RC/DMS</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Final Report</td>
<td>20</td>
<td>6</td>
<td>JB/TL</td>
<td>4</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RC/DMS</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>65</strong></td>
<td><strong>65</strong></td>
<td><strong>JB/TL</strong></td>
<td><strong>65</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

*Table 5: Project deliverables, milestones and payment schedule*

### 6.3.3 Budget

The Consultant was invited to take part in the kick-off meeting coinciding with the AfCAP Regional Workshop in Dar es Salaam, Tanzania. This was not foreseen in the TOR and may require one additional continental air ticket for the TL. This will be confirmed after completion of Task 2 when the total number of trips undertaken for the assignment is known.

The proposed inclusion of Namibia (or Botswana) during the fieldwork consultations is to review good examples of a functional road materials database established in Africa. The additional travel cost can be accommodated in the travel budget for reasons explained earlier.

### 6.4 Project management

The proposed management structure remains as explained in the technical proposal with Rob Dingen, OCA Managing Director, as the Project Manager. He will oversee the project, respond to the Client on contractual issues and provide quality assurance throughout the project. Operational responsibilities for project implementation (planning, budgeting, team management, reporting and risk management) are delegated to the TL, Jan Bijl. OCA has signed a subcontracting agreement with Link Asea for the services of the DMS, Ravindra Corea.

Logistical support will be sought from a local service provider for the preparation and conduct of the regional stakeholder workshop. Since the venue of the workshop is yet to be determined, more detailed arrangements and budgets will be prepared during Task 2 of the assignment.

### 6.5 Logical framework and M&E plan

#### 6.5.1 Contribution to the ReCAP logical framework

The Consultant’s task is to undertake a scoping study for the needs and architecture of a generic road materials database. At this stage (Inception) it is still early to develop a logical framework and M&E plan as the boundaries of the project, e.g. the number of participating countries and the scope of the materials database, are not yet fully defined.

On the basis of a number of assumptions, a first outline of the logical framework has been prepared, as presented in Annex F. This covers all three phases of the project (Phase 1 scoping study, Phase 2 pilot database development and beta testing, Phase 3 roll out and training). It has been assumed that phase 2 (development and testing of the database) will take one year and Phase 3 (roll out and training) another year. Note that this is based on current assumptions on the structure of Phases 2 & 3. If a multi-staged development / implementation approach with concurrent activities in Phases 2 & 3 is discussed and accepted, the sequencing and timing could change considerably. As a modest
start, it is assumed that initially only 3 partner countries will have the resources to adopt, populate and operate the generic materials database. Other partners may follow later.

The logical framework will be developed and refined over the course of the assignment and presented at the regional workshop. It will be finalised and included in the final database report based on comments received from the stakeholders.

In terms of expected outcome, AfCAP supported projects aim for a sustained increase in evidence base for more cost effective and reliable low volume rural road and transport services, promoting and influencing policy and practice in Africa and Asia. Planning and designing road works on the basis of more reliable information on the availability, location and properties of road materials forms an important contribution to this outcome. Table 6 summarises the outcome indicators and the end-of-project targets (assumed to be 31 July 2020).

<table>
<thead>
<tr>
<th>Outcome Indicator</th>
<th>Target by 31 July 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome 1, sustainability of the project measured by the Partner Government and other financiers co-funding research with ReCAP in terms of their contributions.</td>
<td>At least 3 partner countries have adopted the AfCAP supported generic materials database and allocated dedicated staff resources and funding for its operation and maintenance. The amount of expected local contribution cannot be specified at this early stage but will be discussed and quantified during Task 3 and 4 of the scoping study.</td>
</tr>
<tr>
<td>Outcome 2, concrete examples of change influenced by ReCAP research that will be applied to (low volume) roads in the partner countries.</td>
<td>The materials database is pro-actively promoted in support of road maintenance and improvement works in the 3 partner countries that have adopted the materials database. The road materials database is used to support the innovative use of locally available road materials for LVR design. The database holder receives at least 20 materials data requests per year from road industry professionals.</td>
</tr>
<tr>
<td>Outcome 3, number of citations in academic articles of ReCAP peer reviewed articles and/or working papers, conference papers etc.</td>
<td>At least 3 citations from project related documents and papers related to the materials database developed and piloted with support from AfCAP.</td>
</tr>
</tbody>
</table>

Table 6: Outcome Indicators and Targets

Expected outputs, output indicators, means of verification, baseline, milestones and targets for each output are described in Annex F and not repeated here. The M&E plan will be developed jointly with the draft and final logical framework as part of the draft final materials database report.

6.5.2 Community Access and Gender

By improving access to reliable information about the availability of road materials, government road engineers, consultants and contractors are better able to locate materials that are appropriate to the category of roads to be improved or maintained thus reducing wasteful use of scarce resources (e.g. avoiding the use of materials that are of too high standard for base, sub base or selected fill), reducing the cost of the works and improving the level of year-round community access.

The direct target group of the project are road sector institutions and professionals from the industry who will have tools to locate materials sources for road improvement and maintenance projects. The ultimate beneficiaries of the project are the rural communities that will benefit from better quality roads providing all season access to socio and economic services.

The activity itself does not specifically address gender issues but the project will encourage partner institutions to engage female materials engineers, technicians and researchers to be actively involved in the development, population and operation of the materials database. This has been specified in the logical framework milestones and end of project targets, i.e. at least 3 female
materials engineers, technicians or researchers are involved in the development and operation of the materials database.

6.6 Updated risk and assumption matrix

The management of risks and assumptions is a continuous process over the course of execution of the assignment. Table 7 presents an update of the initial assumptions included in the technical proposal. As can be seen from the table, it is expected that most of the assumptions hold.

<table>
<thead>
<tr>
<th>Initial assumptions:</th>
<th>Realization of the assumption:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The assignment will provide recommendations for development of a materials and aggregate database for the road sector. As such stakeholder consultations will be limited to road sector institutions and related research and regulatory bodies</td>
<td>This assumption holds. There seems a common understanding that the materials database will be developed for the road sector only.</td>
</tr>
<tr>
<td>For tendering purposes, it has been assumed that up to three (3) AfCAP partner countries will be visited during fieldwork consultations. Country selection will be agreed upon with the PMU during the inception stage.</td>
<td>This assumption holds. Three AfCAP partner countries are to be selected for task 2 (field work consultations).</td>
</tr>
<tr>
<td>There is a strong commitment from the AfCAP partner countries to establish a materials and aggregate database. Stakeholders will fully cooperate with the Service Provider and responding in a timely manner to requests for information and stakeholder surveys.</td>
<td>This assumption partially holds. The feedback from the stakeholder survey was somewhat disappointing (only 7 out of 12 countries returned the questionnaire on time). It is clear that the level of interest in the development of a generic materials database may not be the same for all partner countries. The Consultant has proposed to initially focus on those countries that have completed and returned the stakeholder survey.</td>
</tr>
<tr>
<td>Each partner country will, upon request by the PMU, nominate a counterpart institution and focal point person to work closely with the Service Provider.</td>
<td>This assumption holds. Each partner country already has an AfCAP country coordinator. In addition, the Cardno Emerging Markets PMU has two Regional Technical Managers (one for east and southern Africa and one for western Africa) to oversee the AfCAP activities in their respective regions.</td>
</tr>
</tbody>
</table>

Table 7: Realization of Assumptions

Annex G presents the updated risk matrix. Based on the findings of the inception stage, there are very few chances compared to the technical proposal. Changes mainly relate to the upgrading or downgrading of the probability and impact levels of the identified risks but not the risk itself:

- **Risk 1 (R1)** Different requirements of AfCAP partner countries may undermine the need for a generic materials database: the probability has been upgraded from high (H) to very high (VH). The stakeholder survey feedback has highlighted some differences between partner countries. The impact remains low (L); the Consultant believes that this can be accommodated in the generic database by building in sufficient levels of flexibility;

- **Risk 2 (R2)** Lack of clear mandate and/or local ownership of the materials database development activity: the probability has been downgraded from medium (M) to low (L). The stakeholder survey shows that in most countries the mandate for materials information management is quite clear and lies with the national road agency or authority. In some countries, a shared responsibility has been noted between the national road authority and local government / rural road authorities but it is not clear at this stage whether this will have a major impact on the outcome of the assignment;
- Risk 4 (R4): Disagreements whether the materials database should cover road or construction industry sector. The probability has been downgraded from high (H) to low (L). The stakeholder survey and the consultations with AfCAP country coordinators during the regional workshop in Dar es Salaam shows that there is a common agreement that this should focus on the road sector only;
- Risk 5 (R5): Resistance to change in materials information management. The probability and impact have been downgraded from medium (M) to low (L). The stakeholder survey shows that very few countries have a materials database in place and there seems to be a general desire to improve materials information management.

6.7 Approach for Task 2 (fieldwork consultations)

The objective of Task 2 is to understand what is lacking in the current situation of materials information management (the problem specification), define the user requirements to determine what the purpose of the generic database should be (what is the database going to do, what problem is it going to solve, what functions will it perform) and how this can be achieved in a sustainable manner (conceptualize the database model, architecture and functional requirements).

Task 2 will take 6 weeks and result in the submission of two separate reports:
- The draft database report, and
- The draft recommendations, action plans and budget for development of the database to be presented at the regional stakeholder workshop.

During task 2, Mozambique, Ethiopia and Ghana will be visited. The Consultant will work closely with the stakeholders in these countries to define the problem, discuss the user needs and start developing the generic database architecture. Since Ethiopia already has a database in place, the focus there will be on the development process of their road database and lessons learned. In each partner country, the Consultant will meet the lead Ministries responsible for national and local roads, the materials and research sections responsible for materials information management, a representative selection of materials laboratories, a representative group of government engineers, consultants and contractors, road asset managers, GIS and IT specialists and, time allowing, external stakeholders. An outline of the country program is presented in Annex H. Each country visit is expected to take 4 – 5 workdays.

In addition to visiting the 3 AfCAP partners, the Consultant also proposes to visit Namibia (or Botswana) as explained earlier. To improve interaction and draw on their complementary skills, it is proposed that both TL and DMS jointly conduct the fieldwork to Ghana and Ethiopia. Only the TL will visit Mozambique and Namibia (or Botswana). After the fieldwork, the TL and DMS will work side-by-side to consolidate findings and prepare the outline of the draft database and workshop recommendations report. The draft recommendations for the workshop will include:

- Draft findings from the consultations (current systems and procedures, problem analysis, user needs, functional database requirements, etc.);
- Recommended concept database model;
- A road map, action plan and budget for the database development (Phases 2 and 3);
- An outline of the workshop design (agenda, presentations, group works, discussion topics and facilitation method).

During this stage, the Consultant will also liaise with the PMU with respect to the preferred country to host the workshop and discuss other logistical arrangements (detailed cost break down and quotations for work shop venues, invitations, accommodation and transport arrangements).
Annex A: Literature references


[16] C J Lawrance and T Toole, TRRL 1984, The location, selection and use of calcrete for bituminous road construction in Botswana, TRRL Laboratory Report, 1122 ISSN 0305-1293;


Annex B: List of persons and institutions contacted

<table>
<thead>
<tr>
<th>Institution</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AFCAP PMU</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Cardno Emerging Markets | Gerome Rich, Program Director ReCAP  
Jasper Cook, Team Leader  
Les Sampson, ReCAP Infrastructure Research Manager  
Nkululeko Leta, Regional Technical Manager  
Pauline Agyekum, Regional Technical Manager |
| **AFCAP Partner Countries** | |
| Kenya, Ministry of Transport and Roads Development | Stephen Kogi, Chief Engineer, Materials  
Democratic Republic of Congo | Billy Tshibambe, Head of Roads Section  
Sierra Leone, National Roads Authority | Tamba Amara, Chief Engineer, Feeder Roads Development  
South Sudan, Ministry of Transport and Roads | Philip Marlow, Deputy Director of Roads  
Ethiopia, Ethiopia Roads Authority | Alemayehu Endale, Director of Research and Development  
Zerai Hadera, Research and Development  
Ehitabezahig Nigussie, Research and Development  
Malawi, Malawi Roads Authority | Francis Dimu, Planning Engineer  
Zambia, Road Development Agency | Dickson Ndhlovu, Director of Planning and Design  
Uganda, Uganda National Roads Authority | Mark Rubarenzya, Head - Research Development  
Tanzania, Presidents Office, Local Government and Local Authorities | Elina Kayanda, Director of Department of Infrastructure Development  
Mozambique National Road Administration | Irene Langa, Head of Maintenance  
Raquel Langa, Project Department  
Rubina Normahomed, Maintenance Department  
Liberia, Ministry of Public Works | Sumoiwuo Harris, Assistant Minister of Rural Development  
Ghana, Ghana Highway Authority | John Obeng Asiedu, Department of Feeder Roads  
Other key informants | |
| Consultants | |
| TRL | Annabel Bradbury, Deputy Group Manager  
Thomas Buckland, Senior Researcher  
Robert Workman, Team Leader GEN 2070A  
Kenneth Mukura, Senior International Consultant |
| ASANRA | Joey Malota, Head of Materials and Design Committee  
Zimbabwe, National Road Administration | Eric Gumbie, Director of Roads  
Malawi, National Roads Authority | Sharmey Banda, Materials Section  
Botswana, Department of Roads | Kgosietsile Solomon, Head of Central Materials Laboratory  
Namibia, Roads Authority | Sophie Tekie, RMS, Divisional Manager  
Palesa Hekandjo, Network Planning and Consultation |
Annex C: Stakeholder survey form

Part A: Institutional Framework for Road Materials

A1. General information
Country:
Institution:
Name of the respondent:
Position of the respondent:
Mobile phone:
Email:
Date:
Name and signature of the officer in charge

A2. Which institution is responsible for road materials information management for the following category of roads?
National roads
Rural roads
Urban roads

A3. How many staff are working in the materials section or department
Academic level (pavement engineers, materials engineers, geologists, etc.)
Technicians
Support staff
Total

A4. Availability of IT expertise
Do you have any IT specialists in your institution? Yes ☐ No ☐

If yes, please state how many, their expertise and responsibility

Would one or more of them be available to support the materials information management function? Yes ☐ No ☐
A5. GIS and Software Packages

Is any of the staff experienced in the use of GIS?  Yes ☐  No ☐

What Geographical Information System (GIS) software does the institution have available?

For what purpose is GIS currently being used?

What data management software packages does the institution have available?

For what purpose are these software packages used?

A6. What is the annual budget of your institution (please specify currency)?

Staff
Operational expenses
Investments
Total

A7. How many materials testing laboratories facilities does your institution manage?

At national level
At subnational level

A8. Are any other road materials laboratories operating in your country?  Yes ☐  No ☐

If yes, estimate number of public materials laboratories

If yes, estimate number of private materials laboratories

A9. Are you involved in any road research activities?  Yes ☐  No ☐

If yes, briefly specify what activities are being undertaken.
Part B: Current Road Materials Data Management Systems

B1. Do you have an operational road materials database?  
Yes ☐ No ☐

B2. Is the database regularly updated?  
Yes ☐ No ☐
    If yes, how often is it updated?  
    Please describe the process for updates – e.g. who is responsible, how is new data obtained, etc.

B3. Describe briefly what data is contained in the database?

B4. Is the database electronic or paper based?  
   Electronic based ☐  Paper based ☐
   If electronic, what database software does it use? (e.g. MS Access/ SQL Server / MySQL / SQL Express, Oracle, other, etc.)  
   What Operating Systems and Server infrastructure does it run on (e.g. Windows, Linux/Unix, Mac OSX)  
   Is it web enabled?  
      Yes ☐ No ☐
   Was it a custom developed or purchased as “off-the-shelf”?  
      Custom ☐ Off-the-shelf ☐
   If custom developed, was it developed internally?  
      Yes ☐ No ☐
   In either case, how is it supported – i.e. using internal resources?  
   Is there a database maintenance contract to a service provider?  
      Yes ☐ No ☐
   Is it linked to a GIS in some way or does it contain significant geographic information?  
      Yes ☐ No ☐
   If 'yes', then what GIS standards or software is it associated with?
Who has access to the database?

B5. Who are the main users of the materials database?

B6. What modules does your database cover (tick the box if the module is covered in your current database)

- Materials properties of existing quarries and borrow areas
- Road subgrade materials testing
- Geotechnical investigations
- Materials and workmanship testing data for road construction and maintenance contracts.
- Road pavement performance data.
- Mapping tools for the locations of quarries, borrow areas and road sections.
- Tools for identifying unexplored sources of road materials.

Any other, please specify

B7. Are external users (consultants, contractors, etc.) paying for information obtained from the materials database? Yes ☐ No ☐

B8. Is the materials database linked to a road asset management system? Yes ☐ No ☐
Part C: User needs and expectations

C1. What are the main challenges with your road materials information management?

Are there any particular stakeholders’ demands that cannot be satisfied by the current database system?

Are there any specific functions that have been prioritised for improvement?

C2. Are there any past or on-going projects to improve the database?  Yes ☐  No ☐

If yes, please describe the projects and briefly state the outcome.

If no, briefly explain why this has not been possible.

C3. What information is taken from the materials database (please specify for each stakeholder)?

Government road engineers

Other government agencies (e.g. transport, environment, natural resource management, mining, etc.)

Consultants

Contractors

Academic or research institutions

Others, please specify:
C4. What functions should the database cover (in order of priority, starting with number 1 for the highest priority):

Materials properties of existing quarries and borrow areas

Road alignment (subgrade) materials testing

Geotechnical investigations

Materials and workmanship testing data for road construction and maintenance contracts

Road pavement performance data

Location mapping of quarries, borrow areas, etc.

Screening tools for initial assessment of unexplored sources of road materials

Other Specify:

C5 Are there any particular training needs identified for road materials inventory and information management?
### Annex D: Stakeholder survey feedback

<table>
<thead>
<tr>
<th>Survey questions</th>
<th>Ethiopia</th>
<th>Ghana</th>
<th>Mozambique</th>
<th>Sudan</th>
<th>Tanzania</th>
<th>Uganda</th>
<th>Sierra Leone Roads Authority (SLRA)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PART A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2. Institution responsible for road materials info management National Roads</td>
<td>Ethiopian Roads Authority</td>
<td>Ghana Highway Authority (GHA)</td>
<td>National Road Administration (ANE)</td>
<td>Ministry of Roads and Bridges, Materials and Research Department</td>
<td>TANROADS, Central Materials Laboratory</td>
<td>Uganda National Roads Authority (UNRA)</td>
<td>Sierra Leone Roads Authority (SLRA)</td>
</tr>
<tr>
<td>Rural roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3. Staff numbers (total)</td>
<td>14</td>
<td>86</td>
<td>6</td>
<td>14</td>
<td>10</td>
<td>26-36</td>
<td>24</td>
</tr>
<tr>
<td>A4. IT expertise available?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>IT staff, how many and type</td>
<td>1</td>
<td>1 Director 6 Programmers 4 Technicians.</td>
<td>-</td>
<td>It is a department within PO-RALG and they are responsible for all IT requirements in the ministry.</td>
<td>5 - ICT Officers (Database Administration, Security, Applications Development, Systems Administration, Hardware and Networks)</td>
<td>6 1 Manager 2 Computer Programmers 3 Deputies Programmers</td>
<td></td>
</tr>
<tr>
<td>Are they available to</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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### Survey questions

<table>
<thead>
<tr>
<th>Support materials information management?</th>
<th>Ethiopia</th>
<th>Ghana</th>
<th>Mozambique</th>
<th>Sudan</th>
<th>Tanzania</th>
<th>Uganda</th>
<th>Sierra Leone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Arc GIS</td>
<td></td>
<td>GTRANS – Ghana transportation systems</td>
<td>Arc Map 10.03.1 Global Mapper Google Earth QGIS</td>
<td></td>
<td></td>
<td>Arc GIS</td>
<td>ArcView 10</td>
</tr>
</tbody>
</table>

**A5. Experience in GIS? What software package do you use?**

- Yes Arc GIS
- Yes GTRANS – Ghana transportation systems
- Yes Arc Map 10.03.1 Global Mapper Google Earth QGIS
- No
- No
- Yes Arc GIS
- Yes ArcView 10

**For what purpose is GIS being used?**

- Planning
- Extensive use at survey and design division.
- Collecting, analysing road data to produce Maps
- -
- -
- Survey and development of location maps, road network database.
- Mapping major roads.

**Data management software packages in use?**

- dTIMS
- Pavement maintenance management software.
- HIMS
- dTIMS, BMS, TIS
- PMMP

**For what purpose?**

- Asset Management
- Prioritising roads for maintenance.
- Road Management
- Data storage, Network data analysis for strategic planning
- Managing road data.

**A7. Number of materials laboratories managed by the institution**

- 1 National
- 1 National
- 11 National
- 1 National
- 1 National
- 1 National
- 1 National
- 1 National
- No other substantial laboratories but the institution monitors various project based laboratories.

**A8. Other road materials laboratories – Public Private**

- 4
- 3
- 1
- 2
- 60
- 4
- 1
- 10
- 6
- 4
- 10
- 15
- 7
- 1

**A9. Road research activities?**

- Yes
- Yes
- Yes
- Yes
- Yes
- Yes
- Yes
<table>
<thead>
<tr>
<th>Survey questions</th>
<th>Ethiopia</th>
<th>Ghana</th>
<th>Mozambique</th>
<th>Sudan</th>
<th>Tanzania</th>
<th>Uganda</th>
<th>Sierra Leone</th>
</tr>
</thead>
<tbody>
<tr>
<td>What areas?</td>
<td>Materials and Transport</td>
<td>Use of polymerised soil and asphalt stabilisers</td>
<td>Proficiency of laboratories Monitoring of existing experimental sections Climate adaptation: Risk management and resilience optimisation</td>
<td>Pavement trial section Geocels technology Stabilisation of black cotton soil.</td>
<td>Back Analysis of trial sections First mile improvement and rural road safety improvement.</td>
<td></td>
<td>Road Asset Management research project - AFACP</td>
</tr>
<tr>
<td>PART B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>B1. Do you have an operational road materials database?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>B2. Is it regularly updated?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>How often?</td>
<td>It is new.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>What is the process for updates</td>
<td>New data obtained from design reports, direct material characterization at the Road Research Centre, etc.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B3. What data is contained in the database?</td>
<td>Engineering characteristics of the material (grading, Atterberg limits, strength etc.), location, quantity estimate and pictures of the material and location</td>
<td>-</td>
<td>Borrow pits and quarries location and materials description.</td>
<td>We have data from Road Assessment, road design, trial sections, and regular testing of road building materials.</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B4. Is the database electronic or paper based?</td>
<td>Electronic</td>
<td>-</td>
<td>Both electronic and paper</td>
<td>Both electronic and paper</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Survey questions</td>
<td>Ethiopia</td>
<td>Ghana</td>
<td>Mozambique</td>
<td>Sudan</td>
<td>Tanzania</td>
<td>Uganda</td>
<td>Sierra Leone</td>
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</tr>
<tr>
<td>What database software does it use?</td>
<td>Access</td>
<td>-</td>
<td>Excel</td>
<td>Excel</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>What operating systems and server infrastructure?</td>
<td>[Windows]</td>
<td>-</td>
<td>Windows</td>
<td>Windows</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Web enabled?</td>
<td>Yes</td>
<td>-</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Custom developed or off-the-shelf?</td>
<td>Custom</td>
<td>-</td>
<td>Custom</td>
<td>Custom / Off-the-shelf</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>If custom – was it developed internally?</td>
<td>Yes</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>How is it supported?</td>
<td>Internal resources</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-Database maintenance contract to a service provider?</td>
<td>Yes</td>
<td>-</td>
<td>No</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Linked to a GIS in any way?</td>
<td>No</td>
<td>-</td>
<td>No</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>If &quot;YES&quot;, what GIS standards or software?</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Who has access to the database?</td>
<td>Researchers and road designers</td>
<td>-</td>
<td>-</td>
<td>Road sector partners</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B5. Who are the main users of the database?</td>
<td>Researchers, designers and design project management teams</td>
<td>-</td>
<td>ANE, Consultants and Contractors</td>
<td>Government Institutions, Academic Institutions, Development Partners, and Contractors</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B6. Which of the following modules are covered in your database?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Survey questions</td>
<td>Ethiopia</td>
<td>Ghana</td>
<td>Mozambique</td>
<td>Sudan</td>
<td>Tanzania</td>
<td>Uganda</td>
<td>Sierra Leone</td>
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<td>--------------------------------------------------------------------------------</td>
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<td>------------</td>
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<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td>borrow areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road subgrade materials testing</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Geotechnical investigations</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Materials and workmanship testing data for road construction and maintenance contracts.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Road pavement performance data.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Mapping tools for the locations of quarries, borrow areas and road sections.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Tools for identifying unexplored sources of road materials.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Others</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>B7. Are external users paying for information from the database?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>B8. Is the materials database linked to a road asset management system?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>PART C</td>
<td>It is new and the challenges are not yet fully identified.</td>
<td>Require support in the use of software to manage road construction materials etc.</td>
<td>An update of data for quarries and BP in whole country and availability and properties and</td>
<td>Data collection, Information base yet to be created and management of the database (including 1. There is no clear information on the quality and quantity of available materials.</td>
<td>N/A</td>
<td>We don’t have a materials data base.</td>
<td></td>
</tr>
<tr>
<td>Survey questions</td>
<td>Ethiopia</td>
<td>Ghana</td>
<td>Mozambique</td>
<td>Sudan</td>
<td>Tanzania</td>
<td>Uganda</td>
<td>Sierra Leone</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
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<td>--------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td><strong>Any particular stakeholders’ demands that cannot be satisfied by the current database system?</strong></td>
<td>It is new. Expect feedback as usage increases.</td>
<td>Private consultants and contractors.</td>
<td>Yes</td>
<td>Geotechnical investigations are difficult to do because of lack of facilities</td>
<td>No database system but existing practise leads to higher overhaul cost and longer period of time to locate proper construction materials.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Specific functions that have been prioritised for improvement?</strong></td>
<td>Attaching it to GIS so that locations and other information are shown on the map</td>
<td>N/A</td>
<td>Construction materials location using GIS</td>
<td>Provision of testing facilities: foundations, bituminous materials and building materials</td>
<td>We would like to have a material database and we have requested AfCAP to assist.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>C2. Are there past or on-going projects to improve the database?</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>If yes, please describe the projects and briefly state the outcome.</strong></td>
<td>Currently internal IT experts are trying to attach the database to a GIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>If no, briefly explain why this has not been possible.</strong></td>
<td></td>
<td></td>
<td>Budget constraints</td>
<td>Lack of qualified personnel and budget for data collection and compiling</td>
<td>We are waiting for AfCAP to approve our concept note.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>C3. What information is taken from the materials database (please specify</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
### Survey questions for each stakeholder?

**Government road engineers**
- Ethiopia: Expect material characteristics data, location and quantity estimates to be of high interest from the preliminary discussions.
- Ghana: Materials location, quality and quantities.
- Mozambique: N/A
- Sudan: N/A
- Tanzania: N/A
- Uganda: N/A
- Sierra Leone: N/A

**Other government agencies (e.g. transport, environment, natural resource management, mining, etc.)**
- Ethiopia: Not known (no request so far as the data base is new).
- Ghana: Idem
- Mozambique: N/A
- Sudan: N/A
- Tanzania: N/A
- Uganda: N/A
- Sierra Leone: N/A

**Consultants**
- Ethiopia: As above
- Ghana: Idem
- Mozambique: N/A
- Sudan: N/A
- Tanzania: N/A
- Uganda: N/A
- Sierra Leone: N/A

**Contractors**
- Ethiopia: As above
- Ghana: Idem
- Mozambique: N/A
- Sudan: N/A
- Tanzania: N/A
- Uganda: N/A
- Sierra Leone: N/A

**Academic or research institutions**
- Ethiopia: As above
- Ghana: Idem
- Mozambique: N/A
- Sudan: N/A
- Tanzania: N/A
- Uganda: N/A
- Sierra Leone: N/A

**Others**
- Ethiopia: N/A
- Ghana: N/A
- Mozambique: N/A
- Sudan: N/A
- Tanzania: N/A
- Uganda: N/A
- Sierra Leone: N/A

### C4. What functions should the database cover (in order of priority, starting with number 1 for the highest priority)?

<table>
<thead>
<tr>
<th>Functions</th>
<th>Ethiopia</th>
<th>Ghana</th>
<th>Mozambique</th>
<th>Sudan</th>
<th>Tanzania</th>
<th>Uganda</th>
<th>Sierra Leone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials properties of existing quarries and borrow areas</td>
<td>Material type</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Quantity Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road alignment (subgrade) materials testing</td>
<td>Subgrade strength (CBR)</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Page 51
### Survey questions

<table>
<thead>
<tr>
<th></th>
<th>Ethiopia</th>
<th>Ghana</th>
<th>Mozambique</th>
<th>Sudan</th>
<th>Tanzania</th>
<th>Uganda</th>
<th>Sierra Leone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geotechnical investigations</td>
<td></td>
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<td>2</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Materials and workmanship testing data for road construction and maintenance contracts</td>
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<td></td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Road pavement performance data</td>
<td></td>
<td></td>
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<td></td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Location mapping of quarries, borrow areas, etc.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Screening tools for initial assessment of unexplored sources of road materials</td>
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<td>5</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td></td>
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<tr>
<td>Other (Specify)</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td>8</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS Are there any particular training needs identified for road materials inventory and information management?</td>
<td>Materials database management (data entry, retrieval)</td>
<td>Use of advanced technology in materials investigation.</td>
<td>Data collection, testing facilities and techniques (asphalt and geotechnical investigations), management and use of data.</td>
<td>The use of topographic map, satellite image and Google earth to locate materials. How to translate the imagery to locate the material.</td>
<td>None so far identified but can be advised on the best available training on the market.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Annex E: Revised work plan

<table>
<thead>
<tr>
<th>TENDER: RAF2101A AFACAP Road Materials and Aggregate Inventory Database – Phase 1</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Plan and Staffing Schedule</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Week of the year</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>Week from the start</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

1.0 Task 1: Inception and Desk Review

1.0.1 Kick off meeting.

1.0.2 Desk review and literature study.

1.0.3 Prepare stakeholder survey, list select group of participants and discuss with PMU.

1.0.4 Circulate survey questionnaire.

1.0.5 Process findings of the survey.

1.0.6 Prepare and discuss country selection for fieldwork.

1.0.7 Update work program, staffing schedule and fieldwork consultation guide

1.0.8 Prepare and submit draft inception report.

1.0.9 Time to comment on draft inception report (PMU and stakeholders, 2 weeks).

1.0.10 Incorporate comments and submit final inception report.

2.0 Task 2: Problem analysis, system requirements, conceptualize database model and system requirements

2.0.1 Field work preparations

2.0.2 Country visits Mozambique, Namibia

2.0.3 Country visit Ethiopia

2.0.4 Country visit Ghana

2.0.5 Agree with PMU on regional workshop, venue and list of participants.

2.0.6 Consolidate findings, recommendations and work on report outline.

2.0.7 Prepare and submit I draft database report to cover architecture and mapping platform, II draft workshop report including budget and recommendations and III action plan and budget for database development.

2.0.8 Time to comment (PMU and stakeholders).

2.0.9 Incorporate comments, prepare and submit final reports.

3 Phase 3: Regional Stakeholder Workshop

3.0.1 Logistical preparations for the regional stakeholder workshop (subcontracted to workshop organizer).

3.0.2 Prepare and conduct 1-day stakeholder workshop.

3.0.3 Prepare and submit workshop report.

4 Task 4: Finalization Database System Architecture and Platform

4.0.1 Prepare and submit draft final Report

4.0.2 Time to comment (PMU and stakeholders).

4.0.3 Prepare and submit final Report

---

Inputs by Key Experts

<table>
<thead>
<tr>
<th>TL</th>
<th>Team Leader (TL): Mr. Jan Bijl</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMS</td>
<td>Data Management Specialist (DMS): Mr. Ravindra Corea</td>
</tr>
</tbody>
</table>

Time for comments, approval and follow up on recommendations by the Client and Stakeholders

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### Annex F: Contribution to the ReCAP logical framework

<table>
<thead>
<tr>
<th>Intervention Logic</th>
<th>Indicator</th>
<th>Source of Verification</th>
<th>Baseline 1 April 2017</th>
<th>Milestone 1 31 July 2017</th>
<th>Milestone 2 31 July 2018</th>
<th>Milestone 3 31 July 2019</th>
<th>End of Project Target (31 July 2020)</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OUTCOME:</strong> Sustained increase in evidence base for more cost effective and reliable low volume rural road and transport services, promoted and influencing policy and practice in Africa and Asia</td>
<td>1. SUSTAINABILITY: Partner Government and other financiers co-funding research with ReCAP. Contributions in kind (K) and Core Contributions (C)</td>
<td>Annual budget and work plan of the Ministry or Road Agency responsible for materials information management.</td>
<td>None</td>
<td>None</td>
<td>At least 1 partner country has adopted the AfCAP supported materials database and allocated dedicated staff resources and funding for population for beta testing of the materials database.</td>
<td>At least 2 partner countries have adopted the AfCAP supported materials database and allocated dedicated staff resources and funding for beta testing of the materials database.</td>
<td>At least 3 partner countries have adopted the AfCAP supported materials database and allocated dedicated staff resources and operation and maintenance of the materials database.</td>
<td>Activity only completed by 31 July 2020.</td>
</tr>
<tr>
<td>2. Concrete examples of change (applied or formally adopted), influenced by ReCAP research that will be applied to #km of road in focus countries.</td>
<td>Annual progress reports of the Ministry or Road Agency’s responsible for materials information management.</td>
<td>None</td>
<td>None</td>
<td>At least 1 partner country has formally adopted the AfCAP supported materials database.</td>
<td>At least 2 partner countries have formally adopted the AfCAP supported materials database.</td>
<td>At least 3 partner countries have adopted the AfCAP supported materials database. They receive at least 20 materials data requests per year from road industry professionals.</td>
<td>Activity only completed by 31 July 2020.</td>
<td></td>
</tr>
<tr>
<td>3. Number of citations in academic articles of ReCAP peer reviewed articles and/or working papers, conference papers etc.</td>
<td>Scientific journals and conference proceedings.</td>
<td>None</td>
<td>None</td>
<td>At least 1 citation of the materials database developed and piloted with support from AfCAP.</td>
<td>At least 2 citations of the materials database developed and piloted with support from AfCAP.</td>
<td>At least 3 citations of the materials database developed and piloted with support from AfCAP.</td>
<td>Activity only completed by 31 July 2020.</td>
<td></td>
</tr>
<tr>
<td><strong>OUTPUT 1: RESEARCH and UPTAKE:</strong> Generation, validation and updating of evidence for effective policies and practices to achieve safe, all-season, climate-resilient, equitable and affordable LVRR and transport services in African and Asian countries.</td>
<td>1.1 LVRR: Number of peer reviewed papers generated from ReCAP supported or related LVRR research projects made available in open access format.</td>
<td>Scientific journals and conference proceedings.</td>
<td>None</td>
<td>None</td>
<td>At least 1 peer reviewed paper published related to the materials database developed and piloted with support from AfCAP.</td>
<td>At least 2 peer reviewed papers published related to the materials database developed and piloted with support from AfCAP.</td>
<td>At least 3 peer reviewed papers published related to the materials database developed and piloted with support from AfCAP.</td>
<td>Activity only completed by 31 July 2020.</td>
</tr>
<tr>
<td>1.3 Engineering Research: National policies, manuals, guidelines and/or research outputs that have been fully incorporated into Government/Ministerial requirements, specifications and recommended good practice as a result of ReCAP engineering research.</td>
<td>Website portal and progress report of the Ministry or Road Agency’s responsible for materials information management. Tender</td>
<td>None</td>
<td>None</td>
<td>At least 1 partner country have prepared materials database guideline and user manual and pro-actively encourages (website, dissemination seminars) its use by industry professionals.</td>
<td>At least 2 partner countries have prepared materials database guideline and user manual and pro-actively encourages (website, dissemination seminars) its use by industry.</td>
<td>At least 3 partner countries have prepared materials database guideline and user manual and pro-actively encourages (website, dissemination seminars) its use by industry professionals. All road project documents include references to the materials database.</td>
<td>Activity only completed by 31 July 2020.</td>
<td></td>
</tr>
</tbody>
</table>
### Project: RAF2101A AFCAP Road Materials and Aggregate Inventory Database – Phase 1

<table>
<thead>
<tr>
<th>Intervention Logic</th>
<th>Indicator</th>
<th>Source of Verification</th>
<th>Baseline 1 April 2017</th>
<th>Milestone 1 31 July 2017</th>
<th>Milestone 2 31 July 2018</th>
<th>Milestone 3 31 July 2019</th>
<th>End of Project Target (31 July 2020)</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(including climate change adaptation and AFCAP and SEACAP adaptations).</td>
<td>documents and materials reports of road maintenance and construction works.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1.6. LVRR and TS information generated for dissemination, and disseminated, that is not peer reviewed. Total to include research papers, final research reports, workshop reports, manuals and guidelines.</td>
<td>Scientific journals and conference proceedings.</td>
<td>None</td>
<td>None</td>
<td>At least 1 non-peer reviewed paper prepared for national or regional conference.</td>
<td>At least 2 non-peer reviewed papers prepared for national or regional conference.</td>
<td>At least 3 non-peer reviewed papers prepared for national or regional conference.</td>
<td>Activity only completed by 31 July 2020.</td>
<td></td>
</tr>
<tr>
<td>OUTPUT 2: CAPACITY BUILDING: The building of sustainable capacity to carry out research on low volume rural roads, and rural transport services in African and Asian countries.</td>
<td>Project progress reports.</td>
<td>None</td>
<td>None</td>
<td>At least 1 national expert takes the lead in the development and beta testing of the prototype materials database.</td>
<td>At least 2 national experts take the lead in the development and beta testing of the prototype materials database.</td>
<td>At least 3 national experts take the lead in the operation and maintenance of the materials database.</td>
<td>Activity only completed by 31 July 2020.</td>
<td></td>
</tr>
<tr>
<td>2.1. African / Asian experts or institutions taking lead roles in ReCAP Research Projects.</td>
<td>Project progress reports.</td>
<td>None</td>
<td>None</td>
<td>At least 1 national female materials engineer, technician and researcher is involved in the development and beta testing of the prototype materials database.</td>
<td>At least 2 national female materials engineers, technicians and researchers are involved in the operation and maintenance of the materials database.</td>
<td>At least 3 national female materials engineers, technicians and researchers are involved in the operation and maintenance of the materials database.</td>
<td>Activity only completed by 31 July 2020.</td>
<td></td>
</tr>
<tr>
<td>2.3. Research projects with female researcher inputs at senior technical level.</td>
<td>Project progress reports.</td>
<td>None</td>
<td>None</td>
<td>At least 1 national female materials engineer, technician and researcher is involved in the development and beta testing of the prototype materials database.</td>
<td>At least 2 national female materials engineers, technicians and researchers are involved in the operation and maintenance of the materials database.</td>
<td>At least 3 national female materials engineers, technicians and researchers are involved in the operation and maintenance of the materials database.</td>
<td>Activity only completed by 31 July 2020.</td>
<td></td>
</tr>
<tr>
<td>OUTPUT 3: KNOWLEDGE: Generated evidence base of LVRR and transport services knowledge is widely disseminated and easily accessible by policy makers and practitioners (incl. education and training institutions).</td>
<td>Project progress reports.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>At least 1 presentation about the AFCAP supported materials database on a high-level international conference.</td>
<td>Activity only completed by 31 July 2020.</td>
</tr>
<tr>
<td>3.2. ReCAP generated knowledge presented and discussed at high level international development debates and conferences</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3.3. ReCAP generated knowledge disseminated through significant workshops and dedicated training, virtually or physically, that are rated by participants as effective.</td>
<td>Project progress reports.</td>
<td>None</td>
<td>At least 1 workshop attended by 50 participants.</td>
<td>At least 2 workshops and 1 training course attended by respectively 100 participants and 20 trainees.</td>
<td>At least 3 workshops and 2 training courses attended by respectively 150 participants and 40 trainees.</td>
<td>At least 4 workshops and 3 training courses attended by respectively 200 participants and 60 trainees.</td>
<td>Activity only completed by 31 July 2020.</td>
<td></td>
</tr>
</tbody>
</table>
### Annex G: Updated risk matrix

<table>
<thead>
<tr>
<th>Potential Risk</th>
<th>Risk Grading</th>
<th>Description of risk</th>
<th>Proposed management and mitigation actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1: Different requirements of AfCAP partner countries may undermine the need for a generic materials database.</td>
<td>Very High (VH)</td>
<td>The ambition to create a generic materials database may not be feasible considering the differences between the AfCAP partner countries, i.e. the different languages (French, English and Portuguese), the different road sector management arrangements and the different stages of materials database development in each of the partner countries. Implementation delays due to hazards / risks at country level.</td>
<td>This does not have to be a major issue. The scoping assignment is developing the system requirements and architecture for the generic database. If divergences exist, they will be spelled out as a key finding. During next phases of the project (database development and roll out), countries may opt not to join the project. Building in some level of flexibility can also accommodate such differences, e.g. modules with differing functionality within the same technical architecture.</td>
</tr>
<tr>
<td>R2: Lack of clear mandate and/or local ownership of the materials database development activity.</td>
<td>Low (L)</td>
<td>Different institutions are responsible for the licensing, extraction and use of road construction materials and aggregates. In some partner countries mandates and responsibilities may not be clearly defined. There is a risk that the Service Provider will operate in a vacuum and have difficulties to identify local ownership.</td>
<td>Each partner country, upon request by the PMU, nominates a counterpart institution and focal point person to work closely with the Service Provider and to facilitate in-country networking.</td>
</tr>
<tr>
<td>R3: Lack of transparency and access to materials information.</td>
<td>Very High (VH)</td>
<td>The availability of geotechnical and soils data is becoming increasingly sensitive and protected due to the economic interest of the extractive industries. There is a risk that the Service Provider will not have full access to materials data.</td>
<td>At this early stage, getting full access to materials data is not critical for achieving the objectives of the assignment. What is required is an open discussion about the current and future use of a materials database and client’s expectations. To ensure effective interaction and local ownership, the same arrangement is proposed as described above (counterpart institution and focal point).</td>
</tr>
<tr>
<td>R4: Disagreements whether the materials database should cover road or construction industry sector.</td>
<td>Medium (M)</td>
<td>Government institutions in some AfCAP partner countries may argue that a materials and aggregate database should not be limited to the road sector and should be widened to the construction sector in general. This may slow progress of stakeholder consultations; there are many potential users under this scenario.</td>
<td>This is best managed in advance of the assignment through discussions between the PMU and the AfCAP partner countries, i.e. by setting the boundaries of the assignment.</td>
</tr>
<tr>
<td>R5: Resistance to change in materials information management.</td>
<td>Low (L)</td>
<td>There may be little appetite for significant change of existing processes and/or preferred approaches may differ from one country to another. This may result in delay and potentially impede the adoption of a common platform.</td>
<td>Attempt to demonstrate benefits from examples elsewhere; ensure that proposals are staged, to proceed in relatively small, easily assimilated steps. During further stages of the project (database development), countries may opt not to be part of the project. Differences may also be accommodated by provision for modules with differing functionality, supporting different processes, within the same technical architecture.</td>
</tr>
</tbody>
</table>

*Probability = the likelihood of this risk occurring despite the management and mitigation activities being in place. Impact: = the effect on the ability of the programme to achieve its objectives without major revision or review.*
## Annex H: Draft country program for Task 2 fieldwork consultations

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Activity</th>
<th>Objective</th>
<th>Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>Briefing AfCAP Country Coordinator</td>
<td>Discuss the program.</td>
<td>Jan, Ravi</td>
</tr>
<tr>
<td></td>
<td>Meeting AfCAP host institution (e.g. CE Road Agency)</td>
<td>Presentation of the team and project briefing.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meeting Head of Materials and Research section in Roads Agency</td>
<td>Project briefing. Review survey questionnaire.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discuss institutional framework, current systems, challenges and ambitions.</td>
<td></td>
</tr>
<tr>
<td>Afternoon</td>
<td>Visit Central Materials Laboratory</td>
<td>Become familiar with existing system and procedures for laboratory management, materials testing and data storage.</td>
<td>Jan, Ravi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 2</th>
<th>Activity</th>
<th>Objective</th>
<th>Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>Follow up visit Central Materials Laboratory (national roads)</td>
<td>Review existing resources for materials information management.</td>
<td>Jan, Ravi</td>
</tr>
<tr>
<td></td>
<td>Meeting local government / rural roads authority.</td>
<td>Discuss specific requirements for local government / rural roads engineers doing in-house road design: their materials information needs, challenges and ambitions.</td>
<td></td>
</tr>
<tr>
<td>Afternoon</td>
<td>If relevant, visit a nearby Provincial / Regional Materials Laboratory.</td>
<td>Become familiar with their systems and procedures for laboratory management, materials testing and data storage for local roads.</td>
<td>Jan, Ravi</td>
</tr>
<tr>
<td></td>
<td>If relevant, visit external stakeholders (environmental agency, natural resource management, mineral resources, etc.)</td>
<td>Discuss synergies with other on-going initiatives. Data collection.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meeting Head of Road Asset Management System</td>
<td>Become familiar with the road asset management system and explore possible links with materials information management.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 3</th>
<th>Activity</th>
<th>Objective</th>
<th>Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>Meeting IT section in the Road Agency.</td>
<td>Review existing IT policy, resources, challenges and ambitions.</td>
<td>Ravi</td>
</tr>
<tr>
<td></td>
<td>Meeting Consultants’ Representatives.</td>
<td>Discuss stakeholders’ needs and expectations of materials information management – consultant’s view.</td>
<td>Jan</td>
</tr>
<tr>
<td>Afternoon</td>
<td>Meeting GIS section in the Road Agency.</td>
<td>Review existing GIS resources in the Road Agency.</td>
<td>Ravi</td>
</tr>
<tr>
<td></td>
<td>Meeting Contractors’ Representatives.</td>
<td>Discuss stakeholders’ needs and expectations – contractor’s view.</td>
<td>Jan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 4</th>
<th>Activity</th>
<th>Objective</th>
<th>Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>Possible follow up meetings.</td>
<td>-</td>
<td>Jan, Ravi</td>
</tr>
<tr>
<td></td>
<td>Meeting Head of Materials and Research in Roads Agency.</td>
<td>Present and discuss main findings of the visit.</td>
<td></td>
</tr>
<tr>
<td>Afternoon</td>
<td>Meeting AfCAP host institution (CE Road Agency).</td>
<td>Debriefing meeting.</td>
<td>Jan, Ravi</td>
</tr>
<tr>
<td></td>
<td>Meeting AfCAP Country Coordinator.</td>
<td>Discuss any follow up work required.</td>
<td></td>
</tr>
</tbody>
</table>