ReCAP Benefit Assessment System

Systems Development Report

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Abstract

This report presents the indicators for assessing the benefits of research investments, a detailed description of the Benefit Assessment System (BAS) and the Monitoring and Evaluation (M&E) framework using the indicators. BAS uses a systems approach where ReCAP-BAS is considered to comprise a number of interdependent and interacting subsystems of an organised whole system. Six subsystems are identified and performance indicators are categorized according to these sub-systems. A scoring system is used for the indicators, and their surrogates for each subsystem are scored according to the relative importance in defining the subsystem. The ReCAP-BAS can be visualized as a report (score) card where grades (or scores) are assigned to the various indicators or groups for each subsystem. Poor performance in one area does not necessarily lead to the conclusion that the program/project is a failure. The relative merits (scores) of the various subsystems of the framework need to be considered in assessing the overall benefits of the program/project in any given time frame. The systems architecture is also presented. It describes the structure of the database and M&E website using Open Source software application. The open source software suite is sustainable and presents a simple yet powerful architecture which integrates very well with other open standard application for data visualization and manipulation

Key words: *Benefits Assessment System, Indicators, Monitoring and Evaluation Framework, Systems Architecture, User Requirements Specification.*

Research for Community Access Partnership (ReCAP)

Safe and sustainable transport for rural communities

ReCAP is a research programme, funded by UK Aid, with the aim of promoting safe and sustainable transport for rural communities in Africa and Asia. ReCAP comprises the Africa Community Access Partnership (AfCAP) and the Asia Community Access Partnership (AsCAP). These partnerships support 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 ReCAP programme is managed by Cardno Emerging Markets (UK) Ltd.
www.research4cap.org

Acronyms, Units and Currencies

AfCAP	Africa Community Access Partnership
AsCAP	Asia Community Access Partnership
ARTReF	African Road and Transport Research Forum
BAS	Benefits Assessment System
B/C	Benefit/Cost
BRRI	Building and Road Research Institute
BSC	Balanced Score Card
CB	Capacity Building
CBA	Cost Benefit Analysis
CSIR	Council for Scientific and Industrial Research
DFID	Department for International Development
DFR	Department of Feeder Roads
DUR	Department of Urban Roads
EIRR	Economic Internal Rate of Return
HDM	Highway Design and Management, software
IT	Information Technology
KTC	Koforidua Training Centre (under MRH)
LCM	Life Cycle Modelling
LVRR	Low Volume Rural Road
MDAs	Municipal and District Assemblies
M&E	Monitoring and Evaluation
MRH	Ministry of Roads and Highways
MoT	Ministry of Transport
NPV	Net Present Value
ODK	Open Data Kit
ReCAP	Research for Community Access Partnership
RED	Road Economic Decision Model
RR	Rural Roads
ToR	Terms of Reference
TRL	Transport Research Laboratory
TS	Transport Services
UAT	User Acceptance Testing
UK	United Kingdom (of Great Britain and Northern Ireland)
URS	User Requirements Specifications

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Executive Summary

The overall aim of this project is to develop a ReCAP Benefit Assessment System (ReCAP-BAS) that will enable the funders and partner countries of ReCAP to assess the benefits and effectiveness of research investments. This report presents the performance indicators necessary for assessing the impacts of such research in terms of the benefits derived by the direct and indirect beneficiaries of the results of the research efforts. The report describes the framework of the benefits assessment system (BAS) and the systems architecture for the Monitoring and Evaluation (M&E) system which includes the database and user interface.

The findings from literature review formed the basis for performance indicators and the approach used for the ReCAP-BAS. Identification of suitable indicators took into account the findings from previous studies and recommendations of the scoping study. Similarly, the systems approach for the BAS is supported by findings from previous studies. The BAS presented is based on a systems approach where ReCAP-BAS is considered to comprise a number of interdependent and interacting subsystems of "an organized whole" system. It comprises six (6) subsystems that operate in an environment that it interacts with and that influences it. The performance indicators are identified and categorised according to these sub-systems. A summary of the subsystems is presented in Table E-1.

A scoring system is used where the indicators and their surrogates for each subsystem are scored according to their relative importance in defining the subsystem. The ReCAP-BAS can be visualised as a report (score) card where grades (or scores) are assigned to the various indicators or groups for each subsystem. Poor performance in one area does not necessarily lead to the conclusion that the program/project is a failure. The relative merits (scores) of the various subsystems of the framework need to be considered in assessing the overall benefits of the program/project in any given time frame.

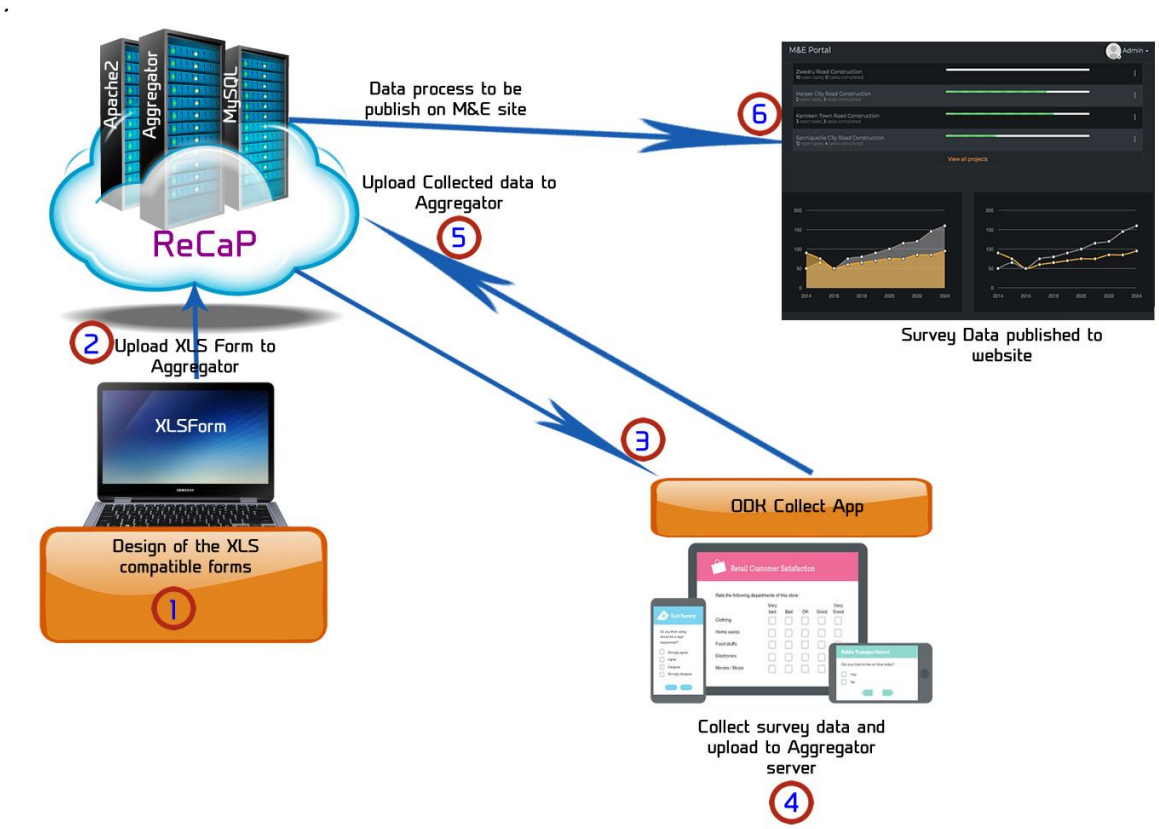
The system architecture (Figure E1) describes the structure of the database and M&E portal. The database uses an Open Source software application. The open source software suite is sustainable and presents a simple yet powerful architecture which integrates very well with other open standard applications for data visualization and manipulation.

The M&E portal will be the main point of links to all other functionalities of the system. From the website a user will have access to the dataset from the Cloud database. The M&E Portal takes the user to the backend where only with the right access level can one login with the username and password provided to user by the site Administrator. The portal will be a PHP application that uses MySQL back-end for storing data.

Table E-1: Groups of Indicators and Log frame Levels

Subsystem	Groups of Indicators and examples	Type	Logframe level
A	Research product & usage • Achievement of Research Objectives • Types of Products from Research • Adoption for Implementation • Extent of Use	Quasi-quantitative	Output & Outcome
B	Economic • Agency Costs (capital and operation) • Vehicle operating costs • User costs (travel and transport costs) • Safety costs	Quantitative	Input, Outcome & Impact
C	Socio-economic • Access to healthcare, social, and educational facilities • Economic activities (farming, retail, etc) • Travel and transport costs • Employment • Household income • Social integration • Women/youth empowerment	Quasi-quantitative	Outcome & Impact
D	Safety • Accident rate/density • Fatality rate	Quantitative	Outcome & Impact
E	Environmental • Climate change • Air quality • Noise abatement • Erosion • Wetland and Nature	Quasi-quantitative	Outcome & Impact
F	User satisfaction and Value • Awareness • Access • Acceptability • Use • Value	Quasi-quantitative	Outcome & Impact

Figure E-1: System Architecture



The report also describes the User Requirements Specification that outlines the functionality of the system, data requirements, and sustainability of the system. It is expected that regional stakeholders will provide inputs to ensure their expectations are met.

1. Introduction

1.1 Study Background

The Research for Community Access Partnership (ReCAP) funded by the UK government through the Department for International Development (DFID) is a programme of research and knowledge dissemination covering Africa and Asia. Cardno Emerging Markets is managing the programme of Research for Community Access Partnership (ReCAP) on behalf of DFID. It is a combination of the Africa Community Access Partnership (AfCAP 2) and the Asia Community Access Partnership (AsCAP). The aim of ReCAP is to build on the previous programmes of high quality research and take this forward to a sustainable future in which the results of the research are adopted in practice and influence future policy. In order to assess the benefits accruing from the investment in research it is necessary to have an appropriate management system to analyze and, where appropriate, quantify all the benefits, both direct and indirect.

This ReCAP Benefit Assessment System (ReCAP-BAS) project is a 15-month assignment to develop a framework to better understand and assess the benefits of research investment. Given the level of ReCAP investment in research there is need to have a system to assess the impacts of such research in terms of the benefits derived by the direct and indirect beneficiaries of the results of the research efforts. The assessment of the benefits would require identification of appropriate indicators and the quantification and qualification of the benefits.

1.2 Project Aim and Objectives

The overall aim of the project is to develop a ReCAP Benefit Assessment System (ReCAP-BAS) as part of the overall technology/research management for ReCAP that will enable the funders and partner countries of ReCAP to assess the effectiveness of research investment over the full innovation value chain (input, output, outcome and impact). It is anticipated that the ReCAP-BAS will be used beyond the current remit of ReCAP.

The objectives of the project are to take the recommendations of the scoping study and develop a credible system for the assessments of total benefits. This includes costs and benefits that are emanating from the investment in research. The system should enable the storage and analysis of large data sets over time in order to allow for proper trend analysis and should also define specific indicators for outcomes and proxy indicators for impact analysis.

1.3 Purpose of Systems Design Report

This report describes the ReCAP benefits assessment system (ReCAP-BAS)framework. The systems architecture for the Monitoring and Evaluation (M&E) system and the supporting database are also described. The performance indicators for the various assessment areas are presented. The report also includes the User Requirements Specifications(URS) that outlines the scope and functionality of the system, data requirements, and sustainability of the system.

1.4 Organisation of Report

This report is organised as follows:

- Section 1 presents an introduction that includes a background to the study, aim and objectives of the project, as well as the purpose of this report;
- Section 2 presents a summary of the literature review
- Section 3 presents the indicators and Benefits Assessment Framework;
- Section 4 presents the database architecture, M&E system, and URS;
- Section 5 presents the conclusions and recommendations; and
- Section 6 presents the next steps.

2. Literature Review

2.1 Introduction

Benefit Assessment system is increasingly becoming important to governments and stakeholders in order to demonstrate benefit of projects to the populace/donors who pay for these projects. For the first phase of AfCAP which commenced in June 2008 and ended in July 2014 (AfCAP1), Cost/Benefit analysis was used to evaluate the programme(Carruthers & Nogales, 2013). However, according to Rust, Strydom, and Hine, (2016), DFID expressed some concerns over the extent and validity of the data used and recommended the need to collect additional relevant cost and performance data and to further explore the use of CBA using a life-cycle cost analysis for ReCAPduring Phase 2 of the project. The current management of ReCAP involves the use of logframes to monitor the progress and deliverables of the programme, as well as some indicators for impact assessment. The need for a more holistic approach to assess ReCAP has become paramount.

Substantial studies have been carried out on impact assessment (benefit quantification) for Research and Development (R&D) activities. One of the most recent studies, ReCAP Benefit Assessment System(ReCAP-BAS) (Rust, Strydom, & Hine, 2016), was done with the principal aim of proposing additional processes and indicators that would describe the full spectrum of benefits in support of the normal benefit/cost calculation currently used to portray benefits from the ReCAP programme. This literature review, relies primarily on the scoping document from ReCAP and a project carried out by John Hine entitled "Proposing a system for cost benefit analysis of AfCAP2 and AsCAP", which were provided as part of the tender package for this project. Other benefit and impact assessment studies, considered to be relevant to the project, were also reviewed and synthesised into the study. From the literature, research benefit assessment systems should evaluate the effectiveness of research investments over the full innovation value chain of input, output, outcome and impact.

2.2 Benefit Assessment Methods

From the extensive review of literature, the following methods have been used for benefit assessment systems:

1) Cost Benefit Analysis(CBA)
2) Linear research and development (R&D) and innovation management models
3) Systems approach

2.2.1 Cost Benefit Analysis(CBA)

Benefit assessment systems are important tools that can assist programme managers perform the under-listed task (Hine, Identifying the Costs and Benefits of AfCAP/AsCAP, 2015):

- identify and prioritise research and development priorities (ex-ante);
- assist with identifying whether projects have been worthwhile (ex-post); and
- provide a mechanism to demonstrate investment and policy priorities

According to (Hine, Identifying the Costs and Benefits of AfCAP/AsCAP, 2015), almost all forms of CBA involve uncertainty as project costs and benefits must

be forecast and that forecasts must also be made of the counterfactual. In road infrastructure projects, CBA has been implemented in software such as Highway Development and Management Model (HDM4) and Roads Economic Decision Model (RED) and used in the economic appraisals of such projects(World Bank, 2000; World Bank, 2006).

However, not all projects are suitable for CBA. Because of the greater uncertainty in forecasting outcomes from research as compared to conventional projects, and the uncertainty on the extent to which the findings of research will be implemented, CBA is hardly used in research evaluation projects (Hine, Identifying the Costs and Benefits of AfCAP/AsCAP, 2015). Again, for most project types, including manuals, design standards, management research, training, conferences, etc., CBA methodologies are not very suitable because of the difficulty in quantifying impact in monetary terms. It is easier to identify and quantify impact from physical works, and some transport services, demonstration projects and hence these are more suitable for CBA (Hine, Identifying the Costs and Benefits of AfCAP/AsCAP, 2015).

From the ensuing, most AfCAP/AsCAP projects are not suitable for CBA, therefore an alternative methodology is required.

2.2.2 Linear R&D and innovation management models

Earlier researchers, for example (Rust, Strydom, & Hine, 2016; Rust, 2009; Wagner-Luptacik, Heller-Schuh , & Leitner, 2006) have indicated that the innovation value chain is a complex system and that linear models are unable to adequately explain the behaviour of the system due to the number of elements in the system, the number of stakeholders, the interaction between the elements and environmental influence. Linear models lack the interactive nature and the interdependency of all internal and external factors and results in the fragmentation of associated benefits and impact derived from a project. These linear innovation management models are not suited for the management of R&D and innovation in transport services and road engineering.

2.2.3 Systems Approach

The systems approach views the benefit and impact assessment as an open system, which is composed of interacting and interdependency parts, called subsystems. That is, the system is viewed as "an organised whole" made up of sub-systems integrated into a unity or orderly totality. These elements operate in an environment that it interacts with and that influences it.

The systems based model has been used e.g. (Rust, 2009; Fekpe, Gopalakrishna, Amer, Nuworsoo, & Babaie, 2003) in the management and benefit assessment of R&D and road infrastructure projects. Rust, Strydom, & Hine, (2016) recommended that a systems approach be followed in ReCAP BAS.

In a Balanced Score Card Approach, indicators (subsystems) could be defined that address all the subsystems in the model to ensure that the full benefit as well as the performance of the programme is assessed.

2.3 Performance Measures/Indicators

As mentioned, different indicators (subsystems) of the whole system have to be assessed. The output from the research, usage and customers (users) satisfaction of the product must be evaluated (Fekpe, Gopalakrishna, Amer, Nuworsoo, & Babaie, 2003). Other important aspect of the positive impacts, which can be derived from transportation investment for example, are as follows (Cambridge Systematics, Inc., 2002):

1. Economic Benefits (boosts industry competitiveness, enhances household welfare, boosts business and leisure travel, reduces economic losses associated with crashes, reduces economic losses associated with congestion, creates jobs in the transportation sector).
2. Environmental Benefits (can improve air quality and energy efficiency, reduce noise pollution, light pollution, protect wetlands and safeguard clean water supplies, provide historic and ecological preservation benefits);
3. Community and Social Benefits (increase mobility and access, provide a greater choice of travel modes, improve safety, enhance the visual appearance of our communities, cities, and natural landscapes, and increase community cohesion.); and
4. The Benefits of Reducing Congestion (wastes time and affects peoples' quality of life, has safety and environmental impacts, affects the economy and travel time reliability).

All the above mentioned subsystems have been considered and indicators from each have been considered for inclusion in the logframe in developing the benefit assessment system. Again, a close attention was paid to the under-listed ReCAP projects in the selection of the performance indicators:

- GEN2018C - Research on New Asset Management Approaches for Maintaining and Improving Local Road Access – Phase 2 and 3 (GEM)
- GEN2014C - Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa
- GEN2033C - Status Review of the Updated Rural Access Index (RAI)
- GEN2136A - The interaction between improved rural infrastructure access and rural transport service provision.

For instance, the Rural Access Index (RAI) (GEN2033C), defined as the proportion of the rural population living within 2 km of an all-season road(Vincent, Status Review of the Updated Rural Access Index (RAI), 2018), is now a Sustainable Development Goal (SDG) which shows levels ofrural accessibility. Indicator 9.1.1 of the SDG was agreed with the same definition as the RAI, requiring regular update of RAI data for the majority of UN countries. The "Economic Growth through Effective Road Asset Management – GEM" indicators (GEN2018C) are intended to support the "headline" indicator for rural access in developing countries, which is the Rural Access Index (RAI).

2.3.1 Crash Costs

Several methods (e.g., human capital, willingness to pay, life insurance-method, etc.) have been used in estimating the cost of road traffic crashes in the literature (Ross Silcock and Transport Research Laboratory (TRL), 2003; Ahadi & Razi-Ardakani, 2015). From extant literature, methods such as the willingness to

pay, which is mostly used in the developed countries, is difficult to use in developing countries as it relates to perceived risk and payment by individuals to avoid a given (hypothetical) level of risk. The human capital method has been prescribed for estimating the cost of crashes in developing countries. The unit cost for each crash severity level (i.e., fatal, serious, slight and damage only) is required in order to evaluate crash cost savings. However, a cursory search revealed data estimate on crash cost for ReCAP partner countries may not be readily available or outdated. For example, the most recent study on estimating the cost of crashes in Ghana was carried out in 2006 which is dated and may not apply currently.

2.3.2 Augmented Indicators

The scoping ReCAP-BAS document (Rust, Strydom, & Hine, 2016) recommended augmenting the current set of indicators in the ReCAP logframe with some indicators that describe the "softer" outcomes from the programme such as number of professionals trained and traffic safety. These indicators, which describe the "softer" outcomes, are listed below (Rust, Strydom, & Hine, 2016):

- Accident rate per km per 100,000 people
- Number of implementation projects where ReCAP research has been applied
- Total monetary value of implementation projects where ReCAP research has been applied
- Number of new/ enhanced capabilities created in Road Authorities
- Number of small contractor and consultant capacity development projects/ company processes improved from ReCAP outputs
- Traffic volume count on Low Volume Rural Roads
- Cumulative benefit/cost ratio for projects assessed
- Portfolio balance: type of research (basic, applied, experimental development, technology transfer)
- Portfolio balance: research focus (materials, design, construction, management systems, environmental impact, transport services)
- Facility performance index (how the solution improves the performance of the facility)
- Number of professionals directly exposed to ReCAP research findings through training and workshop interventions
- Number of professionals exposed to ReCAP through indirect training
- Number of instances of multi-country, inter-regional, or multi-research organisation projects.

2.4 ReCAP Research Projects

A desk study has been carried out on potential ReCAP projects which can be used to implement and test run the system. Stratified random sampling will be used to include projects from all types (i.e., infrastructure, transport services, capacity building and knowledge management) and also from all the four (4) sub-regions of ReCAP (i.e., West Africa, East Africa, Southern & Central Africa and South East Asia). The ease of getting data of a project will also be taken into consideration. ReCAP projects and outputs including manuals, design standards, management research, training, conferences, etc. will be selected and included in the test run of the system.

2.5 Data Requirement, Sources and Validation

For a Benefit Assessment System to be holistic and robust, it will be desirable to have good data on various performance indicators. Sources for data and information relevant to this assignment have been identified. The plan is to gather information from AfCAP and AsCAP project reports as much as possible. The team will also contact national coordinators in AfCAP and AsCAP partner countries, colleagues and organisations who have worked on the selected projects mainly through emails and telephones. These will include organisations in the partner countries such as road and transportation agencies, research institutions and road safety commissions. This, we intend to do through the AsCAP and AfCAP national coordinators. In this regard, names and contact details of all AfCAP and AsCAP national coordinators have been obtained.

It is important to ensure that the quality of the data used in the project management system is verified for correctness and usefulness. The project team will, firstly, rely on ReCAP coordinators to verify data from their respective countries. However, there will also be a data validation process in the project management system. The data validation process will consist of format, range, presence, type, etc. checks (e.g. traffic volume should be a number and not more than 2200 veh/h/lane).

The team is aware that some of the data desirable for the assignment will be subject to some limitations. For example, it is well known that, road traffic crash data from developing countries are under-reported (Peden, et al., 2008; Salifu & Ackaah, 2012). Therefore, they will be subject to some errors. The magnitude of these errors, if known, must be stated to give an indication in the report. If the data (variable) is considered to be too unreliable based on statistical consideration and our experience, the team will decide not to use it. We acknowledge that it is difficult to identify and evaluate the scope of some of these errors. In subsystems where the data is missing or cannot be obtained, no evaluation will be made.

2.6 Conclusions and Recommendation

Cost/Benefit analysis was used to evaluate ReCAP projects. However, not all projects (e.g. capacity building and knowledge management) are suitable for CBA. The literature has recommended the use of the systems approach in ReCAP BAS. In a Balanced Score Card Approach, indicators (subsystems) could be defined that address all the subsystems in the model to ensure that the full benefit as well as the performance of the programme is assessed.

2.7 References

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3. Benefits Assessment System (BAS)

This section describes the Benefits Assessment System (BAS).

3.1 Overview of Benefits Assessment Framework

We propose a systems approach where the benefits and impact assessment is viewed as an open system, that is composed of a number of interacting and interdependent parts, called subsystems. That is, the system is viewed as "an organised whole" made up of sub-systems integrated into a unity or orderly totality. These elements operate in an environment that it interacts with and that influences it. We propose to develop the benefits assessment framework that consists of six (6) sub-systems or assessment areas. The performance measures are therefore categorized according to these sub-systems:

A. Research products and extent of use indicators;
B. Economic indicators (benefits and costs);
C. Socio-economic indicators;
D. Safety indicators;
E. Environmental indicators;
F. User satisfaction and value indicators.

A comprehensive list of performance indicators for each area and the level in the logframe are summarised in Table 1 and a schematic of the BAS presented in Figure 1. The guiding principle in the development of the performance indicators and assessment framework is to ensure that the indicators are relevant, that they capture all types of research, that they are objective enough to highlight the benefits and weaknesses of research programs and projects, and above all, simple enough to be easily understood and applied.

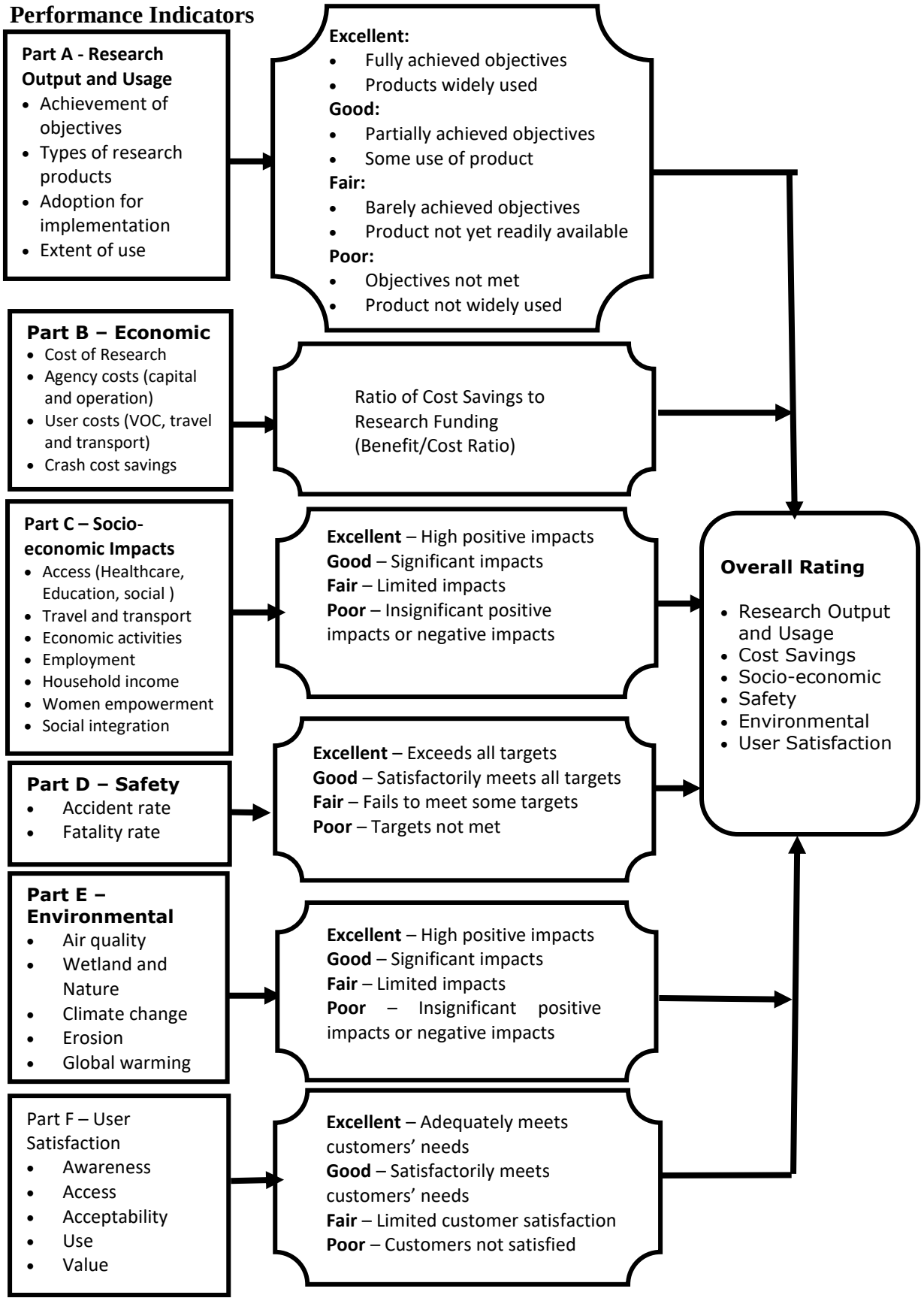
Based on the systems approach as indicated above, the benefits assessment framework can be visualised as a report (score) card where grades (or scores) are assigned to the various indicators or groups and therefore for each subsystem. Poor performance in one area does not necessarily lead to the conclusion that the program/project is a failure. The relative merits (scores) of the various subsystems of the framework need to be considered in assessing the overall benefits of the program/project in any given time frame.

The indicators in each subsystem are weighted based on their relative importance or contribution to defining the indicator for that subsystem. The weighted scores for each subsystem are summarised in a report or score card. This is visualised as a report card but with no aggregated or cumulative score for all the subsystems. Converting all scores to a single score would lose the essence of the assessment exercise where strong and weak points would not be easily identified and documented as lessons learned to help in designing future projects.

Table 1: Groups of Indicators and Logframe Levels

Subsystem	Groups of Indicators and examples	Type	Logframe level
A	Research product & usage • Achievement of Research Objectives • Types of Products from Research • Adoption for Implementation • Extent of Use	Quasi-quantitative	Output & Outcome
B	Economic • Agency Costs (capital and operation) • User costs • Vehicle operating costs • Safety costs	Quantitative	Input, Outcome & Impact
C	Socio-economic • Access to healthcare, social, and educational facilities • Economic activities (farming, retail etc) • Travel and transport costs • Employment • Household income • Household expenditure • Social integration • Women/youth empowerment	Quasi-quantitative	Outcome & Impact
D	Safety • Accident rate/density • Fatality rate	Quantitative	Outcome & Impact
E	Environmental • Climate change • Air quality • Noise abatement • Erosion • Wetland and Nature	Quasi-quantitative	Outcome & Impact
F	User satisfaction and Value • Awareness • Access • Acceptability • Use • Value	Quasi-quantitative	Outcome & Impact

Figure 1: Schematic of BAS framework



3.2 Performance Indicators

The performance indicators form the basis of the BAS. Several indicators are identified for each of the six (6) subsystems as follows.

A. Research products and extent of use indicators;
B. Economic indicators (benefits and costs);
C. Socio-economic indicators;
D. Safety indicators;
E. Environmental indicators;
F. User satisfaction and value indicators.

This section provides details of the indicators in terms of the research types and focus areas, applicable logframe level, sources of data, and assumptions. The indicators are presented and discussed in the following subsections.

3.2.1 Part A – Research Product and Usage Indicators

Definition: The performance metrics in this subsystem or category address the relevance of the research product in terms of the quality or success of the research effort and extent of implementation of the outputs. Four (4) major indicators are identified with several sub-elements or surrogate measures. These are defined below.

A.1. Achievement of Research Objectives

Definition: The indicators in this subgroup address the relevance of research product in terms of the quality/success of the research work. The primary measure of success is if the research achieved its stated objectives. Surrogate indicators of research success include

i. producing of research reports
ii. refereed papers in technical journals
iii. conference presentations, working papers, workshop reports
iv. citations and awards.

A.2. Types of Products from Research

Definition: This indicator identifies the types of research and outputs generated. Surrogate indicators include:

i. Specifications, Guidelines and handbooks
ii. Improved Conventional, New and Innovative Materials
iii. Advanced Technology/Equipment
iv. Software tools and advanced state-of-the-art procedures (e.g., methods and techniques)
v. Technology Transfer Tools

A.3. Adoption for Implementation

Definition: This indicator addresses the level of implementation of the research products identified by the previous metrics.

Notes: For projects whose primary products are specifications, adoption by ReCAP and its partner countries, organisations like World Bank, IRF or other standards setting agencies is critical. For projects whose product is new and improved materials, commercial production of the material is a good indicator of

success. Equipment and technology-based research are considered to be successful if transportation agencies use the product. Projects with software tools as outputs are successful if their software is available as a completed product or in case of agency specific software like RAI, are being used. The success of technology transfer tools is in their creation and wider use.

A.4. Extent of Use at the National and Local Levels

Definition: This indicator assesses the level of usage of the research products. This metric is considered one of the key indicators of the benefits or quality of the research effort. This is because usage of a research product or result is a true reflection of the benefits associated with the research product.

Table 2 below presents details of the indicators in this subsystem.

Table 2. Research Output and Usage

Research type	Research Focus	Indicator	Description	Log-frame Level	Unit of measure	Source of data	Method of data collection	Responsible entity	Assumptions regarding availability of data
All	All	1. Achievement of Research Objectives	Degree of achievement of Research Objectives	Output	Percentage achievement	ReCAP reports and program managers	Primary data via interviews with project/program managers	ReCAP	ReCAP tracks research activities; ReCAP maintains and updates database of research projects; ReCAP website is up to date
All	All	2. Research product 2.1 – Peer reviewed publications	Peer reviewed paper on transport infrastructure / transport services	Output	Number	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	
All	Design/ Specifications	2. Research Product 2.2 Design manuals, specifications, and guidelines	Transport engineering research /transport services design manuals, specifications and guidelines	Output	Number	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	
All	All	2. Research Product- 2.3 Research Information	Research information presented at conference, working paper, workshop	Output	Number	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	
All	Construction materials and methods	2. Research products 2.4 construction materials	Improved conventional and innovative materials	Output	Number	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	

Research type	Research Focus	Indicator	Description	Log-frame Level	Unit of measure	Source of data	Method of data collection	Responsible entity	Assumptions regarding availability of data
All	Construction materials and methods	2. Research products – 2.5 technology and new equipment	Advanced technology, and new equipment for construction, inspection, testing	Output	Number	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	ReCAP tracks research activities; ReCAP maintains and updates database of research projects; ReCAP website is up to date
All	Software tools and procedure	2. Research products – 2.6 software and procedures	Software tools, state-of-the-art procedures	Output	Number	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	
All	Capacity building/technology Transfer	2. Research Product 2.7 Technology transfer	Websites, workshops, clearing houses	Output	Number	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	
All	All	3. Extent of adoption	Measures the number (or proportion) of road agencies that have adopted the research product	Outcome	Number/ Percentage	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	
All	All	4. Extent of usage of research product	Measures the number (or proportion) of road agencies actually using the research product	Outcome	Number/Percentage	ReCAP reports and program managers	Secondary data from ReCAP, Primary data via interviews with project/program managers	ReCAP program managers	

3.2.2 Part B – Economic Indicators

Definition: This subsystem assesses the cost savings or benefits of implementing the research products relative to the research investment. Therefore one of the key indicators is the investment or cost of the resources associated with the conduct of the research project. Cost saving is estimated as the difference in cost with (ex-poste) and without (do nothing or counterfactual) the use of the research product. This includes savings to the implementing agencies and road users. Safety cost savings is captured under the Safety subsystem.

B1 Investment or cost of inputs

This indicator measures investment, cost or resources used in conducting the research. Given the time value of money, the present worth of the investment should be used.

B2 Agency cost savings

Definition: These relate to the cost savings to the implementing agency (typically national and local road agencies) that use the research product. This is made up of capital and operating costs.

Capital Costs **-** For purposes of this analysis, capital costs are defined as costs incurred in the deployment or implementation of the research product. Where cost data is available on more than one project or application, of a research product, the average cost should be used. This includes labour, materials, and equipment costs.

*Operating Cost*s - The cost savings in maintenance operations are classified into two major groups – routine and periodic maintenance and major rehabilitation and reconstruction. This also includes labour, materials, and equipment costs.

Total Agency Costs: The total agency costs is the sum of the annualized capital costs, the annual routine maintenance costs and the annualized major R&R costs. This is dependent on the type of research product or result:

i. Specifications, Guidelines, monographs, and handbooks
ii. Improved Conventional, New and Innovative Materials
iii. Advanced Technology/Equipment
iv. Software tools and advanced state-of-the-art procedures (e.g., methods and techniques)
v. Technology Transfer Tools

B3 User cost savings

Definition: User cost savings includes travel time and vehicle operation cost savings.

Vehicle Operating Cost (VOC) Savings: VOC savings measures the difference between VOC without research products (or do-nothing) operating conditions and following implementation of research products or results.

Travel time and transport savings: This indicator measures the impact of implementing research products and results on beneficiary communities' travel

time and transport costs between given origins and destinations relating to both economic and social activities. Travel time savings can be converted to monetary values using the Value of Time (VOT) concept. The VOT varies by type of vehicle and type of trip. The average cost savings can be estimated by the reductions in travel times multiplied by the VOT and annual average traffic volume.

B4- Crash Cost Savings

Assigning or translating reductions in number, rate, or density of crashes directly to implementation of research products is difficult. Furthermore, placing monetary value on human life due to fatalities is difficult. It is also recognized that the quality of crash data may be poor given that crash records are typically incomplete.

It is recognized that cost data on certain elements may be difficult to obtain. In such cases it may be necessary to make assumptions based on domain knowledge or evidence from similar products e.g., safety. It is important that any such assumption be properly qualified and justified. The cost savings can be expressed per unit or project or application depending on the nature of the research product.

Table 3 presents details of the indicators in this subsystem.

Table 3. Economic Indicators

Research type	*Research focus*	*Indicator*	*Description*	*Logframe Level*	*Unit of measure*	*Source of data*	*Method of data collection*	*Responsible entity*	*Assumptions regarding availability of data*
All	All	Investment or cost	Research funding	Input	Currency	ReCAP / Road Agency	Secondary data from ReCAP/ road agency, Primary data from field studies	ReCAP/Road Agency	ReCAP/Road agency maintains a database
All	All	Agency capital and operating expenditure	Agency budgetary allocations for /maintenance rehabilitation of pilot project roads	Input	Currency	Road Agency approved yearly budget and end-of-year expenditure	Secondary data	Road agency, Project team	Availability of Road Agency annual budget performance report
All	All	Road user cost savings	Vehicle operating cost savings	Outcome	Currency	Road Agency	Secondary data from road agency, Primary data from field studies	Road agency, Project team	ex-ante and ex-post CBA results available
All	All	Road user cost savings	travel time to education, health facilities, markets, etc	Outcome	Currency	Road Agency	Secondary data from road agency, Primary data from field studies	Road agency, Project team	ex-ante and ex-post CBA results available
All	All	Safety	Crash cost savings	Outcome	Currency	Road Agency	Secondary data from road agency, Primary data from field studies	Road agency, Project team	Availability of crash data; estimates of value of life
Technology transfer	Construction materials	Use of innovative/new materials	Cost savings from use of innovative/new materials	Outcome	Currency	Road Agency	Secondary data from road agency, Primary data from field studies	Road Agency, Project Team	
Technology transfer	Technology/ Equipment	Use of new technology/ equipment	Cost savings from use of innovative/new materials	Outcome	Currency	Road Agency	Secondary data from road agency, Primary data from field studies	Road Agency, Project Team	

Table 3. Economic Indicators (Contd).

Research type	Research Focus	Indicator	Description	Level	Unit of measure	Source of data	Method of data collection	Responsible entity	Assumptions regarding availability of data
Technology transfer	Software/ Specification	Training (e.g. in the use of new software, specifications, guidelines)	Design time cost savings from the use of new software, specifications, guidelines	Outcome	Currency	Road Agency	Secondary data from road agency, Primary data from field studies	Road Agency, Project Team	
Basic	Construction techniques	Labour-based rural road rehabilitation and maintenance contracts effectively executed	km of roads rehabilitated and maintained	Impact	Length of roads (km)	Project completion report	Secondary data collection	Road agency, Project team	
Basic	Capacity building	Local civil works contractors trained	By the end of project, -- no. contract managers trained	Impact	No.	Annual Training report	Secondary data collection	Road agency, Project team	
	All	Local civil works supervisors trained	By the end of project, -- no. accredited training delivered	Impact	No.	Annual Training report	Secondary data collection	Road agency, Project team	
All	All	Net Present Value (NPV)	NPV greater than zero	Outcome	Currency	Road Agency	Secondary data from road agency, Primary data from field studies	Road agency, Project team	ex-ante and ex-post CBA results available
All	All	Benefit – Cost Ratio (B/C ratio)	B/C Ratio greater than one	Outcome	Ratio	Road Agency	Secondary data from road agency, Primary data from field studies	Road agency, Project team	ex-ante and ex-post CBA results available
All	All	Economic Internal Rate of Return (EIRR)	EIRR greater than the opportunity cost of capital (12%)	Outcome	Percentage	Desk study, Field data collection	Secondary data from road agency, Primary data from field studies	Road agency, Project team	ex-ante and ex-post CBA results available

3.2.3 Part C – Socio-Economic Indicators

Definition: Indicators in this subsystem measure the socio-economic impacts of the implementation of the research products. These indicators are medium to long term impacts and the benefits are reflected in improved access and mobility for the beneficiaries which ultimately result in poverty alleviation. The benefits are also measured in terms of social cohesion and integration. The benefits are measured in terms of positive changes in these indicators relative to the existing situation prior to implementation of research results or products. Indicators in this subsystem include:

C1 Access to facilities

Definition: This indicator measures the impact of implementing research products and results on beneficiary communities' access to economic, health, educational, social, and other facilities.

C2 Economic Activities

Definition: This indicator measures the impact of implementing research products and results on beneficiary communities' economic activities e.g. farming, retailing, etc.

C3- Travel time and transport savings

Definition: This indicator measures the impact of implementing research products and results on beneficiary communities' travel time and transport costs between given origins and destinations relating to both economic and social activities.

C4 Employment

Definition: This indicator measures the impact of implementing research products and results on beneficiary communities' employment opportunities.

C5 Household income

Definition: This indicator measures the impact of implementing research products and results on beneficiary communities' household incomes.

C6 Social integration/inclusion

Definition: This indicator measures the impact of implementing research products and results on beneficiary communities' ability to undertake social networking activities. It also includes women empowerment by the number of women benefitting from implementation of research products.

C7 Women and youth empowerment

Definition: This indicator measures the percent of women and youth benefiting from implementation of research products.

Notes: Benefits in this category may be difficult to measure directly due to lack of baseline data. Road users and beneficiaries of implementation of research products can only provide rough estimates. Some of the indicators in this category are difficult to quantity and express in monetary terms.

Table 4 presents details of the indicators in this subsystem.

Table 4. Socio-Economic Indicators

Research type	Research focus	Indicator	Description	Logframe Level	Unit of measure	Source of data	Method of data collection	Responsible entity	Assumptions regarding availability of data
All	All	Economic activities/Income generation: • Agricultural activities • Access to agric inputs • Products and Production level • Storage and Post-harvest losses • Retail activity	Factors measuring increases/decreases in the levels of agricultural production	Outcome/ Impact	1. Number of household members involved in agricultural activities 2.Production levels/quantities	Secondary sources, e.g. Project Reports; Primary sources	Content Analysis/ Internet surfing, Household sample survey, Beneficiary Assessment, etc.	Public institutions/Ministries, Department and Agencies MDAs	Secondary data readily available
All	All	Employment; • Self-employment; • Unemployment	Factors measuring the level of unemployment/employment/self-employment among the population	Output/ Outcome/ Impact	Number/percentage of the population that is employed, self-employed and unemployed	Secondary sources, e.g. Project Reports; Primary sources	Content Analysis/ Internet surfing, Household sample survey, Beneficiary Assessment, etc.	Public institutions/Ministries, Department and Agencies MDAs	Secondary data readily available
All	All	Access • to markets • To education facilities • to health facilities • to social and other facilities	Factors measuring access to, location of as well as travel and transport to markets	Outcome/ Impact	1. Type of markets 2. Frequency of marketing production 3. Types of transport services available	Secondary sources, e.g. Project Reports; Primary sources	Content Analysis/ Internet surfing, Household sample survey, Beneficiary Assessment, etc.	Public institutions/Ministries, Department and Agencies MDAs	Secondary data readily available
All	All	Income: • Average Monthly/Annual income	Factors that measure average monthly/annual income and sources of income	outcome	1. Amount received (US$) 2. Major and minor occupation	Secondary sources, e.g. Project Reports; Primary sources	Content Analysis/ Internet surfing, Household sample survey, Beneficiary Assessment, etc.	Public institutions/Ministries, Department and Agencies MDAs	Secondary data readily available
All	All	Expenditure:	Factors that measure	Outcome	Amounts spent	Secondary	Content Analysis/	Public	Secondary

Research type	Research focus	Indicator	Description	Logframe Level	Unit of measure	Source of data	Method of data collection	Responsible entity	Assumptions regarding availability of data
		• Average monthly expenditure on food, health, education, transport etc	the average monthly expenditure		on food, health, education, household assets and transport	sources, e.g. Project Reports; Primary sources	Internet surfing, Household sample survey, Beneficiary Assessment, etc.	institutions/Ministries, Department and Agencies MDAs	data readily available
All	All	Social organisation/integration: • Availability of social networks • Frequency of association/ participation in meetings or programmes	Factors measuring social organisation/integration in terms of the availability of social networks, and frequency of association	Outcome /Impact	1. Types of social groups available 2. Participation in group activities	Secondary sources, e.g. Project Reports; Primary sources	Content Analysis/ Internet surfing, Household sample survey, Beneficiary Assessment, etc.	Public institutions/Ministries, Department and Agencies MDAs	Secondary data readily available
All	All	Women and youth empowerment	Factors that measure women and youth economic and social activities	Outcome /Impact	Percent of women /youth benefitting	Primary and secondary sources	Content Analysis/ Internet surfing, Household sample survey, Beneficiary Assessment, etc	Public institutions/Ministries, Department and Agencies MDAs	Secondary data readily available
All	All	Travel and Transport: • Travel Time • Waiting time • Vehicle type	Factors that measure travel and transport in terms of travel time, cost, waiting time, modes etc	Output/ outcome/ impact	1. Travel time 2. Travel cost 3. Waiting time 4. Transport mode	Secondary sources, e.g. Project Reports; Primary sources	Content Analysis/ Internet surfing, Household sample survey, Beneficiary Assessment, etc.	Public institutions/Ministries, Department and Agencies MDAs	Secondary data readily available

3.2.4 Part D – Safety Indicators

Definition: Safety benefits are quantified by the reduction in number and severity of crashes. Three (3) levels of crash severity are used – fatal, serious, and property damage only. Indicators are relative measures where the crash rate (i.e., number of crashes or fatalities per population or kilometres of travel) and crash density (i.e., number of crash per unit distance of road section). The benefits are measured in terms of safety improvements (i.e., reductions in crash rates) in these indicators relative to the existing situation prior to implementation of research results or products. The indicators in this subsystem are:

D1 Weighted Crash Severity Score

Definition: The total weighted number of crashes on the intervention (Fatal = 5, Serious/Slight = 2, Damage only = 1)

D2 Crash Density

Definition: The number of crashes per unit length of road.

D3 Fatality per kilometre

Definition: The number of crashes per unit length of road improved or construction with new or improved construction materials or methods.

D4 Fatality per population

Definition: The number of crashes per population of beneficiary communities served by the improved road segment

Notes: Attributing or translating reductions in number, rate, or density of crashes directly to implementation of research products is difficult. Furthermore, placing monetary value on human life due to fatalities is difficult. It is also recognized that the quality of crash data may be poor given that crash records are typically under reported.

Any of these indicators could be used to assess the impact on safety.

Table 5 presents details of the indicators in this subsystem.

Table 5. Safety Indicators

Research Type	Research Focus	Indicator	Description	Logframe Level	Unit of Measurement	Source of Data	Method of Data Collection	Entity Responsible for Collecting Data	Assumptions regarding availability of Data
Applied	Transport /Transportation services	Weighted Crash Severity Score	The total weighted number of crashes on the intervention (Fatal = 5, Serious/Slight = 2, Damage only = 1)	Impact	Severity Score	Road traffic crash database/ Police	Retrieval from crash database/ Data collection from Police Stations.	Police/Agency responsible for road safety	That each country keeps crash statistics or can be collected from the Police. Benchmarked against before study
Applied	Transport /Transportation services	Crash Density	Number of crashes per unit length	Impact	Number of crashes/km	Road traffic crash database/ Police	Retrieval from crash database/ Data collection from Police Stations.	Police/Agency responsible for road safety	That each country keeps crash statistics or can be collected from the Police.
Applied	Transport /Transportation services	Fatality per vehicle	Fatality/Accident Rate per vehicle kilometre travelled	Impact	Deaths/Accidents per vehicle kilometre	Road traffic crash database/ Police/Historical traffic volume data	Retrieval from crash database/ Data collection from Police Stations. Historical traffic volume data	Police/Agency responsible for road safety/Road Agency	That each country keeps crash statistics or can be collected from the Police. Historical traffic data is available
Applied	Transport services	Fatality per population	Fatality/Accident rate per 100,000 population	Impact	Deaths/Accidents per population	Road traffic crash database/ Police/Statistical service	Retrieval from crash database/ Data collection from Police Stations/ Population data	Police/Agency responsible for road safety/Statistical Service	That each country keeps crash statistics or can be collected from the Police. Population data is available

3.2.5 Part E – Environmental Indicators

Definition: Indicators in this subsystem measure the impacts of implementation of research products or results on the environment. For example, construction can cause sediment and erosion problems and impact wetlands, streams, etc. Advances in environmentally friendly materials and their use in design is another way by which infrastructure research can impact the environment. The benefits are measured in terms of changes in these indicators relative to the existing situation prior to implementation of research results or products. The indicators in this subsystem include the following.

E1 Global warming

Definition: This indicator measures the average changes in temperature/ Ozone layer concentration in the geographical area where the research products/results have been implemented.

E2 Air quality – Pollution (dust)

Definition: This indicator measures air quality (e.g. in terms of emissions or dust concentration) in the beneficiary communities where the research products/results have been implemented. This is measured by the percentage of population directly impacted.

E3 Noise abatement

Definition: This indicator measures noise levels in the beneficiary communities where the research products/results have been implemented. This is measured by the percentage of population directly impacted.

E4 Erosion

Definition: This indicator measures square metre or linear length eroded area in the beneficiary communities where the research products/results have been implemented.

E5 Watershed and nature preservation

Definition: This indicator measures square metre of area in the beneficiary communities that are affected by the implementation of the research products/results. This is measured by the percentage of population directly impacted.

Notes: While it is clear that some research impacts the environment positively or negatively, it might be difficult to quantify in terms of monetary terms.

Any of these indicators could be used to assess the impact on the environment.

Table 6 presents details of the indicators in this subsystem.

Table 6. Environmental Indicators

Research type	Research Focus	Indicator	Description	Logframe Level	Unit of measure	Source of data	Method of data collection	Responsible entity	Assumptions regarding availability of data
Applied	Climate change	Global warming	Changes in temperature/ Ozone layer concentration	Impact	Degrees ppb	Environmental agency	Secondary data retrieval	Environmental agency	Environmental protection agencies maintain databases
Applied	Environmental impacts	Air quality – Pollution (dust)	% of pop. affected	Impact	Percentage	Road Agency Environmental agency	Secondary data retrieval	Road Agency Environmental agency	Road agency and Environmental protection agencies maintain databases
Applied	Environmental impacts	Noise abatement	% of pop. affected	Impact	Percentage	Road Agency Environmental agency	Secondary data retrieval	Road Agency Environmental agency	Road agency and Environmental protection agencies maintain databases
Applied	Construction Materials Environmental impacts	Erosion	Square area affected (linear measure)	Impact	Metres or square metres	Road Agency Environmental agency	Secondary data retrieval	Road Agency Environmental agency	Road agency and Environmental protection agencies maintain databases
Applied	Environmental impacts Climate change	Watershed and nature preservation	% of pop. Affected by polluted water source	Impact	Percentage	Road Agency Environmental agency	Secondary data retrieval	Road Agency Environmental agency	Road agency and Environmental protection agencies maintain databases

3.2.6 Part F– User Satisfaction Indicators

Definition: Indicators in this category directly address the users' (customers') satisfaction with the research products. Users include national and local road agencies, international funding agencies, and ultimately the travelling public. The indicators used are:

F1 Awareness of the research product,

Definition: This indicator measures whether potential users are aware of the existence of the research product or result. It is measured by the percentage of potential users that are aware.

F2 Access to the product

Definition: This indicator measures the percentage of potential users who are aware of the existence of the research product or result and can access it.

F3 Acceptance of the product

Definition: This indicator measures the percentage of potential users who are aware of the existence of the research product or result, have access to it and accept it as being useful. Acceptance implies the product is reliable in performing its intended functions.

F4 Use of the product

Definition: This indicator measures the percentage of potential users who are aware of the existence of the research product or result, have access to it, accept as being useful and actually use it.

F5 Value that users place on the research product

Definition: This indicator measures the percentage of potential users who are aware of the existence of the research product or result, have access to it, accept it, actually use it and value it relative to others. Placing value on a research product indirectly implies users find it reliable are and comfortable with it.

Notes: User satisfaction indicators assess extent to which users are satisfied by the choice of projects undertaken by the staff, timeliness and accuracy of research products, applicability of research to user problems, responsiveness to requests for technical assistance, and quality of research products.

Table 7 presents details of the indicators in this subsystem.

Table 7. User Satisfaction Indicators

Research Type	Research Focus	Indicator	Description	Logframe level	Unit of Measurement	Source of Data	Method of Data Collection	Entity Responsible for Collecting Data	Assumptions regarding availability of Data
Applied	Transport engineering /Transport services	Awareness	Percentage of potential users aware of product	Outcome	Percentage	Survey	Primary data collection (Questionnaire Survey)	Road Agency	Respondent provide useful and reliable data
Applied	Transport services	Access -	Percentage of potential users that have access to research product	Outcome	Percentage Rural Access Index	Household survey/ Statistical Service	Household survey method GIS-based method	Statistical service/Road Agency	Statistical data for the communities within 2 km are available
Applied	Transport services	Acceptability	How widely users have accepted the research product as useful	Outcome	•Percentage	Survey	Primary data collection (Questionnaire Survey)	Road Agency	Respondent provide useful and reliable data
Applied	Transport services	Use	Number of users benefiting from implementation of research product (traffic volume) using the road facility	Outcome	Number of vehicles per unit time	Road Agency/Field data collection	Historical data/Field data collection	Road Agency	That data before the intervention is available.
Applied	Transport services	Value	Value that users or beneficiaries place on research product	Outcome	Percentage	Survey	Primary data collection (Questionnaire Survey)	Road Agency	Respondent provide useful and reliable data

3.3 Benefits Assessment Framework

Having defined the performance indicators in the previous section, their application in the benefits assessment framework is described in this section. The BAS framework is organised by subsystems in the same manner that the indicators are presented above.

3.3.1 Research Outputs and Usage Subsystem

As noted in the previous section, four groups of indicators are identified for this subsystem. These indicators cannot be expressed quantitatively and therefore some weighting factors are assigned to the ranges of subjective measures.

3.3.1.1 A.1. Achievement of Research Objectives (10%)

The primary measure of success is if the research achieved its stated objectives. Consequently this measure is given the maximum weight. Recognizing that achievement cannot be binary, a scale from zero to three is provided with zero representing unmet objectives and three representing fully met objectives. Additional measures of research success include publishing of research reports, refereed papers in technical journals and conferences, citations, and awards. These measures are given a lower weight with a binary value representing if a measure was met or not. Finally dividing the score by the maximum possible normalizes this metric.

Table A-1. Achievement of Research Objectives

Performance Measure	**Weight** (5 = critical, 0 = not achieved)	Level of Achievement				**Score** (level * weight)	**Maximum Score Possible** (max level * weight)
		0 = not	1 = barely	2 = partially	3 = fully		
Stated objective of program/project	5						15
Additional Measures		***Level of Achievement***					
		0 = No		1 = Yes		--	--
Project report	4						4
Papers published in peer reviewed Journals	3						3
Working papers, conferences, workshops	2						2
Awards or Citations for Product	1	0					1
Total							25
Metric Score(total score / max score)							

3.3.1.2 A.2. Types of Products from Research (15%)

It is recognized that all projects do not produce all possible research products. In the analysis, the assessor would select products that are relevant to the research area under consideration. Relevant products are assigned a weight of 5 while non-applicable products are given a zero weight. The level of development represents the status of the product with zero representing no development while three representing a completed product. These metrics are normalized in a similar manner as Table A-1.

Table A-2. Types of Products from Research

Performance Indicators	**Weight** (5 = critical, 0 = Not Applicable)	Level of Development				Score (level * weight)	**Maximum Score Possible** (max level * weight)[1]
		0 = not developed	1 = initial stages	2 = partially developed	3 = fully developed		
Specifications (Design, construction, inspection, testing, maintenance etc.)	5						15
	0						0
Guidelines/Handbooks (including tables, charts, monographs)	5						15
	0						0
Improved Conventional and New Innovative Materials	5						15
	0						0
Advanced Technology and New Equipment (construction, inspection or testing)	5						15
	0						0
Software Tools (design, analysis, management, testing, inspection, etc.)	5						15
	0						0
Advanced state-of-the-art procedures (e.g., methods, techniques)	5						15
	0						0
Technology Transfer (websites,, workshops, clearinghouses)	5						15
	0						0
Metric Score -- (total score / max score)							--

[1]Note that the scores are not additive unless the research products are more than one

3.3.1.3 A.3. Adoption for Implementation (30%)

This metric addresses the level of implementation of the research products identified by the previous metrics. It might not be possible to obtain exact numbers for this measure. Thus, four major groupings were developed (expressed in terms of road agencies) as follows:

- **None** – no national or local road agencies, institutions or other agencies use the research (0 points)
- **Few** – less than 20% of the expected national road and local agencies, institutions and others using the research (1 point)
- **Several** – 20% to 50% of the potential national and local agencies, institutions and others using the research (2 points)
- **Widespread** – more than 50% of national and local agencies, institutions and others using the research or if the product has been used by national and international agencies (3 points).

Table A-3. Adoption for Implementation

Performance Indicators	Weight (5 = critical, 0 = Not Applicable)	Level of Adoption				Score (level * weight)	Maximum Score Possible (max level * weight)[2]
		0 = No	1 = few	2= several	3 = fully		
Specifications (including Design, construction, inspection, testing, maintenance)	5	Have the specifications been adopted as National Specifications?				10	15
	0						0
Guidelines/Handbooks (including tables, charts, monographs, etc.)		Do National and local road agencies or similar organizations and institutions adopt the guidelines/handbooks?					15
	0						0
Improved Conventional and New Innovative Materials	5	Are the materials developed available commercially?					15
	0						
Advanced Technology and New Equipment (including construction, inspection or testing)	5	Are the technologies and equipment in regular use by transportation agencies (excluding pilot projects)?					15
	0						
Software Tools (for design, analysis, inspection, testing or	5	Is the software available, installed, tested and in use by agencies?					15

[2]Note that the scores are not additive unless the research products are more than one

Performance Indicators	Weight (5 = critical, 0 = Not Applicable)	Level of Adoption				Score (level * weight)	Maximum Score Possible (max level * weight)^2
		0 = No	1 = few	2= several	3 = fully		
management)	0						
Technology Transfer Applications (including websites, clearinghouses, workshops, etc.)	5	Have technology transfer applications been created and implemented?					15
	0						
Total							15
Metric Score - (total score / max score)							

3.3.1.4 A.4. Extent of Use (45%)

This metric assesses the level of usage of the research products. This metric is considered one of the key measures of the benefits of the research effort. This is because its usage is a true reflection of the benefits associated with the research product. It is assumed that such information can be gathered through focus groups.

Similar to the previous indicator it might not be possible to obtain exact numbers for this measure. Thus, four major groupings were developed (expressed in terms of road agencies) as follows:

- **None** – no national or local road agencies, institutions or other agencies use the research (0 points)
- **Few** – less than 20% of the expected national road and local agencies, institutions and others using the research (1 point)
- **Several** – 20% to 50% of the potential national and local agencies, institutions and others using the research (2 points)
- **Widespread** – more than 50% of national and local agencies, institutions and others using the research or if the product has been used by national and international agencies (3 points).

Table A-4. Extent of Use

Performance Measures	Weight (5 = critical, 0 = Not Applicable)	Extent of Use by Local and National Road Agencies and Institutions				Score (level * weight)	Maximum Score Possible (max level * weight)
		0 = none	1 = few	2 = several	3 = widespread		
Specifications (including Design, construction, inspection, testing, maintenance)	5	Number of agencies using the specifications					15
	0						0
Guidelines/Handbooks (including tables, charts, monographs)	5	Number of agencies that recommend or use of the guidelines, handbooks etc.					15
	0						0
Improved Conventional and New Innovative Materials	5	Number of agencies with reported applications of the materials					15
	0						0
Advanced Technology and New Equipment (including construction, inspection or testing)	5	Number of agencies who have procured the equipment or the technology					15
	0						0
Software Tools (for design, analysis, inspection, testing or management)	5	Number of agencies with users of software[4]					15
	0						0
Technology Transfer (including websites, clearinghouses, workshops etc.)	5	Number of agencies which have requested additional information about technology or Number of agencies attending workshops or related training courses					15
	0						0
Total							15
Metric Score(total score / max score)							

3.3.1.5 Overall Score for Research Output and Usage

The overall score for the research output and usage subsystem is a weighted score combining the scores of the four groups of indicators. The relative weighting factor represents the relative significance of a performance measure in assessing the benefits of research program or product. For example, achievement of research objectives is given the lowest weight because completion of a research project and the findings accepted by the project sponsor only indicates that the project objectives have been achieved. Completion of the research project does not guarantee that the results would be adopted and/or implemented. On the other hand, the extent of use of the research project findings or product is given the highest weight because a widely used research product or findings is an indication of its usefulness in addressing problems that the project was designed to solve.

Table A-5. Overall Score for Part A

Performance Indicator	Relative Weight (w)	Measure Score (s)	Weighted Score (w*s)
A.1. Achievement of research objectives	10%		
A.2. Types of Products from Research	15%		
A.3. Adoption for Implementation	30%		
A.4. Extent of Use/ Number of Users of Research Product	45%		
Total Score	100%		
RATING (%)			

Rating Scale – Part A

Score > 75% – Excellent: The research fully achieved its objectives, has developed products that are readily available and adopted by national agencies. These products are widely used by local and national agencies, and other institutions.

60% < Score ≤ 75% – Good: The research partially achieved its objectives, has partially developed products that are available and adopted by national agencies. Several local and national agencies, and other institutions use these products.

45 < Score ≤ 60% – Fair: The research barely achieved its objectives, has developed products that are in the early stages of availability and adoption by national agencies. Few local and national agencies, and other institutions use these products.

Score < 45% – Poor: The research did not quite achieve its intended objectives, has not developed products that are available and adopted by national agencies. Few or no local and national agencies, or other institutions use these products.

The rating scale is an outcome of expert knowledge and brainstorming sessions. It is based on the premise that scoring 3 out of 4 or 75% is quite an achievement and it is therefore assigned excellent rating. Given the number of indicators and complexity of the system, it is envisaged that attaining high scores can be difficult.The same rating scale is applied to all subsystems of the BAS framework.

3.3.2 Economic Subsystem

3.3.2.1 Agency Cost Savings – Capital costs

For purposes of this analysis, capital costs are defined as costs incurred in the deployment or implementation of the research product. Where cost data is available on more than one project or application, of a research product, the average cost should be used.

3.3.2.2 Agency Cost savings – operational costs

The cost savings in maintenance operations are classified into two major groups – routine maintenance, periodic maintenance, and major rehabilitation and reconstruction.

3.3.2.3 Crash Cost Savings

This is defined as difference in costs savings with the use of the research product and without use of the research product.

Table B-1. Agency Cost Savings

Research Program/Project				
Capital Cost Savings of "activity" per Unit (If project reduces capital costs)				
Benefit Areas	**Applicability** (Yes = 1, 0 = No)	**Cost With Use of Research Product**	**Cost Without Use of Research Product**	**Differential**
– Design Labour Savings (expressed in $)				
– Construction Materials ($)				
– Construction Labour ($)				
– Other ($)				
Cost Per Unit (1)				
Total Capital Costs (2) = (1)*(N)				

Planned Service Life (in years) (S)				
Total Capital Cost for enhanced service life = (3) = (2)*($S_{with}/S_{without}$)				
Total Annualized Capital Cost (AC) for enhanced service life (4)				
AND/OR Operating Costs Savings Per Unit				
AND/OR Routine Maintenance Cost Savings (If project reduces routine maintenance costs)				
Cost Per Inspection	**Applicability (Yes = 1, 0 = No)**	**Cost With Use of Research Product**	**Without Use of Research Product**	**Differential**
Maintenance Frequency				
Average Maintenance Labour Costs ($)				
Average Equipment Costs ($)				
Maintenance Management Labour Costs				
Other				
Annual Cost per Unit (5)				
Total Annual Routine Maintenance Costs = AR (6) = (5)*(N)				
AND/OR Major Rehabilitation and Reconstruction (R&R) Cost Savings (If project reduces major R&R costs)				
Costs Per Major R&R	**Applicability** (Yes = 1, 0 = No)	**Cost With Use of Research Product**	**Without Use of Research Product**	**Differential**
Average Maintenance Labour Costs ($)				
Average Maintenance Material Costs ($)				
Average Equipment Costs ($)				
Other ($)				
Cost of Major R&R (7)				
Total Cost of R&R (8) = (7)*(N)				
Service Life Enhancement (in years) (S)				
Total R&R Cost for enhanced service life = (9) = (8)*($S_{with}/S_{without}$)				
Total Annualized Major R&R Cost (AM) for enhanced service life (10)				

Total Annual Operating Costs = (11) =*(6)+(10)*				
Total Annual Agency Costs = (12) = *(11)+(4)*				
Percent change				%

Table B-2. User Costs

User Cost Savings (If project produces user benefits)				
Savings Area	**Applicable** (0 = No; 1 = Yes)	**Annual Costs (Dollars)**		**Differential**
		Cost With Use of Research Product	**Without Use of Research Product**	
Vehicle Operating Cost				
Travel and transportation cost				
Crash costs				
Annual User Costs (13)				
Percent change				**%**

3.3.2.4 Overall Cost Savings

The annual cost savings is the sum of agency, user, and safety savings per unit. The annual research funding provides the basis for evaluating these cost savings. The ratio between the annual cost savings and the annual research funding is used to determine the rating for the project in terms of costs.

Table B-3. Overall Cost Savings

Ratio of Cost Savings to Research Finds Calculations		
	Cost With Use of Research Product	**Cost Without Use of Research Product**
ANNUAL AGENCY COSTS ***Table B-1 (12)***		
ANNUAL USER COSTS ***Table B-2 (14)***		
Total ANNUAL COSTS (15) = *(12)+(14)*		
Total Cost Savings Per Year *CS = (15)$_{with}$ –(15)$_{without}$*		
Total Research Funding *(I)*		
Ratio of Total Cost Savings over Research Funding *(TCS/I)*		

Rating Scale – Part B

This ratio represents the magnitude of benefits generated by the research program or project. In the real sense, this ratio is not a benefit-cost ratio or return on investment because all the benefits and costs are not included in the calculation. No rating scale is suggested for cost savings because the ratio in itself is a standard performance measure.

3.3.3 Socio-Economic Subsystem

The Likert scale concept is used to assess the socio-economic impacts resulting from the implementation of research products. It is difficult to quantify these indicators accurately because respondents will not be in the position to provide quantitative data and their estimates may at best be guesses. Five levels are defined to reflect beneficiaries' or assessors' perception of the impacts of implementation of the research products or results as follows:

- **Very low** – no noticeable change (1 point)
- **Low** – less than 20% of population impacted due to implementation of research products (2 points)
- **Medium**– 20% to 50% of population impacted due to implementation of research products (3 points)
- **High** –50% -75%of population impacted due to implementation of research products (4 points).
- **Very High** –greater than 75% of population impacted due to implementation of research products (5 points).

Table C-1. Socio-Economic

Performance Indicators[3]	**Weight** (5 = critical, 0 = Not Applicable)	**Degree of Impact**					Score (level * weight)	**Maximum Score Possible** (max level * weight)
		1= very low	2 = low	3 = medium	4 = high	5 = very high		
Access to facilities (education, social, health, etc)	5							25
	0							0
Economic activities/Income generation - Agricultural activities (access to agric inputs; production level; storage and post-harvest losses)	5							25
	0							0
Economic activities/Income generation - Retail activity etc	5							25
	0							0
Travel and transport time savings	5							25
	0							
Employment opportunities	5							25
	0							0
Household monthly income	5							25
	0							0
Household monthly expenditure	5							25
	0							0
Social integration/cohesion	5							25
	0							0
Women empowerment	5							25
	0							
Youth empowerment	5							25
	0							
Total								
Metric Score(total score / max score)								
RATING (%)								

[3]Each of these metrics can be used to indicate the impacts of implementation of research products. Therefore the indicators are equally weighted.

Rating Scale – Part C

Score > 75% – Excellent: Implementation of research product or result has significantly positive socio-economic effects

60% < Score ≤ 75% – Good: Implementation of research product or result has some positive socio-economic effects.

45 < Score ≤ 60% – Fair: Implementation of research product or result has marginal positive socio-economic effects.

Score < 45% – Poor: Implementation of research product or result has no significant positive socio-economic effects.

3.3.4 Safety Subsystem

Metrics for assessing safety cost savings include the number and severity of crashes. While improvements in highway geometry and surfaces can be shown to improve safety, the number and severity of crashes can only be used as indicators of improvements rather than direct results of highway improvements. This is because other human and environmental factors contribute to highway crashes. Furthermore, it is difficult to place monetary value on human life. As noted in the literature review section of this report, several methods for estimating the cost of road traffic crashes are available. These include, human capital, willingness to pay, life insurance-method, among others. The human capital method has been prescribed for estimating the cost of crashes in developing countries. The unit cost for each crash severity level (i.e., fatal, serious, slight and damage only) is required to evaluate crash cost savings. However, a cursory search revealed data on estimates of crash costs for ReCAP partner countries may not be readily available or outdated. For example, the most recent study on estimating the cost of crashes in Ghana was carried out in 2006 which may not apply currently.

Thus, five levels are defined to reflect beneficiaries' or assessors' perception of the impacts of implementation of the research products or results as follows:

- **Very low** – no noticeable reduction in crash rates/density (1 point)
- **Low** – less than 5% reduction in crash rates/density (2 points)
- **Medium** – 5-10% reduction in crash rates/density (3 points)
- **High** –10% to 20% reduction in crash rates/density (4 points).
- **Very High** – more than 20% reduction in crash rates/density (5 points).

Table D-1. Safety

Performance Indicators[4]	**Weight** (5 = critical, 0 = Not Applicable)	**Degree of Impact**					Score (level * weight)	**Maximum Score Possible** (max level * weight)
		1 = very low	2 = low	3 = medium	4 = high	5 = very high		
Weighted crash severity score	5							25
	0							0
Crash density	5							25
	0							0
Fatality per kilometre	5							25
	0							0
Fatality per population	5							25
	0							
Metric Score – (total score / max score)								
RATING (%)								

Rating Scale – Part D

Score > 75% – Excellent: Implementation of research product or result has significantly improved road safety by reduced crashes and fatalities.

60% < Score ≤ 75% – Good: Implementation of research product or result has improved road safety by reduced crashes and fatalities to some measurable extent.

45 < Score ≤ 60% – Fair: Implementation of research product or result has marginal effects on road safety.

Score < 45% – Poor: Implementation of research product or result has no significant effect on road safety.

[4]Each of these metrics can be used to indicate the impacts of implementation of research products. Therefore the indicators are equally weighted

3.3.5 Environmental Subsystem

It might not be possible to obtain exact numbers for this measure. Thus, five major groupings were developed (expressed in terms of road agencies) as follows:

- **Very low** – high negative – more than 20% of population negatively impacted (1 point)
- **Low** – less than 20% of population negatively impacted (2 points)
- **Neutral** – no noticeable impact (3 points)
- **Medium** – less than 20% of population positively impacted (4 points).
- **High** – more than 20% of population positively impacted (5 points).

Table E-1. Environmental

Environmental Indicators[5]	Weight (5 = critical, 0 = Not Applicable)	Level of Impact					**Score** (level * weight)	**Max Score Possible =** (max level *weight)
		1 = high negative impact	2 = low negative	3 = no noticeable	4 = low positive	5 = high positive		
Global Warming	5							25
	0							0
Improvement in Air Quality or Emissions Reduction or dust control	5							25
	0							0
Noise Abatement	5							25
	0							0
Erosion	5							25
	0							0
Wetland and nature preservation	5							25
	0							0
Metric Score - (total score / max score)								
RATING (%)								

Rating Scale – Part C

Score > 75% – Excellent: High positive environmental impacts
60% < Score ≤ 75% – Good: Significant environmental impacts
45% < Score ≤ 60% – Fair: Limited environmental impacts
Score < 45% – Poor: Insignificant positive or negative impacts

[5]Each of these metrics can be used to indicate the impacts of implementation of research products. Therefore the indicators are equally weighted

3.3.6 User Satisfaction Subsystem

The following performance measure directly addresses the users' satisfaction with the research products. Users include local and national road agencies and sometimes, international bodies, and ultimately the travelling public. The measures used are awareness, access, acceptance, use, and value that users place on the research product. User satisfaction metrics assess extent to which users are satisfied by the choice of projects undertaken by the staff, timeliness and accuracy of research products, applicability of research to user problems, responsiveness to requests for technical assistance, and quality of research products. A scale of 1 to 5 is used to indicate the level of satisfaction (1 being least and 5 being best). All measures are equally important and therefore are weighted equally.

Table F-1. User Satisfaction

Performance Indicator[6]	**Weight** (5 = critical, 0 = not applicable)	Level of Satisfaction 1 = very low; 5 = very high					**Score** (level * weight)	**Maximum Score Possible** (max level * weight)
		1	2	3	4	5		
Awareness of research product								
Access to research product								
Acceptance of research product								
Use of research product								
Value of research product								
Total								
Metric Score - (total score / max score)								--
RATING (%)								

Rating Scale – Part F

Score > 75% – Excellent: Meets users' needs adequately
60% < Score ≤ 75% – Good: Meets users' needs satisfactorily
45% < Score ≤ 60% – Fair: Limited users' satisfaction
Score < 45% – Poor: Users not satisfied with research product.

3.3.7 Overall Scorecard

The outputs from the various parts can be summarised as shown in the table below. The score or output from each component of the framework is recorded separately.

[6]Each of these metrics can be used to indicate the impacts of implementation of research products. Therefore the indicators are equally weighted

This is visualised as a report card but with no aggregated or cumulative score for all the components. Converting all scores to a single number would lose the essence of the assessment exercise.

An aggregated score will mask the contribution or performance of each subsystem and the strengths and weaknesses of the entire system would not be highlighted. Furthermore, research projects have different focus areas therefore an aggregated score would not give a true reflection of the performance of subsystem most relevant to the research focus of the particular project. For example, projects that are not primarily focused on addressing environmental concerns, an aggregated score would suggest that equal contribution from all subsystems including environmental subsystem. This could be misleading.

Aggregating the scores from the various subsystems would also violate the underlying principle of a systems approach where the subsystems are interacting and interdependent parts of an organised whole system. It is for these reasons that the individual subsystems are weighted equally.

Table 8. Overall Scorecard

PART	PERFORMANCE INDICATOR	SCORE	REMARKS
A	Research Output And Usage		
B	Economic /Cost Savings		
C	Socio-Economic		
C	Safety		
E	Environmental		
F	User Satisfaction		

3.4 Conclusion

The overall scorecard shows the relative levels of benefits derived from conducting the research and implementation of results generated thereof. The system described and presented in the table format will be represented in the M&E portal.

4 System Architecture and URS

This section describes systems architecture which includes the database and M&E framework. The URS is also described.

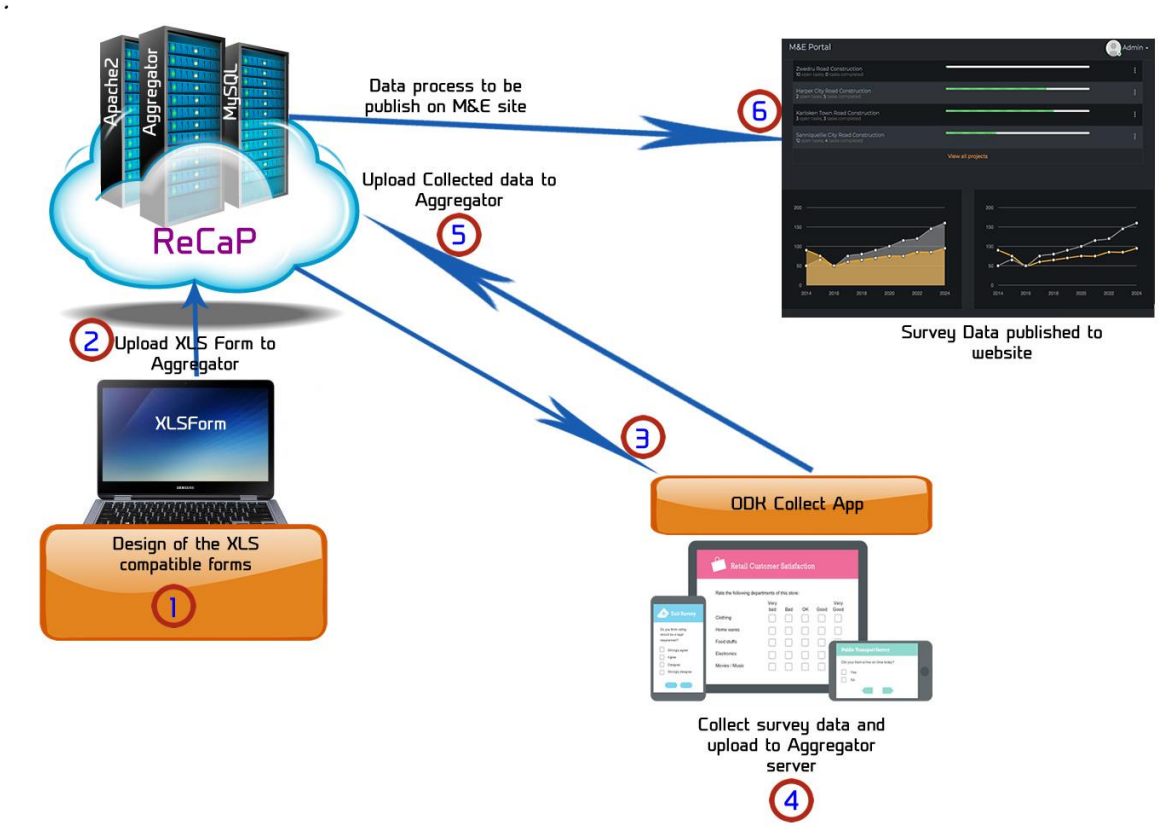
4.1 Concepts for M&E Framework and Database Architecture

In this task we will transform the architecture into reality by developing the database and M&E website using the software applications selected to ensure sustainability of the software application beyond the life the ReCAP program. As noted in our proposal we would rely on our experience in a previous ReCAP project to develop the database management system and the M&E website. The various elements of the system are described in the following subsections.

4.1.1 Architecture Workflow

Figure 2 below shows the system architecture for the database and the M&E websites to be developed in this project. The system architecture will consist of several elements as follows:

Figure 2: System Architecture



1. Design of the XLS Compatible forms: We will first create the survey form which should be compatible with the Aggregator server. This same form will be available to be downloaded to the survey devices.
2. Upload of XLS Form to Aggregator: When we create the XLS compatible forms, we will then upload them to the cloud server hosting the Aggregator application for survey devices to download from to collect data in the field.
3. ODK Collect App: All devices that will be used for data collection need to be connected with the right login information to the Aggregator cloud server to either get the survey questions or upload the completed questions back to the server for data manipulation and visualization.
4. Data Processed and Uploaded to M&E Portal and Website: When we get the data into the database server it can be checked and visualised, the resulting information can be published on the main website and M&E portal as a dataset in CSV format or a json file to be used in any other data processing software.

4.1.2 Cloud Server

Our preferred cloud server solution would have been ReCAP cloud servers, where we will get an SSH access to host this project. However, if ReCAP is not having its own server solution, we recommend to host the system on Linode- Asia Data Centre (https://www.linode.com/) for data collection server and Dreamhost (https://www.dreamhost.com/) for M&E domain hosting and site hosting. The main reason to host on a cloud server is to help user of the system, regardless of location, to be able to upload their survey data and also to download datasets for use which will be available on the main site as well as API available for any user who wants to download the datasets for other uses.

Linode Server: The server will have Ubuntu server OS installed on it with Apache2, PHP7 and MySQL server running in order to power the application server of ODK, which is the Aggregator. This application will upload the data collection forms to the Aggregator server after they have been developed from the XML file. With the right login information, users of the system will be able to connect to the Aggregator server and download all the data collection forms onto their mobile devices wherever they may be.

Dreamhost Server (Share Hosting): All domain names that we will use for this project will point their NS records to this server and we will host all emails on this server as well. Dreamhost will be the cloud server that will enable us to host the web portal files and any other document that needs to be uploaded to the main site.

We chose the two cloud hosting solutions because of cost and security. Also Linode is relatively fast for the kind of application to be developed in this project. However, Linode does not host domain names which, Dreamhost does really well with email hosting and cpanel for management.

4.1.3 Database systems

Our proposed approach is guided by the recommendation in the TOR that the benefit assessment system must be supported by an efficient, user friendly data acquisition and management system with the following aspects:

- How the data is collected;
- Data validation;
- Data storage;
- Data processing;
- Presentation of data, and
- Availability of data to users and stakeholders.

The systems will be developed using an Open source software application to facilitate updates and modifications without the need to pay for licensing and updating fees. We propose to use data collection and aggregation system called Open Data Kit (ODK) which is an open-source system that is available to all with the source code that can be customized to suit individual needs. The ODK suite enables a simple yet powerful architecture which integrates very well with other open standard application for data visualization and manipulation.

ODK is a suite of tools that allows data collection using Android mobile devices and data submission to an online database server, even without an Internet connection or mobile carrier service at the time of data collection. The screenshot below (Figure 3) shows how one can download the mobile app for the data collection and the screen shot in Figure 4 shows how one can use it to connect to the database to download the survey and use it.

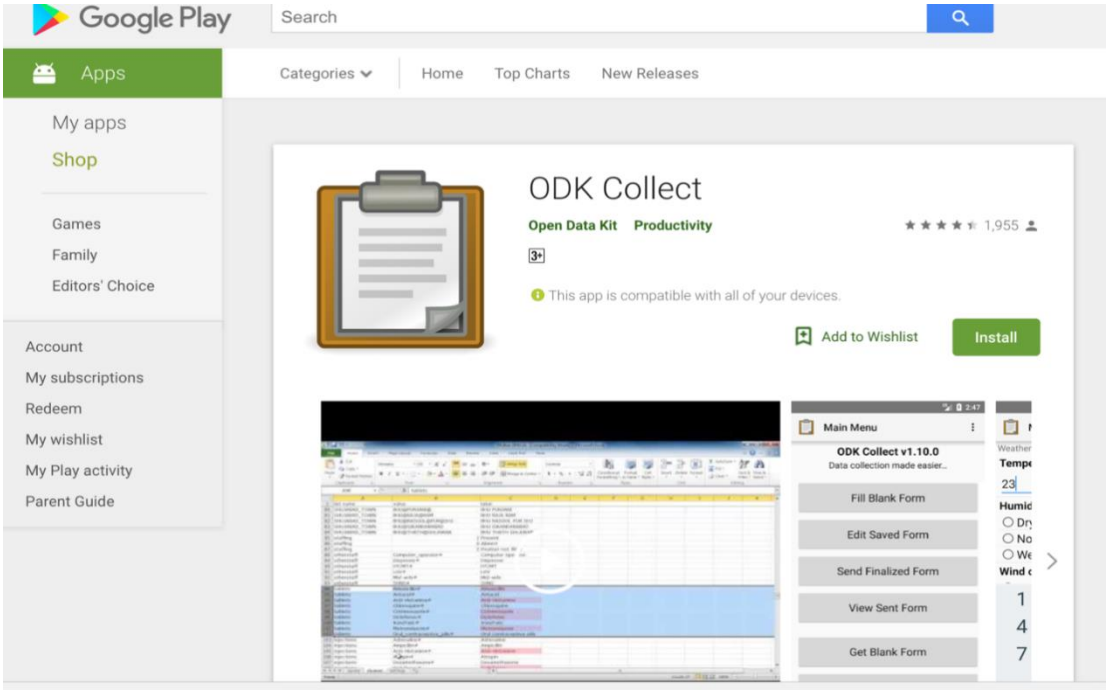


Figure 3. ODK on playstore

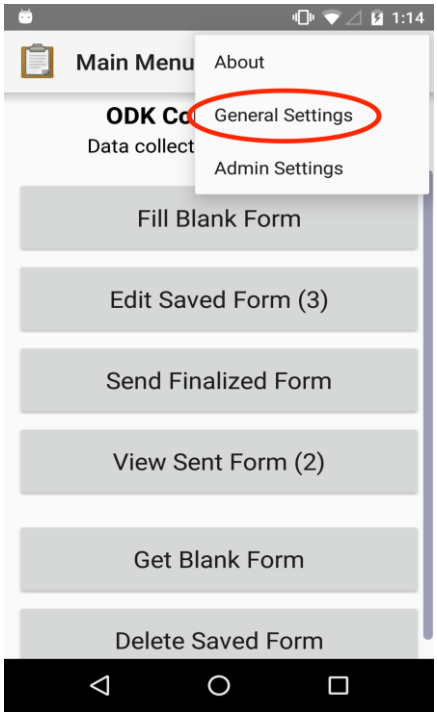


Figure 4: Mobile app showing connection to database

Our team has employed ODK for the *Rural Mobility and Socio-Economic Baseline Pilot Study in Liberia Project Reference: LIB2135A* project. This approach to data capture, storage and manipulations has several advantages over traditional database systems:

- ability to collect data with smartphones built on the Android platform.
- ability to collect a variety of data types: text, location, photos, video, audio, and barcodes.
- ODK Build enables users to generate forms using a drag-and-drop form designer.
- real-time field team management: - each of the devices for data collection connect in real time to the database.
- centralized data administration: ODK suite provides a ready to deploy online repository to store, view and export collected data. This data sits in a backend database suite that is open source as well called MySQL.
- flexible data visualization and reporting: ODK data visualization and reporting tool, makes the database flexible to use in generating and exporting reports in .csv or publishing in real time.

Figure 5 represents an example of data visualization and reporting capability of the system. Different attributes can be selected and displayed as pie-chart or bar-charts.

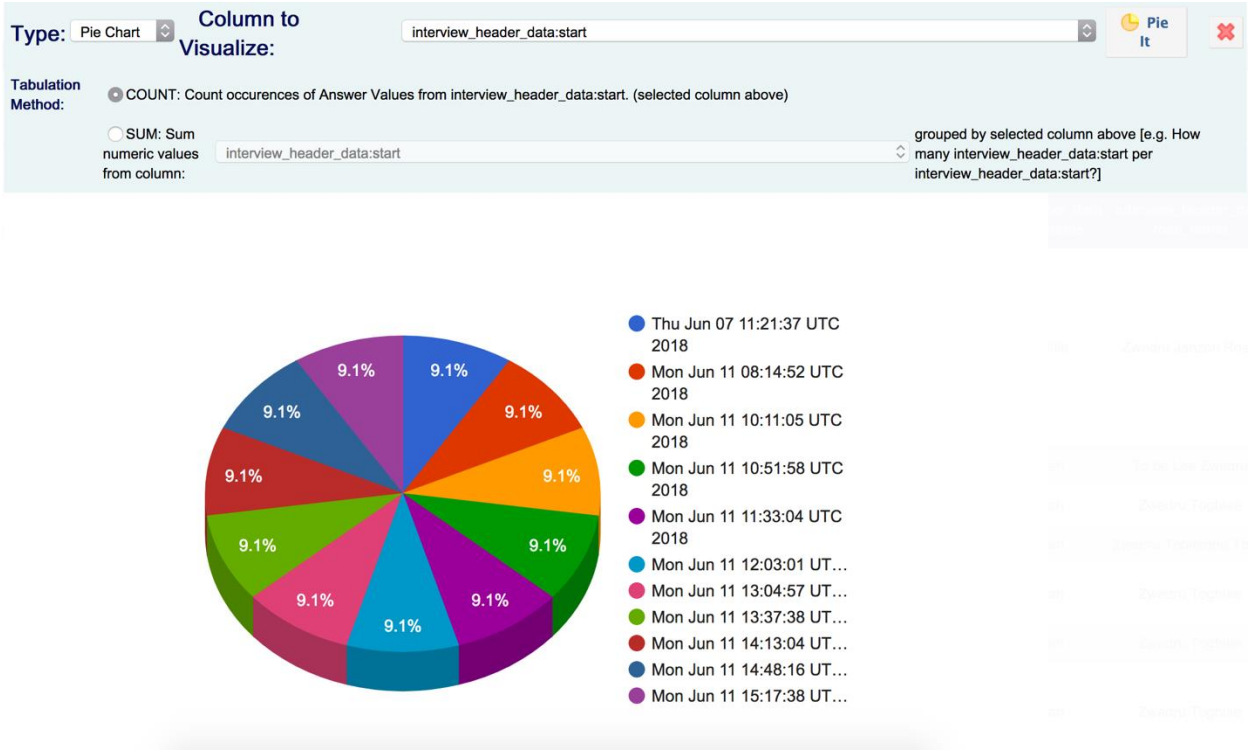


Figure 5. Data Visualization using ODK Aggregator

4.1.3 M&E Portal and Website

The M&E website will be the main point of links to all other functionalities of the system. From the website, a user will have access to the dataset from the Cloud database for each project. The M&E Portal will take the user to the backend where only with the right access level that one can login with the username and password provided to by the site Administrator.

The portal will be a PHP application that uses MySQL backend for storing data. This portal will give the M&E director or the site Administrator an overview of progress of projects and who has worked on what project, milestones completed and any report relating to that project.

The portal will have three access levels:

1. The main **site administrator:** This role will let one see everything and edit everything.
2. **Designated Officer** level: The officer gets to see the project they are working or have worked on and can update the project records.
3. **Donors**: This access level will only let one see project progress at a glance and reports relating to that project.

The main website will house all links to all dataset and reports as well as the M&E portal, hence we will be having only one url that users' need to remember. This is the root domain name that will be used with SSL certificate.

4.2 User Requirements Specification (URS)

The User Requirements Specification (URS) describes the stakeholders' needs and expectations from the system to be developed in this project. The requirements are derived from information included in the terms of reference for this project and inputs solicited from ReCAP coordinators (stakeholders). The stakeholder requirements are summarized in this section. Detailed inputs from the individual stakeholders are included as an Appendix to this report.

4.2.1 System Requirements –

The Benefits Assessment System (BAS) is designed to be able to perform the following functions:

- ReCAP projects are focused on rural roads and transport services. Therefore appropriate indicators are identified for use in developing the BAS. The indicators are expected to cover a wide range of benefit areas, to be forward looking, and not limited to those that are currently in use.
- The system is designed to enable assessment of benefits from different subareas including research output and data usage, socio-economic, economic, safety, environment, and user satisfaction.
- Individual data collection devices can be connected to the Aggregator Cloud server to allow data access from the system
- Collected data can be visualized and manipulated to make meaningful deductions.
- The database and the M&E system are linked to Cloud servers to ensure data is stored online and readily available to all users.
- The M&E portal will be able to generate reports based on the indicators from any of the subsystems e.g., research output and data usage, economic, socio-economic, safety, environment, user satisfaction.
- M&E portal can be used to evaluate projects, assign, and monitor projects.
- ReCAP-BAS is designed to be simple and user-friendly to benefit of all users
- ReCAP-BAS is designed to accommodate all ReCAP research types and focus areas noting that ReCAP projects focus on rural roads and transport services.
- ReCAP-BAS is designed such that it records the number of road agency personnel trained in the use and implementation of the research products. This is expected to indicate the level of involvement of local experts in the implementation research project products
- ReCAP-BAS is also designed to measures the extent of use of research products by local road agencies. This indicator serves as proxy of the extent of use local resources, both human and physical.
- ReCAP-BAS includes indicators that allow for assessment of the extent of uptake and embedment of research outputs
- Indicators are included to help assess women and youth empowerment by percentage of women or youth benefitting from implementation of research products
- System provides for different access levels for different users

4.2.2 Data Requirements

Data requirements define the format and types of data that the benefit assessment system can process:

- All types of data can be collected with forms designed according to ODK data collection guidelines and format so that it can be compatible with Aggregator database.

- Data collection forms are developed from MS Excel and the XLS data collection forms accept both numeric and string data types.
- Data types can be exported in CSV or JSON formats which then will be used on MySQL server that support M&E portal.
- The data structure allows for both qualitative and quantitative assessment
- ODK Collect tool is simple and can be used with tablet, Smartphone, or PC.

4.2.3 Sustainability Requirements

Usage and long term sustainability of the system is a desired requirement for the benefits assessment system. It is for this reason that an Open Source Solution was selected. ODK Collect tool and the underlying database of M&E portal, that is MySQL, are both open source. With the open source solution, periodic subscription and/or renewal fees are not required. Thus, the open source software suite is sustainable and presents a simple yet powerful architecture which integrates very well with other open standard application for data visualization and manipulation.

It is however important to keep the system current through constant updates to ensure that the code base of the system is up-to-date with current technology. Therefore, the systems administrator should have an update plan and script that will download updates from each of these open source application pages which are free and online.

It is expected that the final product of this project i.e., ReCAP-BAS would be available to local agencies without any proprietary restrictions. To the extent feasible, it is also expected that the system is flexible enough to allow some limited customization by users.

5 Conclusions

This report describes the ReCAP-BAS framework and the concept for the M&E portal. The ReCAP-BAS is based on a systems approach that is backed by extant literature. The indicators for each subsystem are described in detail and the appropriate logframe levels for each indicator identified. The ReCAP-BAS framework uses a scoring system where the indicators and their surrogates for each subsystem are scored according to their relative importance in defining the subsystem. The ReCAP-BAS can be visualized as a report (score) card where grades (or scores) are assigned to the various indicators or groups thereof for each subsystem. The overall scorecard shows the relative levels of benefits derived from conducting the research and implementation of results generated thereof.

The system architecture describes the structure of the database and M&E portal. The M&E portal will serve as the main point of links to all other functionalities of the system. From the website a user will have access to the dataset from the Cloud database. The portal will be a PHP application that uses MySQL backend for storing data. The database uses an Open Source software application. The open source software suite is sustainable and presents a simple yet powerful architecture which

integrates very well with other open standard application for data visualization and manipulation.

This report also describes the User Requirements Specification that outlines the functionality of the system, data requirements, and sustainability of the system. Stakeholders are expected to critically review this draft document and to provide feedback. This is to ensure that the final product meets their needs and expectations.

6 Next Steps

The following are the next immediate activities after approval of the Systems Development Report.

1. Develop data collection template based on the indicators included in the Systems Development Report and inputs from stakeholders on URS
2. Finalize arrangements for web hosting by service providers
3. Continue to work with ReCAP to identify project/program managers for the purposes of identifying data collection opportunities
4. Compile comprehensive list of relevant ReCAP projects

Appendix A: Inputs from Stakeholders for User Requirements Specifications (URS)

Country	Comments on Systems Development Report and Input for URS	Project Team's Response
Ghana	Under Research Product and Usage, we think it will be good to have a measure that distinguishes between research "uptake" and research "embedment". This is the focus of ReCAP and that distinction in the scoring should be emphasized	In subsystem A- Research output and Usage, there are separate indicators for update or adoption of research products and extent of implementation of research products. Uptake of research products measures the degree to which research products such as specifications, are adopted by ReCAP and its partner countries, organizations like World Bank, IRF or other standards setting agencies.
	In the same vein, can you include a measure of access to the research by other researchers? This could be measured through research citations.	already captured in subsystem A of framework
	Under the socioeconomic indictors (C 6), I suggest you change the "social integration" indicator to "social inclusion".	Noted -We have both "social cohesion" and "social integration" in the data collection template
DRC	Regarding your request, I have at this stage no specific remark on the User specifications.	Noted
Zambia	We have perused through the draft Systems Development Report and noted that the document was well researched. However, in addition to what has been captured in the draft report, kindly include the needs and expectations with regard to:	Noted
	1. Systems Requirements:	
	i. a register of bottlenecks experienced during execution of the research project;	This will not be captured in BAS. It will be included in the report that documents the finding of the individual research projects

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Zambia	ii. a record of positive or negative political influence as the research project was in progress;	This cannot be possibly captured in the BAS. It is expected that the individual projects should capture any limitation including these influences in their final reports to serve as lessons learned to guide future projects
	iii. a record of proportion of women benefiting directly or indirectly during or after implementation of the research project as women are a vulnerable group in terms of rural and urban poverty;	Noted. Captured in socio-economic indicators
	iv. a record of proposed amendments to manuals, guidelines or designs in line with the observed outcome or any other changes;	This could be captured in the recommendations after running the BAS
	v. a record of the extent of involvement of local experts in the research project; and	Economic indicators in subsystem B of BAS captures the number of road agency personnel trained in the use and implementation of the research products
	vi. a record of the extent of use of local resources in the research project.	The implementation of the research results obviously would utilize local resources. Subsystem A of BAS measures the extent of use of research products by road agencies. This indicator serves as proxy of the extent of use of local resources both human and physical
	2. Data Requirements:	
	Atlas.ti, may also be used for data collection and processing of large filed data sets. Atlas.ti is a software that provides all-in-one access to a range of platforms. It works on Windows, Mac, and Android devices and is used for field data collection and processing. Training in the use of this software should also be encouraged.	That software appears to be similar to ODK Data Collect. We recommended and use ODK Data Collect tool for the system based on our experience. We cannot have two different softwares for fear of lack of interoperability

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Zambia	In addition, extensive use of excel format data entry should be encouraged as it is easy to access. It is equally easy to export to other data processing platforms.	The data capture format is based on MS XLS file
	As research is mainly centered on low volume (rural and urban) roads, plans should made to engage personnel from local road authorities (councils) to collect data in Zambia. This will require training of technical staff from respective councils.	Training on the use of the BAS will be provided at regional workshops towards the end of this project
	It is our expectation that the system will provide baseline data of research projects for future improvements and further research.	The system will need baseline data from partner countries to populate database that will then serve as baseline for future comparisons
Sierra Leone	1. User Requirement Specifications	
	As for the system requirements, I suggest we leave it as it is for now, once we started the training, more suggestions and recommendations will be provided.	Noted
	In the case of data requirements, numeric and string data types are both good and data must be exported in CSV format as it is one of the most commonly used formats.	The data format has been designed as such
	2. Training on Data Collection	
	I cannot download ODK Collection tool from my iPhone App Store, but was able to downloaded ''my mobile community version: 1.2'' are these two the same tool with different names?	These are not the same. ODK only works on Android. You can access online on PC
	More questions will arise when MySQL server come to play.	Noted
Mozambique	**(i) User Requirement Specifications** –	
	System Requirements – *functions that we expect the system to perform,*	
	· System should be able to compare the various technical solutions in LVR construction in terms of durability and cost;	This requirement is outside scope of BAS project. This can be derived from the BAS outputs

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Mozambique	· System should include an indicator which can predict the life span of the project based on the geometric and structural design associated to the foreseen traffic during the life span and recommend measures to be considered in case of variations in the original parameters.	This requirement is outside scope of BAS project. BAS is not a prediction model
	· System should make a judgment in the social viability of the investments;	BAS itself cannot make that judgment. However, the results of the BAS will guide decisions on viability of research investments. Indicators in the Economic subsystem are designed to achieve that
	· System should be able to develop a risk analysis associated to increase of heavy traffic after investments;	This requirement is outside scope of BAS project
	· The M&E should have a base line indicator from any of the benefit areas;	Noted- the system is so designed
	The Systems should be simple and user-friend for benefit of all stakeholders including people at district level.	Noted- the system is designed to be flexible and user friendly
	Data Requirements *– format and types of data that we expect the system to be able to process:*	
	The required data should be simple to acquire, using basic equipment available in most African countries;	Noted - ODK Tool is easy, user friendly and accessible via internet on PC and smartphone
	The system should avoid extensive data to be populated in data base in order to keep people interested in updating.	Noted. However sufficient data is needed to be able to adequately assess benefits in several areas
	(ii) **Training on Data Collection** –	
	· The possibility to conduct the training for both engineers seating in different provinces;	the partner countries will nominate the training participants
	· If **ODK Collect** application can be downloaded in I**Phone or notebook.**	ODK only works on Android. It is available online and accessible with your laptop

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Afghanistan	· The M&E portal will be able to generate reports based on the indicators from any of the benefit areas including GPS Points.	Yes
	· The system should be able to provide information and lesson learnt ensuring that the projects are set up correctly in the first place, delivered successfully, in the right way and the citizens have received the promised improvements.	The system will not generate that information directly. The results should be used to develop lessons learned and guide future research investment decisions
	·Is able to promote good practice from past projects and apply them to current and new projects	The intention is for the BAS to provide guidance in the selection of future projects
	· Is able to measure performance, value for money and create a virtuous circle of lessons learned	The benefits versus the costs will provide indications of value for money. BAS captures this in the Economic subsystem
	· Is aligned with the Government's functional standard: Project Delivery – portfolio, programmed and project management;	This is outside scope of BAS project
	· Provide Socio-economic impact evaluation of rural road projects,	Yes, these are captured by the indicators in Socio-Economic subsystem
	· any other issues related to Re-CAP projects with focus on rural roads and transport services.	BAS is designed to accommodate all research types and focus areas
	· Is a user friendly and is linked to Clouds to ensure data is stored online.	Yes - database and M&E portal are linked to cloud servers
Uganda	**System Requirements:** The system should be able to:	
	Allow for assessment of benefit from various indicators	Yes, system is designed to allow benefits assessment in different areas
	Allow for different levels of managing users and research projects	Different access levels to the system are provided
	Allow for both qualitative and quantitative assessment	System is designed to handle both

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Uganda	Allow users to apply weights to different subsystems for different research projects	The system is designed such that results from all subsystems will not be aggregated. Users cannot apply their own weights to outputs from various subsystems.
	Allow assessment of the progress of different strategic research areas (such as transport services, road design, etc.) by integrating the assessment of different research projects within those research areas	the user can assess progress of the different research areas from results of analyses in the M&E system
	Allow for the creation of new indicators in the different subsystems	This will be problematic if the system allows users to create new indicators. This is because incorporating any new indicators in the system will require re-development of BAS. However, new indicators may be introduced during updates to the system
	Allow for assessment of the extent of uptake and embedment of research outputs	In subsystem A- Research output and Usage, there are separate indicators for update or adoption of research products and extent of implementation of research products. Uptake of research products measures the degree to which research products such as specifications, are adopted by ReCAP and its partner countries, organizations like World Bank, IRF or other standards setting agencies.
	Allow for assessment output to be exported into XLS format.	Yes - this functionality is part of the system
	Data Requirements	
	Data can take both numeric and string data types.	Yes - this functionality is part of the system
	Data can be exported in CSV format or JSON which then will be used on	Yes - this functionality is part of the system
	MySQL server that supports M&E portal	Yes - this functionality is part of the system

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Liberia	1. **Organizational M&E Functions**	
	System reflects number of M&E staff trained to use the system-accessibility	number of staff trained is an indicator in the BAS in Economic subsystem
	No. of projects the system is applicable to (whether the online system can be used for all road works in rural areas)	There is no limitation on the number or type of projects
	Identify M&E gaps and performance issues because of systems operations	yes - outputs from the M&E system
	Review the structure of the M&E division and its efficiency	This is internal to the road agency. Output from running the system may provide information that can be used by the road agency for this purpose
	2. **Human Capacity for M&E**	
	Frequency of use by M&E staff and knowledgeable of the system.	Use of the M&E system can be monitored by the systems administrator
	Ability of staff to manipulate and update the system and its data	System will not allow users to manipulate the system and its data. Users can however navigate the system
	No. of staff trained and retained to operate the system.	System cannot determine this. This is at discretion of the agency
	We suggest capacity building initiatives to ensure that they keep up with current and emerging trends in the field.	One approach is through the training via workshops. Follow-up training may be taken up by ReCAP
	3. **M&E frameworks/Logical Framework**	
	System to reflect the following key indicators:	
	Improved transport service	captured in socio-economic indicators
	Improved access to education	captured in socio-economic indicators
	Improved access to Health care	captured in socio-economic indicators
	Improved agriculture production and marketing	captured in socio-economic indicators
	Improved local economic activity	captured in socio-economic indicators
	Economic empowerment for women	Noted. Will be captured in socio-economic indicators
	Economic empowerment for youth	captured in socio-economic indicators

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Liberia	4. **Communication & Policies and Updates of MPW**	
	System reflects changes and updates of policies and strategies within the organization to promote M&E functions	outside scope of BAS
	5. **Supportive Supervision and Data Auditing**	
	Every M&E system needs a plan for supervision and data auditing. Supportive supervision implies that an individual or organization is able to supervise regularly the M&E processes in such a way that the supervisor offers suggestions on ways of improvement. This will require continuous collaboration with Senior Management Team at MPW and all relative stakeholders at supervisory level. Data analysts will be charged with the responsibility of auditing all triangulated data.	outside scope of BAS
	6. **Data Dissemination and Use**	
	Reflect number of institutions using accessing data from the system	captured as indicator in the Research Outputs and Usage subsystem of BAS
	Reflect results of all surveys and data bases use by other institutions	captured as indicator in the Research Outputs and Usage subsystem of BAS