Asset Management Plan (Bridge)

July 2021

Local Government Engineering Department

Local Government Division
Ministry of Local Government, Rural Development, & Cooperatives
Government of the People's Republic of Bangladesh

Local Government Engineering Department

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This Asset Management Plan (Bridge) is cocreated by the Local Government Engineering Department (LGED) and the United Nations Office for Project Services (UNOPS) under the National Resilience Programme (NRP).

The NRP is a joint programme of UNOPS, UN Women, and UNDP in partnership with the Local Government Engineering Department, Department of Disaster Management, Department of Women Affairs and Programming Division of the Government of Bangladesh (GOB). The Programme is funded by the governments of the UK, Sweden, and Bangladesh.

This AMP, in line with the ISO 55000, is a key component of the LGED's overarching Asset Management System (AMS) and aims to specify the detailed activities, resources, responsibilities, timescales and risks for achieving the specified Asset Management Objectives for bridge assets of LGED. It is a 'live' document and will evolve over time as the organisation tests, implements and improves the asset management practices.

Executive Summary

Infrastructure is a central pillar for sustainable and resilient development. Physical infrastructure assets provide a means for delivering essential services and play an important role in enhancing and protecting the lives and livelihoods of people and for the developing economy to thrive in Bangladesh.

The Local Government Engineering Department (LGED) under the Ministry of Local Government, Rural Development & Cooperatives is responsible for planning, developing, maintaining and managing local level rural roads, urban and small-scale water resources infrastructure nationwide. LGED recognizes that it is essential to manage assets to sustainably deliver appropriate levels of services to the community and to meet the expectations and needs of the present and future generations.

LGED's strong commitment to fulfilling this responsibility is evidenced by the development of an integrated, interdisciplinary Asset Management System (AMS). Asset Management (AM) provides a new lens through which LGED can refocus strategies and resources to deliver sustainable long-term value and performance from the local level infrastructure assets.

The Asset Management Plan (AMP) is a key component of the AMS and aims to specify the detailed activities, resources, responsibilities, timescales and risks for achieving the specified AM Objectives for a specified asset class.

This AMP applies to LGED's Bridge asset portfolio and all the actions, plans and activities across the asset lifecycle including planning, creation and/or acquisition, operation, maintenance, renewal and disposal. The AMP is a 'live' document and it will evolve over time as the organisation tests, implements and improves the asset management practices.

This document aims to:

Set out the operating context, governance, scope, and range of activities intended to achieve the agreed performance and levels of service to meet demand(s);

Ensure 'line of sight' from strategic objectives identified in the AM Policy, and Strategic Asset Management Plan (SAMP) through to implementation of lifecycle activities across LGED's bridge asset portfolio;

Demonstrate a transparent match to the context of the levels of service to be delivered, and the nominated asset management and related discipline standards;

Identify key resources required, as well as roles and responsibilities, to ensure this plan is implemented; and

Outline necessary development of asset management practices improvement opportunities for LGED when managing its road assets and delivering services.

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Glossary of terms

Terminology	Definition
Asset Management	Asset management (AM) is the coordinated activity of an organisation to unlock the value of its assets. It involves the balancing of costs, opportunities and risks against the desired performance of assets, to achieve the organisational benefits.
Asset Management System	An asset management system is a set of interrelated and interacting elements of an organization, whose function is to establish the asset management policy and asset management objectives, and the processes needed to achieve those objectives.
Asset Valuation	An organisation's process for defining and capturing 'as built', maintenance and renewal unit costs and the methods used by an organisation for the valuation and depreciation of assets. This includes ensuring that the quality of financial information is appropriate for the financial reporting framework of the organisation.
Backlog	The monetary value of work required to close the gap between current performance provided by an asset and the required performance.
Asset Condition	Asset condition is a measure of the health of an asset. Asset Condition is a key parameter in determining remaining useful life, and can be used to predict how long it will be before an asset needs to be repaired, renewed or replaced. Asset condition is also an indicator of how well it is able to perform its function
Frequency	A measure of the number of occurrences based on time.
GRC	Gross Replacement Costs
Hazard	A source of potential harm
Inventory	The asset inventory or registry is a database of all assets within an asset group or service for which the asset management plan is being developed.
Key Performance Indicator (KPI)	A quantifiable measure used to evaluate the success of an organisation or of a particular activity in which it engages.
Level of Service (LoS)	Parameters, or combination of parameters, which reflect social, political, environmental and economic outcomes that the organisation delivers.
Lifecycle Plan	The document output from the process of maintaining an asset from construction to disposal and predicting future performance of an asset or group of assets, based on investment scenarios and maintenance strategies.
LGED	Local Government Engineering Department
Maintenance	Maintenance describes the management, control, execution and quality of those activities which will reasonably ensure that design levels of availability and performance of assets are achieved in order to meet business objectives.

Terminology	Definition
Monitoring	Observing the status of a system, process or activity.
Performance	Measurable result.
Performance Measure	A direct or indirect, financial or non-financial evaluation of the performance of an organisation's asset, asset management or asset management system.
SAMP	Strategic Asset Management Plan
Risk	Chance of something happening that will impact on objectives.
Risk Assessment	The process of risk identification, risk analysis and risk evaluation.
Risk Identification	A process of determining risks that could potentially prevent an organisation from achieving its objectives.
Risk Management	A coordinated set of activities and methods used to monitor and control the many unplanned events that can affect an organisation's ability to achieve its objectives. It includes the identification, assessment, prioritisation and treatment of risks to reduce, monitor, and control the probability and/or consequence of unwanted events or to maximise the realisation of opportunities.
Risk mitigation	A systematic reduction in the extent of exposure to a risk and/or the likelihood of its occurrence.
RSDMS	Road and Structure Database Management System of LGED
Treatment Option	An action that may be taken to manage a risk. Terminate (Risk avoidance), Treat (risk reduction), Tolerate (Acceptance; Take advantage (opportunity)
Lifecycle Cost (LC) or Whole Life Cost (WLC)	The total cost of ownership over the life of an asset.

1. Introduction

1.1 Scope and Objectives

This Asset Management Plan (AMP) relates only to the assets in the Bridge asset class, listed in Section 3.1 and for which the Local Government Engineering Department (LGED) is responsible. It applies to LGED's Bridge asset portfolio and applies to all activities across the asset's lifecycle including planning, creation and/or acquisition, operation, maintenance, renewal and disposal.

The objectives of this AMP are to:

- Define levels of service and a performance management framework for different categories of bridges;
- Establish an efficient and effective operational lifecycle management plan;
- Deliver consistency in AMPs across infrastructure disciplines by taking an integrated lifecycle approach to develop cost-effective management practice for long-term that meet the defined level of service;
- Define the information and analysis requirements required to justify longer term funding requirements;
- Embody the guiding principles of LGED's AM Policy and demonstrate alignment and integration with LGED's AM Objectives and AM Framework;
- Provide a baseline of current work program for the subject assets, including allocated budgets and service level requirements; and
- Identify and assess key risks with appropriate risk management actions.

This inaugural AMP documents current asset management practices and will assist in guiding improvements to LGED's Asset Management (AM) approach in the short, medium and long term as outlined in Section: 11.0. It is a 'live' document and will evolve over time as LGED develops, tests and implements improved AM practices.

Where data is required but is not readily available, findings are supplemented by organisational experience, judgement and assumptions. These areas require further investigation and validation.

1.2 Relevant Documents

This document should be read in conjunction with the following documents:

- LGED Asset Management Policy 2019;
- LGED Strategic Asset Management Plan 2020;
- LGED Asset Information Strategy 2020;
- LGED Professional Development Strategy for LGED Asset Management System 2019;
- LGED Capability Building Plan for LGED Asset Management System 2020;
- LGED Rural Road and Bridge Maintenance Policy 2013;

1.3 Implementation and development

This is the first AMP prepared by LGED and as the inaugural version is intended as a 'live' document. The AMP will progressively evolve, improve and mature as the AMS and associated support elements such as people, processes, available technologies are developed as 'business as usual'. With increasing maturity, it can be expected that the AMP will progressively move from a top-down or network level view to a more advanced perspective encompassing much more detailed granularity and knowledge relating to the asset class, as shown in Figure 1 below.

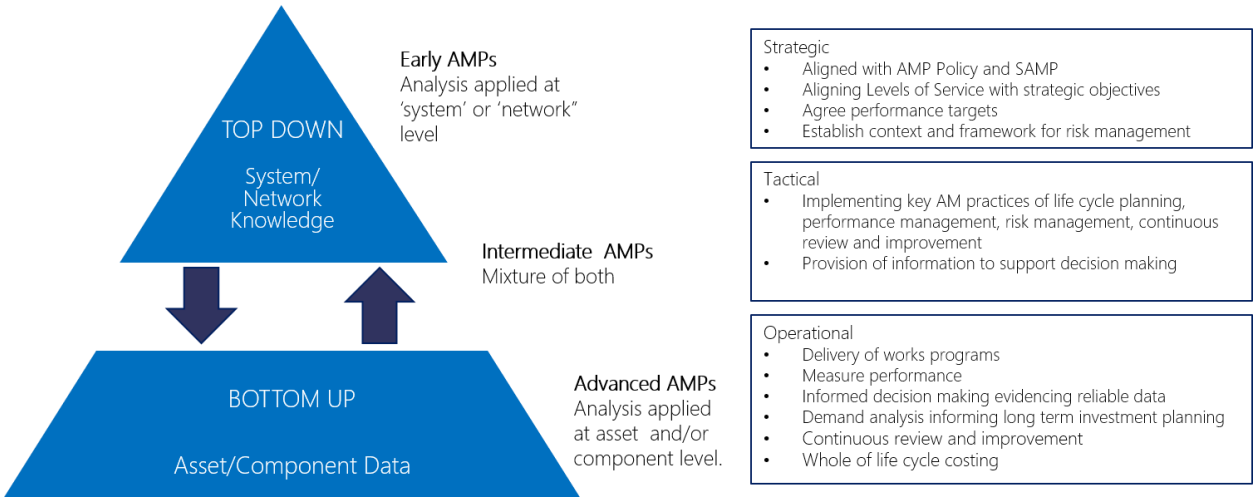


Figure 1: Maturity levels of AMPs; Source: after IIMM (2015)

Improvements to enhance LGED's development of this AMP are identified throughout the document and have been classified as "Further Actions/Opportunities in Section 11" for immediate/ short-term resolution or mid to longer term development and implementation.

1.4 Review

This AMP will be reviewed annually or as needed for the first three years in order to refine and adapt the AMP through an iterative process. This review is centred around achieving a satisfactory level of quality and achievability. Review intervals will be re-evaluated after 3 years, and the frequency could be increased in response to changing business needs, constraints, environmental, political or technological changes.

LGED's Asset Management Committee (AMC) will play the key role for the development and implementation of this AMP and for being appropriate, accurate and achievable. The AMC shall ensure that this document is reviewed and updated as necessary. Continual review and improvement of the AMP will be achieved in collaboration with key stakeholders within LGED.

2. Asset Management Context

LGED will effectively and efficiently manage local infrastructure through a comprehensive Asset Management System (AMS). The AMS will provide a structured, long-term approach to lifecycle management of local level infrastructure to deliver improvements in financial, social, economic and environmental performance. LGED's AMS provides a strategic and systematic process of operating, maintaining, and improving infrastructure assets, with a focus on both engineering and economic analysis based upon information, to identify a structured sequence of maintenance, repair and replacement actions that will achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost.

Key components of the AMS which ensure a clear line of sight are:

- Asset Management Policy;
- Strategic Asset Management Plan (SAMP), including Asset Management Objectives, and
- Asset Management Plan - this document.

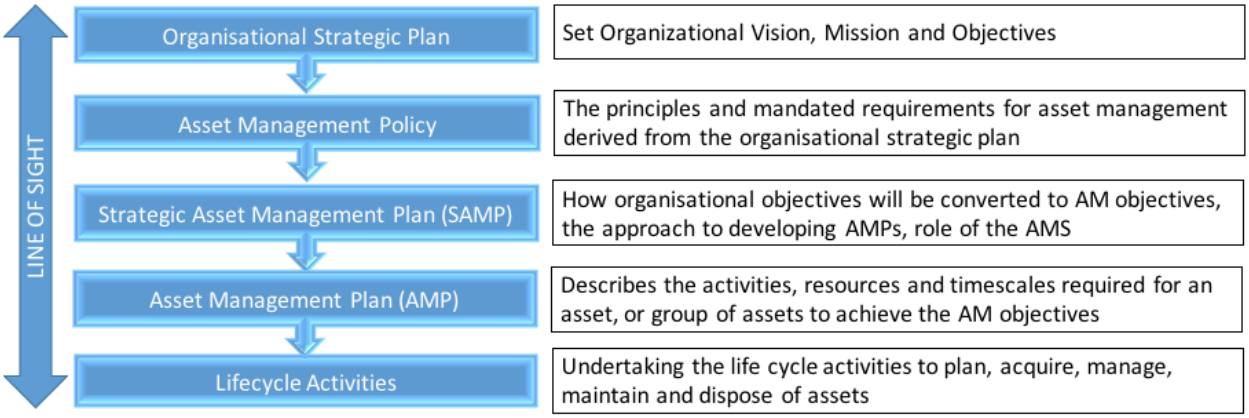


Figure 2: Policy, SAMP, and AMPs Line of Sight, after ISO 55000

2.1 Asset Management Policy

LGED's Asset Management Policy (2019) provides the first stage of 'line of sight' between LGED's organisational mission, vision, and LGED's AM objectives and infrastructure asset interventions. LGED's Asset Management Policy Statement is as follows:

'LGED is committed to sustainable asset management, complying with all legislative and regulatory requirements, to contribute to improved resilience and delivering services to current and future generations by managing risk, optimising performance and managing expenditure on infrastructure assets throughout the whole of asset lifecycle.' [1]

[1] LGED Asset Management Policy (2019)

2.3 Asset Management Objectives

It is the intention that the LGED's Asset Management principles and objectives, presented in the SAMP are translated through this AMP into the below practices:

- Asset management decisions to complement strategic planning objectives;
- Asset management decisions adopt risk-based maintenance approaches where appropriate;
- Empower LGED to start proactively managing their assets;
- Provide justification for future investment and manage level of service for assets;
- Ensure road networks are managed at optimum cost over the longer term;
- Provide a platform for innovation and development of asset management good practice; and
- Establish accountability for asset condition and performance.

It is recognised that this AMP outlines several Asset Management practices, some of which are not currently being practiced, others adopted disparately and others which are applied to specific projects only.

A consolidated list of actions and recommendations to guide LGED's development and improvement of AM practices is provided in "Section 11: Further Actions/Opportunities".

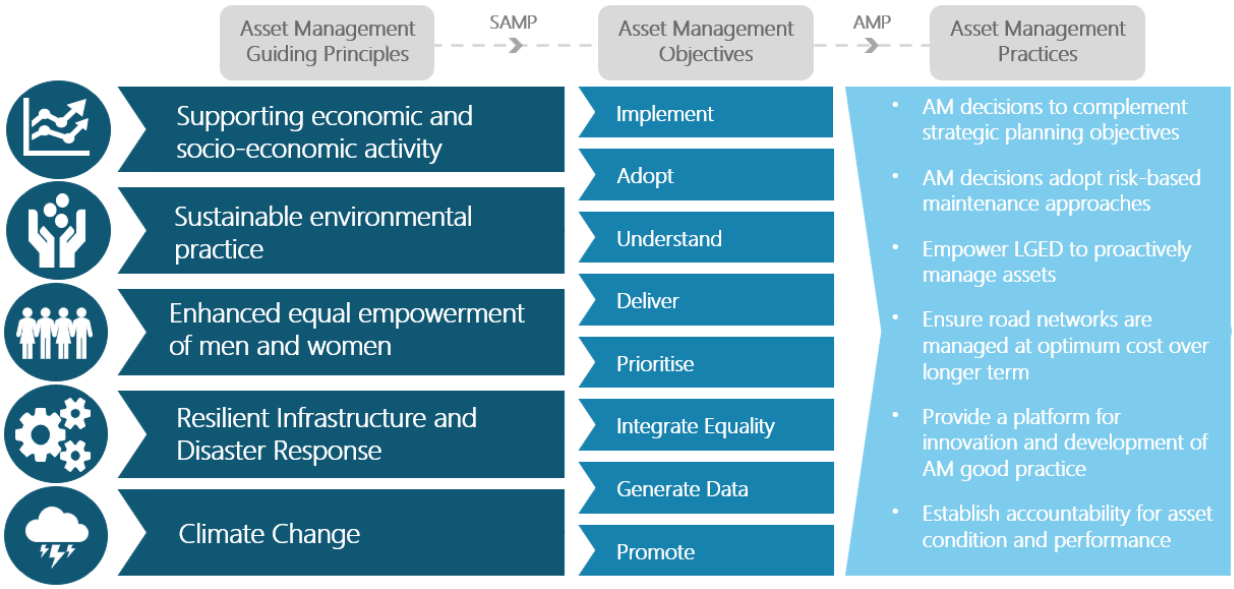


Figure 3: AM Guiding principles, objectives, and practices

3. Bridge Assets Portfolio

Effective asset management planning requires knowledge of an asset, its condition and its use. This entails the collection and maintenance of asset data that can assist asset managers to assess, analyse and report on performance and progress. Good asset data is the foundation on which asset management processes are built. The availability of appropriate asset data allows all staff involved in the process to obtain an overall view and to apply a consistent management approach.

Accurate and current asset data is required to enable the following asset management processes to be undertaken:

- Effective monitoring of and reporting on the performance of the rural road network;
- Assessment of the expected lifespan of individual assets or asset components;
- Assessment of current and development of future Level of Service (LoS);
- Assessment of current and development of future performance indicators;
- Development of future maintenance options;
- Identification of future investment strategies;
- Development of short, medium and long-term forward works programmes;
- Development of budget requirements that will form the work programmes; and
- Valuation assessments for each of the assets and the calculation of how they have depreciated in value since they were created.

Once completed, these processes will allow informed and cost-effective management decisions to be made and will contribute to the effective management of risk.

This section presents an overview of the current knowledge of LGED's rural bridges and cross-drainage structures portfolio that is provided by available asset data and aggregated information.

3.1 Bridge assets definition

This AMP covers local level structures located on Upazila, Union or Village roads. Any structure located on these roads, and less than 1500 meter long, is the responsibility of LGED. These structures are defined in Table 1 below:

Table 1: Structure type and description

Structure Type	Description
Box Culvert	Box Culvert is a rectangular-shaped, reinforced concrete drainage structure either cast in situ or precast in sections. They are most commonly used for water courses.
U-Drain	U-drains are very small length structures provided for passing water. There is no wing wall in the structure. Only two vertical walls (either brick masonry or reinforced cement concrete) are provided which work as abutments and a top slab is provided over it.

Structure Type	Description
Pipe Culvert	Pipe culvert is a buried pipe for carrying a watercourse below ground level. It can be made of polyethylene pipe, concrete and metal pipe. Its main purpose is to provide cross drainage facilities in particularly low priority roads.
Slab Culvert	Culvert is a structure constructed over running water or physical obstruction. The main purpose of constructing culvert structure is to provide passage over the obstruction. Slab culvert, a type of culvert, could be three-sided or simply a deck slab. It is embedded in the soil on both sides.
RCC Girder Bridge	A girder bridge, in general, is a bridge that uses girders as the means of supporting the deck. The girders themselves are the primary support for the deck, and are responsible for transferring the load down to the foundation. The whole structure is usually made of concrete.
Iron Bridge	An iron bridge is a bridge that uses EI rail, MS angle and timber as its principal structural material. The piers are constructed with EI rail. Wooden planks are used for deck slabs and MS angles are used for railing and rail post. It is a temporary structure for passing light traffic vehicles (pedestrian, bicycle, motorcycle and three wheelers).
Light Traffic Bridge	Light Traffic Bridge is one kind of RCC Girder Bridge with very narrow width. These types of bridges were installed in rural roads where connectivity was required but there was very less possibility of vehicular movement. These bridges were made within a limited cost and thus these bridges are also called low-cost bridges.
Hydraulic Structure	Sluice Gate typed structures are commonly constructed to control the water flow in a defined channel. Typical construction materials are cast iron for the frame, gate, and guides. Wedges, thrust nut, lift nut, and couplings are bronze castings. Seat facings are extruded bronze. Stems and fasteners are stainless steel.
Arch Masonry	An arch bridge is a bridge with abutments at each end shaped as a curved arch. Arch bridges work by transferring the weight of the bridge and its loads partially into a horizontal thrust restrained by the abutments at either side. Stone, brick and other such materials are strong in compression and somewhat so in shear, but cannot resist much force in tension.
Wooden Bridge	A timber bridge or wooden bridge is a bridge that uses timber or wood as its principal structural material. It is a bridge with wooden spans and supports. Timber bridges may also have concrete supports.
PC Girder Bridge	It is similar to the RCC girder bridge with a contrast that the girders are constructed with prestressed (compressed) concrete is a form of concrete used in construction. This compression is produced by the tensioning of high-strength "tendons" located within or adjacent to the concrete and is done to improve the performance of the concrete in service.
Bailey Bridge (with/without) Steel Deck	The Bailey bridge is a type of portable, pre-fabricated, truss bridge. It was developed by the British during World War II for military use and saw extensive use by British, Canadian and the American military engineering units.
Truss with Steel Deck / Truss with RCC Slab	A truss bridge is a bridge whose load-bearing superstructure is composed of a truss, a structure of connected elements usually forming triangular units. The connected elements (typically straight) may be stressed from tension, compression, or sometimes both in response to dynamic load.

Structure Type	Description
Steel Beam & RCC Slab	It is a composite bridge consisting of steel girders and concrete deck. It usually uses where longer horizontal clearance is required to reduce deflection in and size of the girder. This is done using 'shear connectors' fixed to the steel beams and then embedded in the concrete.

Note: The scope of this AMP does not include Sluice gates and regulators, Dams, Embankments, Ghats, Jetties, and Buildings.

3.2 Bridge Assets Hierarchy

Infrastructure assets generally have a hierarchical relationship that cascades down from a network level to assets and their components. An asset hierarchy provides a framework to structure and store asset data. The asset hierarchy provides a common structure and terminology for use across LGED. By adopting an appropriate asset hierarchy and minimum level of componentization for road infrastructure assets, LGED seeks to realise the following organizational benefits:

- Improved data integration;
- Increased reporting efficiencies;
- Improved availability and greater confidence in asset-related data aggregation and analysis to inform forward planning processes;
- Greater transparency and evidence for financial asset valuation; and
- Improved data analytics for asset performance monitoring, reporting and decision making.

The following asset classification structure outlines the asset hierarchy for LGED's bridge infrastructure:

Table 2: LGED Bridge assets hierarchy

Level 1 Asset Class	Level 2 Asset sub-class	Level 3 Asset Type	Level 4 Asset sub- type	Level 5 Asset Component
Rural Road Infrastructure	Structure	Bridge	• PC Girder Bridge • Steel Structure • Bailey Bridge • RCC Bridge • Box Girder Bridge • Arch Bridge • Sluice Gate	• Wing wall • Abutment • Girder • Slab • Railing • Rail post • Expansion Joint • Walkway • Wheel Guard • Pier & Pier Cap • Cross Girder • Diaphragm • Bearings

Level 1 Asset Class	Level 2 Asset sub-class	Level 3 Asset Type	Level 4 Asset sub- type	Level 5 Asset Component
		Cross Drainage	• Pipe culvert • Box culvert • Slab culvert • U-Drain • Arch Culvert • Wooden Bridge • Iron Bridge	

3.3 Bridge Asset Data Management System

Bridge asset data for all structures located on rural roads under LGED is managed through a database called Road and Structure Database Management System Version 7 (RSDMS-VII). The RSDMS is accessible in each Upazila, District and in the Road Maintenance and Road Safety Unit (RMRSU) at LGED HQ Dhaka.

The database contains detailed information about the physical attributes of the structure, along with condition data, geographic/location data, and construction and maintenance records, detailed further in the sections below. Capturing, quantifying and recording LGED's bridges portfolio is an ongoing process. Management of LGED's asset data is regularly reviewed and improvement initiatives agreed to reflect LGED's changing needs, technology and software advancements.

3.3.1 Bridges asset data attribute

The types of chainage-wise data and attributes stored in RSDMS are shown in Table 3.

Table 3: Bridge/Culvert attributes stored in RSDMS

Data Type	Item
Asset Attributes	Road Type
	Road Code
	Structure code
	Structure SI No.
Geographic / Location Data	Division
	District
	Upazila
	Road Name
	Chainage
Structure type	Bridge structure type
	Drainage structure type
Design / Construction Data	Construction year (estimated or actual)
	Funding source

Data Type	Item
Superstructure	No. of spans
	No. of beams
	Left walkway width (m)
	Right walkway width (m)
	Railing type
	LHS rail bar post condition
	RHS rail bar post condition
	Bridge deck condition
	Expansion joint seal condition (back)
	Expansion joint seal condition (front)
	Road safety element damage (posts, signs, etc)
	Road safety element paint (posts, signs, etc)
	Paint on Truss

Data Type	Item
	Construction cost
Design Load	Load weight restriction (ton)
Geometry	Structure width (m)
	Carriage width (m)
	Clear span length (m)
	Total structure length (m)
Hydraulic	Cleaning status of waterways (upstream)
	Cleaning status of waterways (downstream)

Data Type	Item
	Overall superstructure condition
Substructure	Abutment material type
	Pier material type
	Wing wall material type
	Abutment foundation type
	Pier foundation type
	Overall substructure condition

3.4 Asset Inventory

One of the key supporting components of the management of assets is to record, quantify and document assets that comprise the bridges portfolio for which LGED is responsible.

Inventory data describes the physical asset, its constituents and other relevant data associated with the definition and may also describe its current service or function (such as structure type, route designation and geometric location).

The current inventory of bridges and hydraulic structures from the database is presented in Table 4.

Table 4: LGED Structure inventory

Structure Type	Count	Total Length (km)
Box Culvert	72107	310140
U-Drain	57340	79459
Pipe Culvert	53615	56453
Slab Culvert	41180	119826
RCC Girder Bridge	17996	420023
Iron Bridge	7289	119205
Light Traffic Bridge	6500	123291
Hydraulic Structure	2158	Not specified
Arch Masonry	667	2242
Wooden Bridge	656	9518
PC Girder Bridge	358	56735
Bailey Bridge	313	8662
Truss with Steel Deck	277	10690

Bailey with Steel Deck	121	6643
Steel Beam & RCC Slab	118	2637
Truss with RCC Slab	105	2187

Bridges and Culverts population as of October 2019 (Source: LGED Road and Structure Database, 2019).

3.5 Bridge Asset Inspections

Inspections are formalized assessments undertaken to identify defects and hazards as well as to assess the overall condition and performance of the assets. They are carried out both in response to requests by the community/authority and as part of a regular inspection program by knowledgeable, skilled personnel.

LGED currently aims to undertake a four-level inspection regime, reflecting leading road network asset (including bridge assets) management practices, as below:

Level 1 – Routine Maintenance Inspections

Routine Maintenance Inspections are visual inspections to check the general serviceability of the asset, particularly for the safety of users, and to identify emerging issues. It provides a quick assessment of the general condition of the road network and the effectiveness and efficiency of routine maintenance.

Level 2 – Condition Inspections

Condition Inspections assess and rate the condition of the assets. This information is used as a basis for assessing the effectiveness of past maintenance treatments, identifying current maintenance needs, severity of damages, modelling and forecasting future changes in condition and estimating future budget requirements.

Level 3 – Detailed Engineering Inspections

Detailed Engineering Inspection is an extensive inspection which may include physical testing and structural analysis to assess the assets structural integrity, quantify the current and projected deterioration of the asset, to identify the appropriate repair procedure and quantify the amount of work required with estimation of cost, Data obtained from this survey will be used in preparing working estimate of scheme.

Level 4 – Incident Inspections

Undertaken in response to stakeholder enquiries or after disaster or an incident condition report to be prepared for use in legal proceedings and the gathering of information for the analysis of causes of accidents and the planning and implementation of asset management and safety measures. The subsequent inspection will be conducted by an appropriate inspector.

LGED's Road Maintenance and Road Safety Unit (RMRSU) operates this activity on an annual basis.

The above listed inspection processes are designed to support asset management decision processes within LGED at different levels.

3.6 Bridge Asset Condition

Asset condition data comprises measurement and observational rating of the condition of elements of the asset, derived from either physical testing, condition surveys or visual inspection. This provides the data and information to assess the likelihood of failure and aids in determination of when to intervene with maintenance or rehabilitation to extend asset life and maintain the level of service.[2]

Understanding the condition and performance of structures' assets provides the data and information to assess the likelihood of failure and aids in the determination of when to intervene with maintenance or rehabilitation to extend asset life and maintain the level of service.[3]

To capture structure asset condition in a comprehensive and efficient manner, several categories of data inform either in aggregate or synthesised format the condition of bridges and culverts, and may include:

- Design information – geometric and material properties;
- Surface and structural defects (cracking and crack progression, exposed reinforcement, spalling of concrete, presence of corrosion, etc);
- Construction and maintenance history;
- Utilisation of structure – traffic information or hydraulic information.

Not all structures' condition scores have been established, and it is understood that LGED have embarked upon the task to collect condition data for all of their structures. No timetable has been provided, however when all structures' condition scores have been collected, the high-level outputs and observations should be provided in this section.

There are known challenges which include condition consistency and completeness of data, which limits the accuracy and quality of conclusions that can be drawn from the current data recorded of the bridge asset portfolio.

3.6.1 Condition monitoring

Bridge and hydraulic structure condition monitoring seeks to provide an indication of the overall condition of the structure by identifying and recording defects in the road pavement and surfacing. The goal of effective and efficient condition monitoring is to provide reliable

[2] Austroads AGAM13-08
[3] Austroads AGAM Part 6 Section 4.1

inputs to develop investment – capital and maintenance – programs of works to ensure optimal distribution of available funding.

Condition monitoring of bridge assets is highly dependent on adequate and timely condition data. LGED's current practice for collecting and analysing condition data is predominantly manual. Lack of reliable condition data affects the ability to plan maintenance activities in an effective way.

For rural bridges and culverts, the condition data shown in Table 5 below is currently measured by LGED.

Table 5: Rural bridge and culvert condition data attributes measured by LGED

Condition Data Type	Item
Asset Attributes	Road Type
	Road Code
	Structure code
	Structure SI No.
	Inspection date
	Inspected by
Geographic/ Location Data	Division
	District
	Upazila
	Road Name
	Chainage
Structure type	Structure type
	Structural width
	Non-structural condition rating

Condition Data Type	Item
At superstructure condition point	Settlement
	Tilting
	Movement
	Rebar exposed of pier/ pile
	Rebar exposed other components
	Calculated Superstructure condition
At substructure condition point	Settlement
	Tilting
	Movement
	Rebar exposed of pier/ pile
	Rebar exposed other components
	Calculated sub-structure condition

Structural condition data is collected through surveys of differing levels of scrutiny. There are three survey types applicable for all bridges and culverts[4], which are detailed further below.

3.6.2 Condition evaluations

LGED bridge condition data comprises measurement and observational rating of the condition of structural and functional elements of the asset derived from either visual inspection, non-invasive or

[4] Training Manual on Road Maintenance Management from the Rural Infrastructure Maintenance Management Unit p66.

invasive testing. This allows for investigation into the cause of asset defects in order to prioritise maintenance or rehabilitation treatments.

The condition of bridge assets is informed through structure condition surveys, undertaken as described in the table below.

Table 6: Structure condition surveys undertaken by LGED

Condition Survey Details	Structure Condition Survey 1 (SCS-1)	Structure Condition Survey 2 (SCS-2)	Advance Condition Survey (ACS)
Purpose	To condition score bridges and culverts	To inform maintenance and rehabilitation assessment	Bespoke inspection where significant maintenance measures may be required.
Responsibilities	Sub-assistant Engineer (SAE) responsible for undertaking survey. Upazila Engineer (UE) responsible for checking reports.	UE responsible for undertaking inspection. SAE responsible for subsequent reports.	Conducted by member from Bridge Expert Team at request of UE. Bridge Expert responsible for completion/accuracy of survey.
Record	Survey recorded on SCS-1 Bridge/Culvert Inspection Report Form	Survey recorded on SCS-2 Bridge/Culvert Maintenance and Rehabilitation Assessment Form	No standardised form to record outputs of survey.

Note: If it is demonstrated to be more efficient, the practices implemented under the bridge project supported by the World Bank (SupRB) can serve as a substitute.

SCS-1 focuses largely on condition information that can be observed from visual data, whereas SCS-2 requires information regarding the structural elements that need rehabilitation attention or replacement.

The outputs of the above inspections are uploaded in RSDMS-VII.

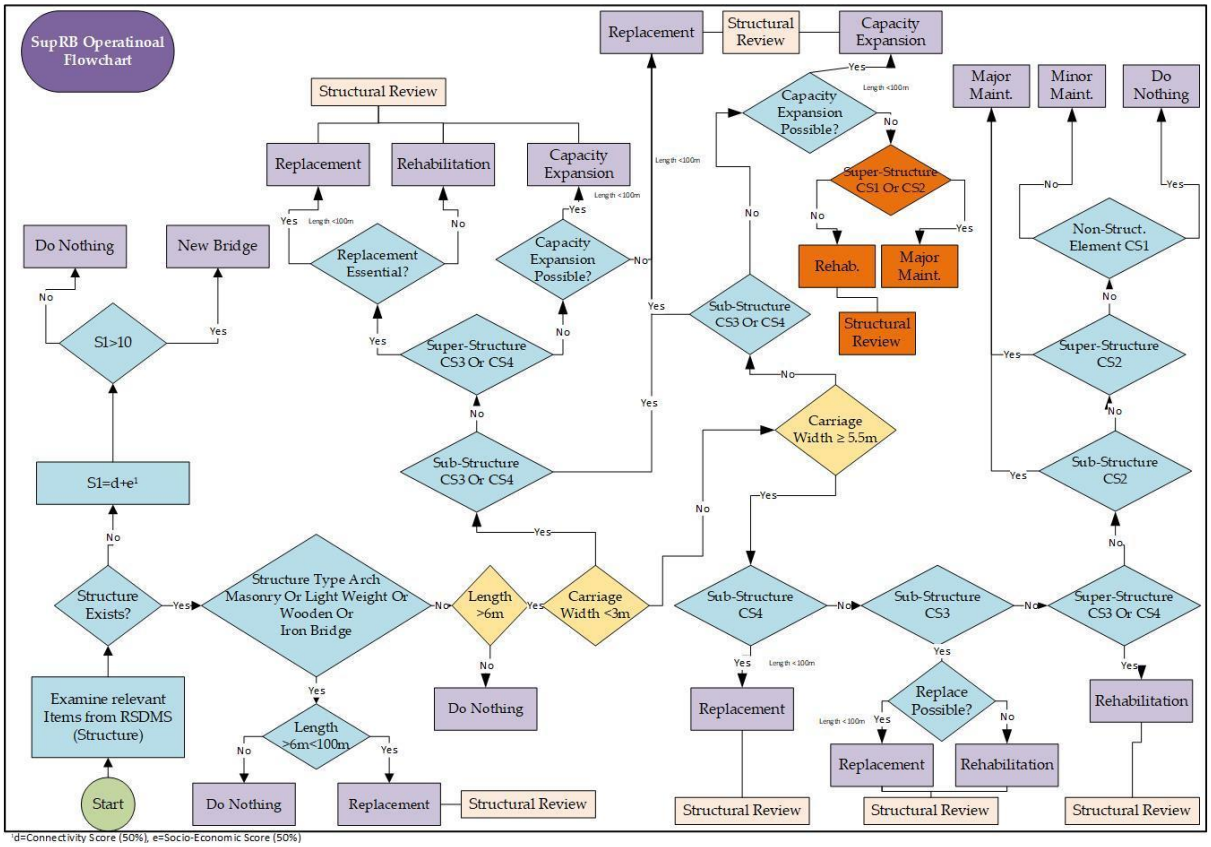


Figure 4: SupRB Operational Flow Chart

3.6.3 Condition reporting

The condition of bridge and hydraulic structure elements are currently rated as per the table below. This rating scheme is expected to be superseded by the "Future Asset Condition Surveys".

Table 7: Condition states for bridge elements

Condition Rating	Condition Narrative
A	No damage
B	Minor damage
C	Minor elemental damage
D	Major elemental damage

The condition of bridges listed as LGED assets is monitored and reported on by different authorities according to bridge length. Table 8 below shows the division of bridges and the corresponding responsible authorities for condition monitoring and reporting.

Table 8: Responsible Authorities for LGED Bridge assets condition monitoring and reporting

Bridge Length	Responsible Authority
Above 100m	LGED HQ
50m - 100m	Regional Superintending Engineer
Less than 50m	District Executive Engineer

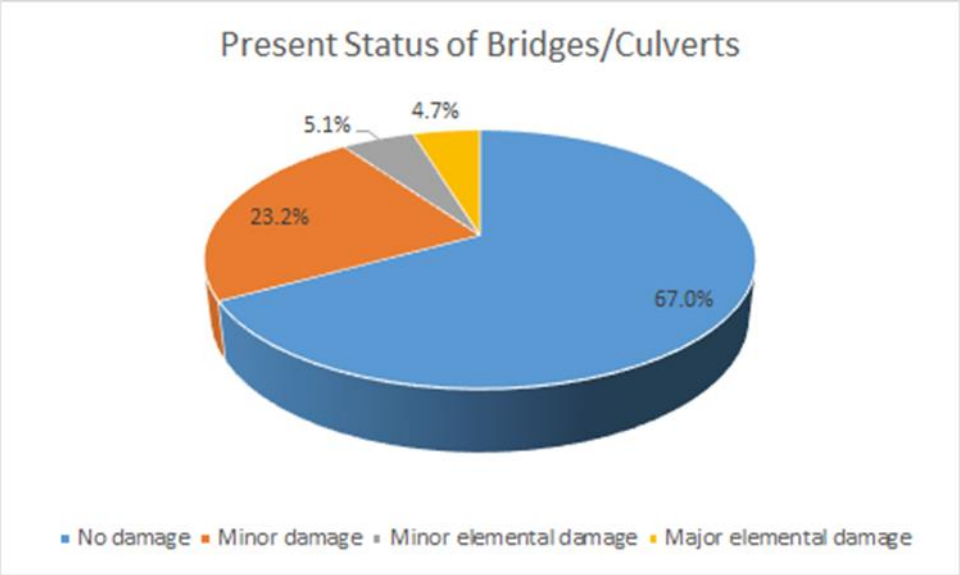


Figure 5: Condition summary of bridges and culverts condition status (2020)

There are no defined guidelines for assessing the condition of road embankments (shoulders and slopes) or drainage assets. Condition is currently based on expert judgement and recorded when visual inspection or maintenance activities are undertaken.

3.6.4 Future Asset Condition Surveys

LGED proposes to adopt a condition rating system where each bridge element will be scored using the **Bridge Health Condition Rating Index** is summarised in Table 9 below. It is noted that assessment of all bridges conditions is underway with the support from a World Bank funded project.

Table 9: Bridge health condition ratings

Condition code	Condition rating
CS-1	Good
CS-2	Fair
CS-3	Poor
CS-4	Severe

The Multi-Criteria Bridge maintenance or rehab algorithm provides a process to determine the overall structure's condition score through weighting individual element condition scores

reflected in the structural significance factor (S_i). The inclusion of this factor ensures that condition scores for primary structural elements have a higher influence than ancillary elements (e.g. handrails).

Other factors that are considered during the overall condition scores are:

- Material Vulnerability Factor (M_i)
- Casual factor (CF), which is the combination of the below characteristics:
  - Age (A) - a younger bridge is statistically less prone to show defects
  - Environment - an asset subject to more aggressive environments are likely to deteriorate faster
  - Road type (R) - the importance of the road's performance to the network
  - Inspection uncertainty (I) - reflecting the competency of the inspector and therefore robustness of inspection outputs

3.7 Data Collection and Utilisation

Asset data collection activities are undertaken to support asset management decision processes that will meet LGED business needs at all levels in the organisation. Asset data for LGED's assets is collated through visual inspections and condition surveys.

In order to ensure collected data in the database provides meaningful input to the decision-making process, it is important to collect data on the asset's design, construction, maintenance and condition. Asset design and construction data or information provides insight to defects that may have occurred during that period that may affect the asset's intended design life, while maintenance and condition data provide visibility over the current status of the asset.

3.7.1 Methods and frequency

The structural condition surveys, as detailed in Section 3.5 above, involve visual inspections and non-invasive testing. The frequency of structure surveys is generally related to the physical condition of the structure. Typical frequencies of the different levels of structure surveys are present in Table 10 below.

Table 10: Structure survey frequency

Condition	Description	Survey Type		
		SCS-1	SCS-2	ACS
A	No Damage	Yearly	2 Years Interval	-
B	Minor Damage	Yearly	Yearly	-
C	Major Element Damage	Yearly	Yearly/half yearly	As directed
D	Major Structural Damage	Yearly	As directed	As directed
Responsibility		Sub-Assistant Engineer	Upazila Engineer	Bridge Expert Team from LGED HQ

In the case of extreme weather conditions or natural disasters, additional inspections should be carried out in order to ascertain the emergency response and rehabilitation measures required.

3.7.2 Collection process

The data collection process begins with establishing the data needs. Data needs will vary depending on the complexity and scale of the road network, the level of asset management maturity, available technology and skilled and knowledgeable resources.

LGED's data capture and validation process are illustrated in the diagram below. Current practice in LGED evidences the occurrence of the activities is infrequent and overall compliance with this process is very low.

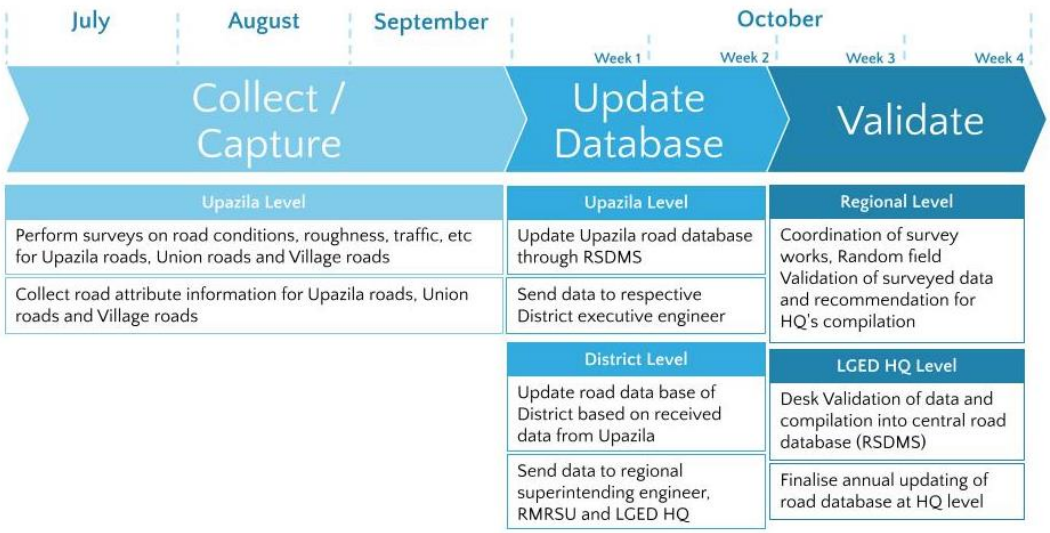


Figure 6: LGED's data capture and validation process

3.8 Data Quality, Management and Validation

Good asset data is the foundation on which asset management processes are built. The availability of appropriate asset data allows all staff involved in the process to obtain an overall view and to apply a consistent management approach.

LGED's Asset Information Strategy (AIS) outlines LGED's overall approach to the management of asset information and aligns with and supports LGED's Asset Management Objectives and Asset Management Policy. LGED's AIS also outlines the controls and processes for the collection, collation, storage, maintenance and transfer of asset information.

LGED's AIS presents an assessment of the current situation of asset information management for road pavement and structures. It recommends what constitutes best practices, and suggests actions which should move LGED to make improvements with a continued focus on line of sight to the organisation's outcomes. This is built on an already strong base of many years of good data management, and it is felt that within five years LGED could have moved forward significantly creating a strong enabling platform for good asset management. LGED's AIS should be read in conjunction with this AMP.

3.8.1 Data Quality

There is a tendency to think of data quality as either good or poor but in reality, there are different attributes that combine when considering data quality. Each of these attributes are important in understanding data quality and therefore the confidence that should be placed in using the data for an intended purpose. These attributes are:

- **Completeness** – the degree to which a dataset is populated with all the required data. This relates to the presence of a record as well as the degree to which the mandatory attributes are completed.
- **Accuracy** – whether the data record is a correct reflection of the asset it is related to.
- **Consistency** – data should be consistent across different datasets. Identifiers should be the same and the record should be representing the same physical entity.
- **Uniqueness** – there are no duplicate records in the system. Records represent a physical entity once in the system.
- **Validity** – the data adheres to the rules outlined in the data model. This can be ensuring the correct codes are used or ensuring relationships between records are valid.
- **Timeliness** – data should be available when decisions need to be made. This means that the time taken between an asset being added, removed or modified and the update of the asset register record is appropriate for the intended use of the data.

The data currently held within LGED's RSDMS should be assessed based on these attributes, starting with critical assets and their attributes. The assessment should be made using the asset information specification and input from data owners.

The following constraints and limitations have been identified in LGED's current structure asset condition management processes, and are tabled below as potential opportunities for improvement initiatives.

Table 11: Limitations-current asset condition management processes (quality attribute)

Quality Attribute	Limitation	Details
Completeness	Data unavailable.	Where data is required but is not readily available, findings are supplemented by organisational experience, judgement and assumptions. These areas require further investigation and validation.
	Absence of data for superstructure, foundation type and substructure details	These are static data and a good number of structures of such details are provided.
	Pavement test data not captured.	DCP and deflection survey data currently not being collected and stored in data management system.
	Observation of non-structural elements of structures are not captured	Condition of Slopes, Protective Works, Surfacing Course, wearing course, Repairing/Replacement, Road Safety, etc. are not being collected and stored in data management system

	Observation of individual component of structures are not captured	Component-wise defects (Cracks/Corrosion, Concrete Spalling/Ravelling, Damaged or Missing Section/ Section Loss, Rebar Exposed, Settlement, Tilting, Movements, Scouring and Obstructions) are not being collected and stored, particularly of the structures having a length less than 6m.
	Missing of observation of Inadequateness of Structure	Adequateness of Structure cannot be assessed as requisite information of Carriage Width, Length of Structure, Traffic Volume, Condition of Superstructure, Condition of Sub Structure, Possibility of Capacity Expansion are missing.
Completeness & Timeliness	Access to database/ internet/ electricity.	Access to the RSDMS database/internet/electricity in some rural Upazila can lead to absences in reliable data for maintenance fund allocation/decision-making. Rural accessibility is crucial in accurate and timely data collection.
Consistency	Customer expectations.	Baseline customer expectations not formally recorded to provide input into Levels of Service.

3.8.2 Data Management

The storage and constant improvement of asset information within LGED's RSDMS and records management systems is a key stage in the asset information lifecycle. The purpose of data management and storage is to ensure the asset information is available to all who require the information in a secure manner. This is either in its native asset register record structure or once it has been aggregated, filtered or presented graphically as an output from analysis and reporting.

LGED's data stores have typically grown organically and there is the real possibility that significant amounts of data currently stored, captured and maintained are not actually being used due to limited visibility of the data by the wider business.

The following constraints and limitations have been identified in LGED's current asset management approach and condition management processes and are listed below as potential opportunities for improvement initiatives:

- Inherent limitations of RSDMS software relative to its up-grading and conversion into cloud hosted and/or web versions enabling increased accessibility across LGED;
- Inadequate and incompetent human resources;
- Lack of modern technology and equipment; and
- Technological limitations experienced across LGED's devolved organisation and locations.

3.8.3 Data validation

The validation of data is crucial to determining maintenance need and priority of the infrastructure assets, and enables a reliable and robust decision-making process. This decision-making process can be made more reliable through adopting the following:

- Validation of distance measurement;
- Validation of equipment measurement;

- Repeatability and bias;
- Assess validity of measured data;
- Distribution analysis;
- Data collection, aggregation and segmentation and use in monitoring and reporting.

LGED has developed an Asset Information Strategy (AIS) as part of the AMS improvement planning. For a more detailed explanation of data validation, it is recommended to consult the AIS alongside.

3.8.4 Data management

Effective data management strategies are instrumental to informed decision-making and best-practice asset management processes. The Asset Information Strategy (AIS) provides a high-level approach and direction for the definition, collection, management, reporting and overall governance of LGED asset information. The AIS aims to align the existing capacity of LGED with future asset management direction and goals. Upon assessing the current state of asset information management and comparing this to the desired state of asset information management, the AIS sets out recommendations to enhance LGED's current capabilities. Figure 7 below shows this comparison.

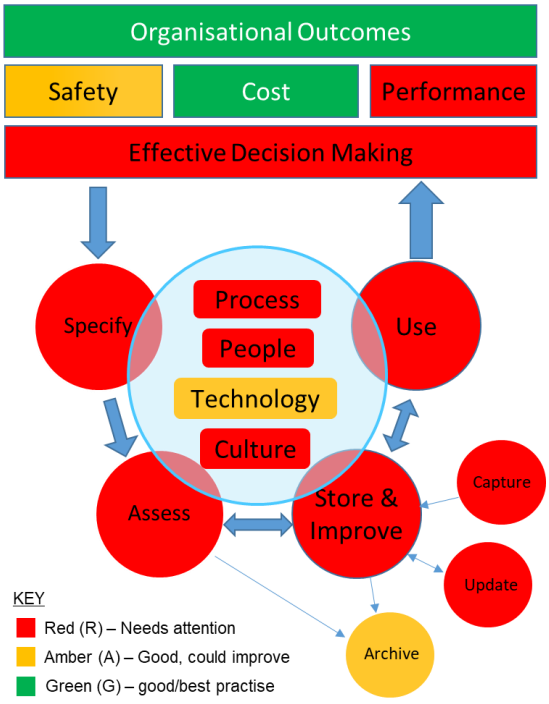


Figure 7: The current state assessment of Structure asset information management

Source: LGED Asset Information Strategy 2020

3.9 Constraints and limitations

The following constraints and limitations have been identified in LGED's current structures asset condition management processes, and are tabled below as potential opportunities for improvement initiatives.

Table 12: Bridge and culvert asset known data limitations

Quality theme	Limitation	Details
Accuracy / Consistency	Human error	Manual handling of data between districts and LGED HQ increases the risk of human error. Improved accessibility to LGED ICT systems may help minimise this.
Accuracy / Validity	Inconsistency in bridge condition database output.	The condition attributes collected in the database output for bridges do not appear to comprehensively capture the condition of the structure. It is unclear how the condition of the structure is observed and rated from this output. For example, there are different levels of risk associated with exposed sections of steel reinforcement in different sections of the bridge/culvert and the potential causes of that exposed reinforcement, however the database output does not appear to capture this, which can have impacts in understanding the residual life of that element/structure.
	No photographic evidence of defects/inspections provided	Condition ratings should be supplemented with inspection reports with images of defects that can also be stored in the database. This way the progression of defects can be effectively monitored to facilitate desktop decision-making for maintenance or rehabilitation.
Completeness	Bridge maintenance records unavailable	Bridge maintenance history records unavailable.
	Condition scores not available for all structures	Not all structures' condition scores have been established. It is understood that LGED has commenced collection of condition data for all of their structures. Condition scoring all bridges provides a baseline of condition data for the portfolio of assets to assist in being able to direct investment plans accurately.
	No records for risk mitigation measures	No records for risk specific mitigation measures, specifically for: scour, hidden critical elements including elements submerged in water, fatigue prone elements.
Completeness / Consistency	Data challenges	Known challenges include condition consistency and completeness of data, which limits the accuracy and quality of conclusions that can be drawn from the asset data.
	History of defects unavailable	No work order dataset or history of defects is available. This limits LGED's ability to determine root causes and trends
Completeness / Timeliness	Access to database / internet / electricity	Access to the RSDMS database/internet/electricity in some rural Upazilas can lead to absences in reliable data for maintenance fund allocation/decision-making. Rural accessibility is crucial in accurate and timely data collection.

Quality theme	Limitation	Details
Completeness / Validity	Incomplete dataset	Incomplete dataset for bridge condition and asset database. Visually inspect all bridges formally recording observations to provide assurance that all bridges are fit for purpose.
	Road accident data not collected	Collection of road accident data is necessary to inform safety focused decisions and understand trends to prevent the occurrence of future incidents
Completeness / Validity / Timeliness	Absence of programme for inspections	Establish a programme of visual, detailed inspections for each asset to provide ongoing assurance that bridges continue to be fit for purpose. The programme should be monitored for compliance to ensure districts are managing the condition of assets and provide an understanding of barriers to compliance.
Consistency	Inspection data collection	Suite of inspection software has been in use for many years but not consistently deployed across the country, nor actively enforced, owing to knowledge and resource deficiencies.
	Quality Inconsistencies	Quality inconsistencies as no formal training for inspectors is available to achieve consistent quality recording
Consistency / Accuracy	Inconsistency in bridge condition inputs and recording	Inconsistency between available bridge condition data and bridge/culvert inspection form inputs. Bridge/culvert inspection report form provided in Appendix 3 Attachment 3.5 (a) of RMRSU Maintenance Guidelines 2010

4. Performance and Levels of Service

4.1 Performance Management

A performance management framework is a systematic process that evaluates LGED's ability to deliver and achieve a defined Level of Service (LoS). Monitoring and reporting performance provides a systematic approach to measure progress in the implementation of asset management. Performance management is an iterative and continuously evolving process that reflects the needs of the organisation as it matures and systems improve.

By introducing a performance management approach LGED will improve their ability to be held accountable for the work it undertakes on the structures on the rural road network. Performance management is important to demonstrate whether LGED is using available funding effectively to meet the Levels of Service (LoS) and performance targets as presented in this section.

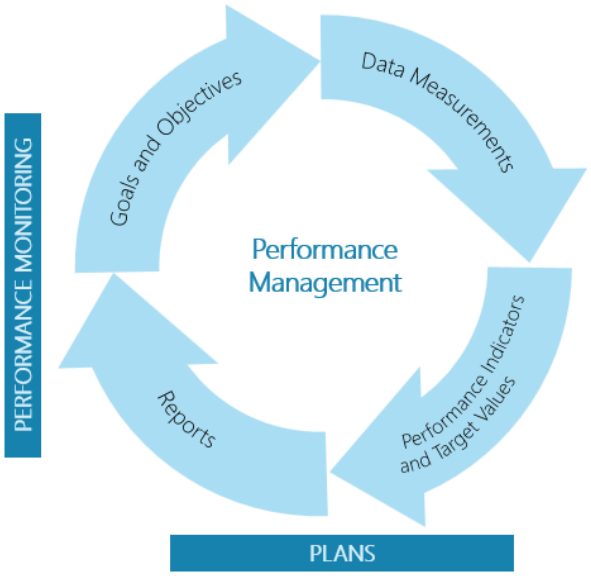


Figure 8: PIARC Performance Management Process, AM Guide Section

Current performance needs to be monitored, audited and communicated to decision-makers on a periodic basis. This will allow LGED to compare actual and expected performance by identifying any existing gaps or non-compliances. A performance gap in the monitoring process is the difference between the current performance of the asset and the expected performance reported in the AMP.

Leading international road asset management and performance management guides outline elements of a Performance Management Framework and their relationship between Levels of Service, performance measures and targets. The diagram below is sourced and referenced by both PIARC and HMEP UKRLG.

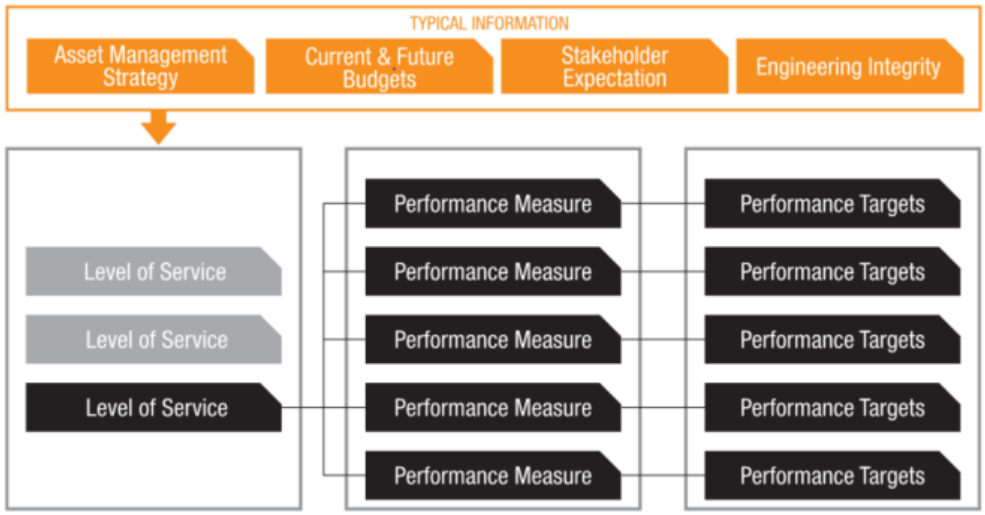


Figure 9: Elements of a performance management framework

Source: PIARC, UKRLG HMEP

Currently, in LGED, performance management framework to evaluate, through systematic monitoring and reporting, organisational ability to deliver a defined Level of Service for road assets is not in place. A Performance Management Framework is needed to achieve the following objectives:

- Express LGED's long-term goals and objectives in relation to the rural road asset portfolio through performance measures and targets that are trackable, comparable and informed by accurate data;
- Provide a line-of-sight from strategic objectives to Levels of Service, lifecycle and day to day activities;
- Improve and deliver effective communication between key stakeholders;
- Evaluate the performance of LGED's road network(s); and
- Outline improvements in strategic decision making.

The Performance Management Framework will outline how to adopt, implement and maintain performance management function(s) to facilitate the following:

- Strategic monitoring - Provide a systematic approach to measure progress in the implementation, development and improvement of asset management practices;
- Enable auditing and monitoring of the delivery of LGED's SAMP and AMP(s) to verify that outcomes are being met and assess the effectiveness and efficiency asset management;
- Identify any performance gaps and develop improvement actions for implementation; and
- Report on LGED's compliance with applicable legal and other regulatory or absolute requirements,

The performance management process also allows for the development and implementation of improvement plans. These plans can be used to measure the progress of improvement actions against the performance management framework.

Depending on the scope of the performance indicator and improvement actions being implemented, there may be a delay before any significant improvements are achieved. In these cases, the annual trends need to be documented throughout the review cycle.

4.2 Levels of Service

Levels of Service (LoS) describe the quality of services provided by the asset for the benefit of the users. They go beyond the performance of the physical assets to reflect the wider social, economic and environmental goals of the communities they serve. Asset management strategies and plans are developed with a focus on achieving (at a minimum) the required Levels of Service.

LGED is currently transitioning from a condition-driven management approach to a level-of-service approach, reflecting an emerging shift where user or customer-driven priorities such as safety, reliability of travel, and availability are emerging as key drivers. The figure below illustrates how customer values drive and inform Levels of Service statements.

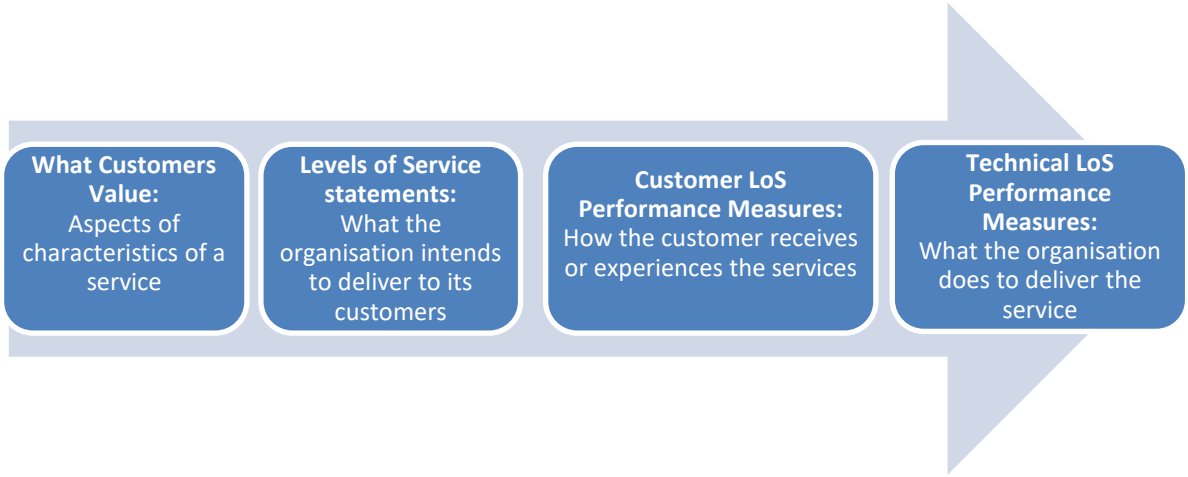


Figure 10: Aligning Levels of Service with customer values

Source: Austroads AGAM 04-18

LGED's initial version of LoS statements for the rural bridges are tabled below.

Table 13: Initial version of Level of Service (LoS) statements

Theme	LoS Statements
Preservation of rural bridges	Upazila or union road bridges that are in good and fair condition
Improved rural connectivity	Upazila or union road new bridges built or replaced with climate resilient features in 19 coastal districts
Improved rural connectivity	Length of severed or constrained Upazila or union road links made fully operational

LoS statements expanding on key themes for LGED's future consideration are tabled below:

Table 14: LoS statements expanding on key themes for LGED's future consideration

Future Theme	Future LoS Statements
Customer	LGED is focussed on providing a good service to bridge users.
Financial performance	LGED plans and manages the road network in an efficient and financially sustainable way.
Availability/Reliability	The structures on rural road network is free flowing and journeys are reliable.

4.3 Performance measures

Performance measures are used to monitor whether the LoS are being met and to report the actual performance. A combination of technical (i.e. based on engineering measurements) and non-technical measures has been selected using a SMART approach (Specific- the measure is specific, clear and unambiguous; Measurable - it can be measured using data that are available/can be collected; Attainable - the measure is realistic and there is a clear plan on how to achieve it; Relevant - it must be linked to an asset management objective/strategic goal; and Time-bound - it must be measured over a set period).

LGED's performance measures should be selected or developed by those responsible for asset management with the support of senior decision makers. LGED's performance measures should maintain the 'line-of-sight'.

Performance targets have been selected, where appropriate, to describe the performance that needs to be achieved over the next five years to align with LGED's budgetary and planning cycle. These also focus on the technical aspects of service provision such as cost effectiveness, condition and compliance with technical standards and specifications.

LGED's performance measures and the associated performance targets developed through collaborative workshops to be adopted and implemented are tabled below. In developing performance targets, consideration has been given to past and current performance and affordability, accounting for planned capital investments and operational budgets.

Table 15: LOS statements and performance targets

Theme	LoS Statements	Performance measures and targets (where applicable)
Preservation of rural bridges	Upazila or union road bridges that are in good and fair condition	85,000 meters of bridges to be maintained by 2023
Improved rural connectivity	Upazila or union road new bridges built or replaced with climate resilient features in 19 coastal districts	29,000 meters bridges to rehabilitated and widened by 2023
Improved rural connectivity	Length of severed or constrained Upazila or union road links made fully operational	20,000 meters bridges to be replaced or newly constructed by 2023

Source: Programme Appraisal Document of Supporting Rural Bridges (SuPRB), October 2018

5. Lifecycle Planning

The asset management lifecycle refers to the stages involved in managing an asset. This includes activities to plan, create, utilise (operate and maintain) and decommission (or dispose) of assets. The overarching process of managing these tasks is referred to as 'lifecycle planning'.

Lifecycle planning describes the approach to managing an asset over its life (from planning through to construction and to decommissioning (if required) to achieve a target level of service while minimising life cycle costs. It involves identifying future performance needs of an asset, or a group of assets, based on investment scenarios and maintenance strategies. The objectives of lifecycle planning are summarised below[5]:

- Predict future performance and needs of road infrastructure assets;
- Determine the maintenance strategy and investment required to achieve required performance and Levels of Service; and
- Minimise costs over the lifecycle while maintaining the required performance.

The lifecycle planning process overview is illustrated below[6]. The lifecycle plan is the documented output from this process.

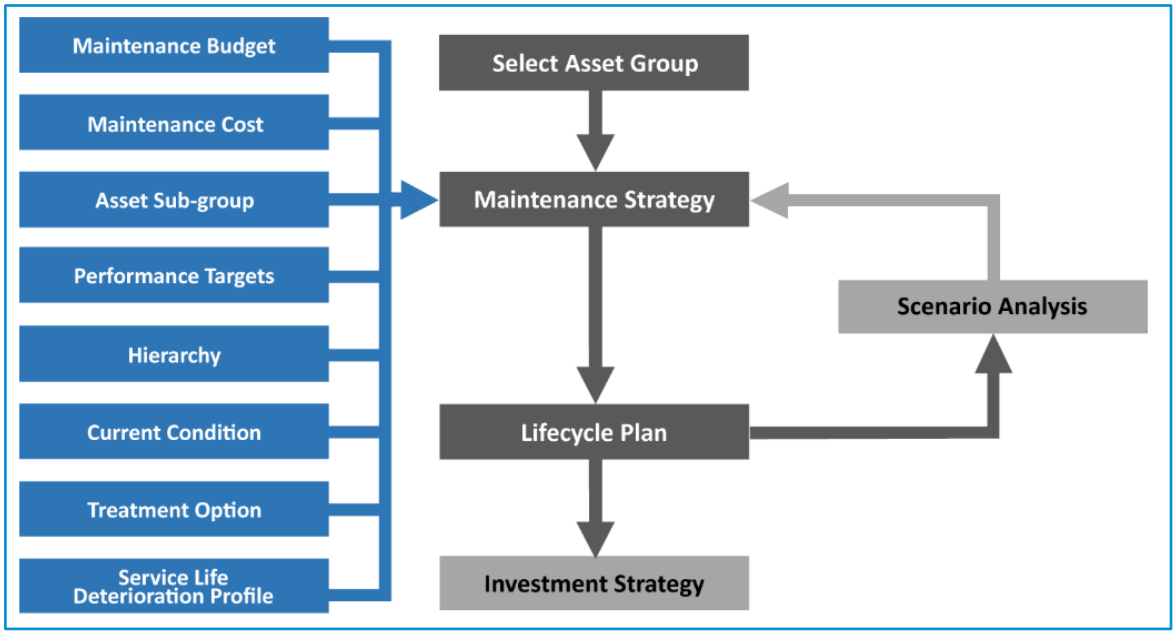


Figure 11: Lifecycle planning process

Source: Highway Infrastructure Asset Management, HMEP, UKRLG (2013)

LGED's current practices of lifecycle planning are in their "infancy" representing an awareness of the need and benefits and an internet to progress in line with LGED's improvement of asset management maturity. LGED is currently well positioned to develop, integrate and coordinate

[5] PIARC Lifecycle Planning Asset Management Manual Section 2.4.1;
[6] UKRLG and HMEP, 2013

lifecycle planning across the organisation and will be able to demonstrate systematic progression over time.

Lifecycle planning can be applied to all infrastructure assets and can adopt a range of basic approaches depending on the maturity of the organization and the skills and capabilities of its staff. Adopting a lifecycle planning approach will support LGED to apply the principles of asset management to set maintenance strategies and standards that are affordable and achievable.

When applying a lifecycle approach, the following questions may be considered for short, medium, and long-term period of planning for each asset class:

- What funding is needed to achieve the right maintenance standards (or performance targets)?
- If there is insufficient funding to meet the required maintenance standards, what is the resulting asset performance expected to be?
- What funding is required to maintain the asset in a steady state or in any other condition?
- What is the lifecycle plan that delivers the minimum whole-life cost?

Maintenance strategies may be developed that consider different treatment options and balance renewal with routine maintenance. These strategies should take into consideration the service life for each treatment option and balance the costs over a planned period of time. The objective of this process is to provide a lifecycle plan for an asset that will support the implementation of the asset management strategy and objectives. The interface of lifecycle planning and maintenance strategies and line-of-sight is illustrated in the diagram below:

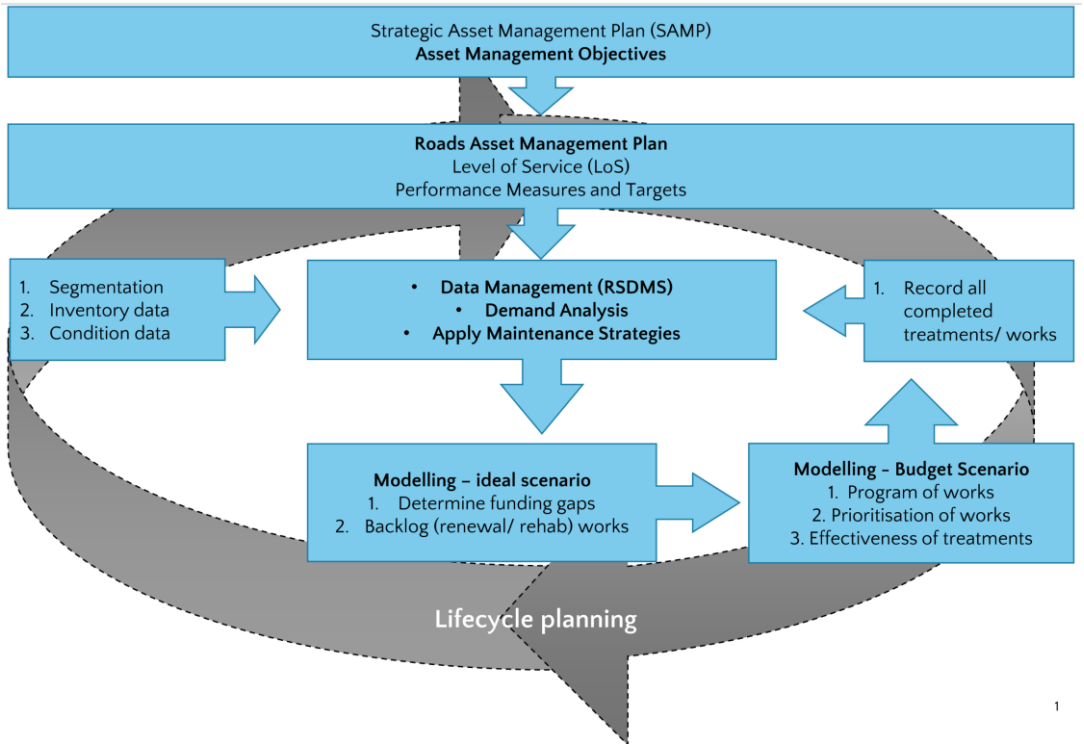


Figure 12: Line of sight and lifecycle plan interface with maintenance strategies

Consideration should be given to the selection of the planning time period for the lifecycle plan. Depending on the planning period, different maintenance strategies may provide the lowest lifecycle costs as shown in Figure 13 below.

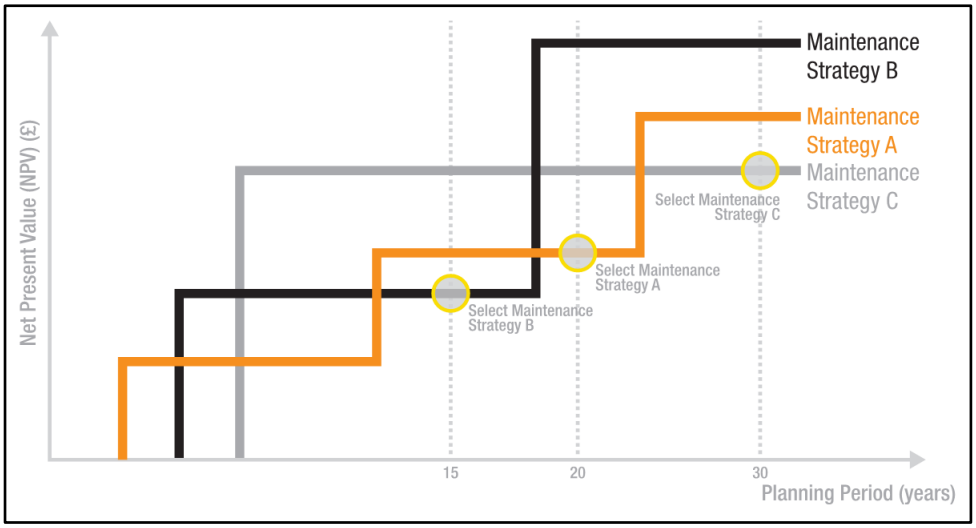


Figure 13: Comparison of maintenance strategies

Source: HMEP, UKRLG (2013)

Lifecycle Plans are beneficial to high value assets which may require considerable funding, and are high risk and/or seen as critical assets. In light of the current initial development phase of LGED's AM Framework practices and procedures, LGED needs to adopt a lifecycle plan approach being a collection of treatments over the entire life of asset class or subgroup, with refinement as systems, practices and AM capability improves.

5.1 Future demand

Future demand is identified as the "gaps" between a performance target and the current or future situation.[7] The ability to predict future demand for services enables asset managers to plan ahead and identify the best way of meeting that demand. This may be through a combination of demand management, operations and investment strategies.[8]

LGED recognises that demand analysis typically includes the analysis of future demand for the service(s) level requirements, reliability and criticality of local level infrastructure assets.

Traffic growth or decline is influenced by the changes in population growth, land use patterns, social/ political/ economic/ legislative framework, introduction of alternate modes of transportation (railway, inland water) and technological changes. Environmental factors such as climate change or demand for improved disaster resilient infrastructure could also drive a change in demand.

When evaluating future demand, several elements require consideration including:

- Historic demand;
- Drivers for demand (i.e. population increase or economic growth centres);

[7] Austroads AP-R447-13 Section 2.4.3, p 13.

[8] IAM The Anatomy

- Future demand and change in demand over time (particularly where the population is expected to grow and how this might skew the Rural Accessibility Index);
- Changes in required levels of service;
- Current and future utilisation and capability of assets; and
- Impact on the future performance, reliability, condition, and capability.

Other considerations may also be appropriate including the United Nations Sustainable Development Goals, targets and indicators and socio-economic benefits.

The diagram below outlines a high-level process for demand analysis which provides guidance in developing, establishing and implementing an appropriate demand analysis process.[9]. The work commences with preparing the demand analysis strategy. Analysis planning is then undertaken to identify assumptions, data requirements, scenarios to be tested. The Analysis is then undertaken. The process is repeated for different scenarios and to adjust inputs as required. Outputs are then published and action is made in follow up to the analysis.

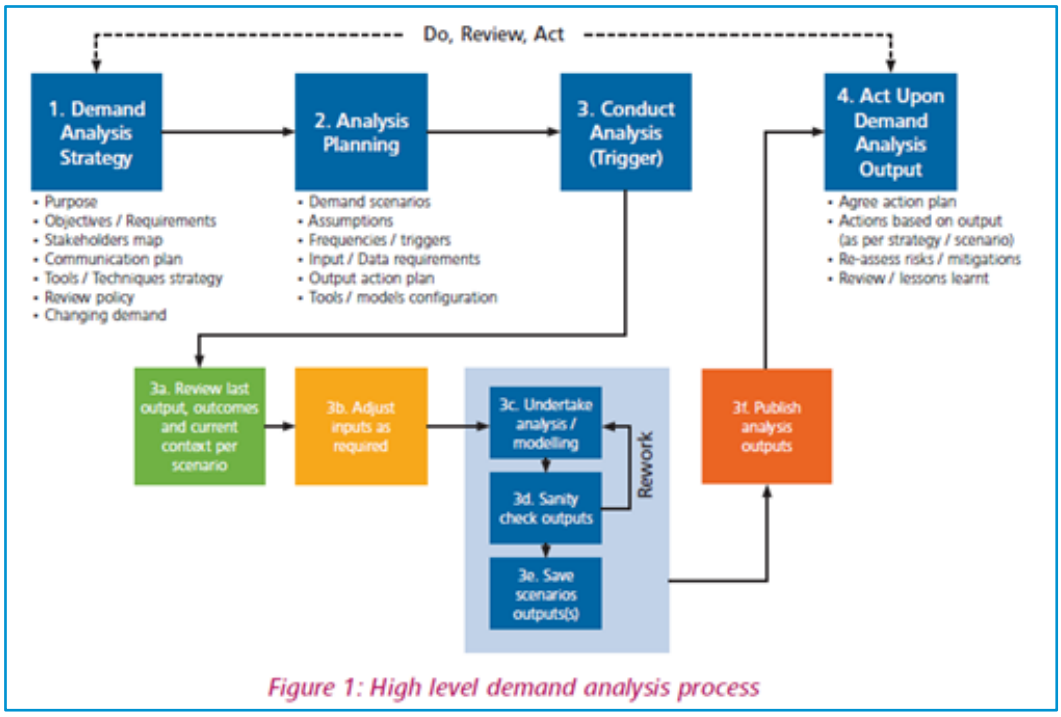


Figure 1: High level demand analysis process

Figure 14: Source: IAM SSG, Demand Analysis

5.2 Lifecycle Delivery

Lifecycle delivery includes activities to plan, create, utilise (operate and maintain) and decommission (or dispose) of assets. It is important to note that the lifecycle stages are interconnected and activities and decisions should be made in an integrated manner. LGED has adopted the following four life cycle stages terminology and definitions:

Plan This stage is the first stage of the asset lifecycle. This stage establishes and verifies asset needs, benefits to be realised, technical details, environmental/ sustainability/ stakeholder/ economic considerations, cost and risk. Activities include identifying, understanding and/or

[9] IAM Subject and Sector Guidance publication - Demand Analysis

addressing a new or changed need, establishing and understanding future demand, identifying risks and opportunities, and evidence-based decisions to proceed based on prioritisation, criticality assessments and/or cost benefit analysis.

Create This stage inherently follows the planning stage and covers activities such as designing and procuring an asset. Appropriate application of these activities aims to guarantee that an asset is fit for use. Typical activities may include all or some of the following: establish and document technical standards and legislation to be met, cost estimation, secured funding, agreed procurement method and supply/ delivery processes. In the context of road assets, 'create' predominantly infers construction and commission, manufacture, installation and configuration.

Utilise This stage commences following the creation and commissioning of an asset and covers concurrent activities including operation and maintenance. The utilise phase for infrastructure assets generally relates to activities during the functional period for which the asset was designed. This stage comprises asset inspection, testing, monitoring and reporting, maintenance and repairs, rehabilitation to prevent or mitigate the deterioration of performance of assets in service and manage the risk of failure. These activities ensure the asset continues to meet the service and performance requirements.

Decommission When an asset reaches its end of a useful life, it can be treated as a surplus, or otherwise is considered as an underperforming asset. Decommissioning or disposal should be treated in the perspective of the effects of the decision on service delivery and ongoing responsibilities. liabilities and obligations. Decommissioning activities and options will vary depending on the asset, organisation and local requirements. Decommissioning activities and options may include: withdrawal of the asset from use, disposal, selling on, recycling or reuse, preservation (heritage) or replacement.

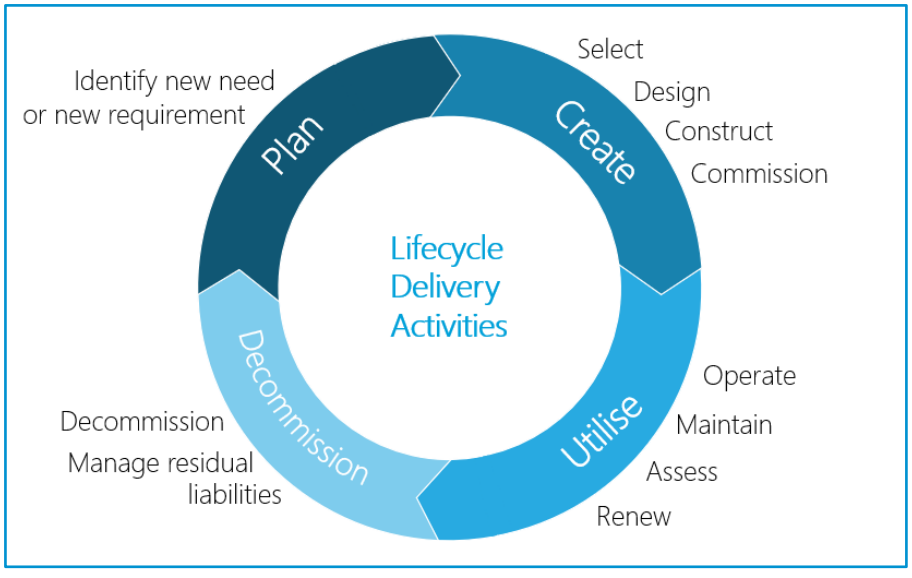


Figure 15: Lifecycle Delivery Activities

5.2.1 Plan

Currently, LGED does not have a formal documented Standard Operating Procedure (SOP) with regards to planning for road infrastructure. Historic planning practices of LGED are

largely based on evaluation, analysis and synthesis of data captured in the Road Database (RSDMS). In general, planned investment projects are identified as specific projects. New investment interventions (and projects) are planned and prioritized by applying various criteria. Refer Section 8 for more detail on investment prioritisation.

Planned roads are usually packaged by districts/divisions/regions and included in Development Project Proposals (DPPs) and submitted to higher level (Planning Commission) for consideration and approval. In the process (both at the preparation stage and approval stage) the following factors, among others, are taken into account:

- Contribution of the project in achieving national development goals;
- Alignment with government policies and strategies;
- Linkage with economic growth, productivity, poverty reduction, and social development;
- Balanced development.

Rural Infrastructure improvement planning covers the following:

- Improvement from earth to paved roads from among the important Upazila Roads, Union Roads;
- Improvement of culverts/bridges to bridge the existing gaps to ensure all-weather accessibility to all other rural roads (Union Road and Village Road-A) with some ancillary earth works for spot improvement;
- Improvement of Growth Centres and ghat facilities at Growth Centres located on the bank of inland waterways to facilitate better integration of the rural transport and trading system;
- Connecting Union Parishad Complexes and other socio-economic institutions.

5.2.2 Create

New rural infrastructure assets are identified throughout the lifecycle process and/or in alignment with target sets out in sectoral plans/five-year plans/perspective plans of the government. Infrastructure assets are created through implementation of investment projects. Once an investment project is approved by the Government, the project team which comprises LGED officials/engineers led by a Project Director is mobilised to execute the road infrastructure schemes included in the project document (DPP). The approval process of investment projects is simply illustrated as below.

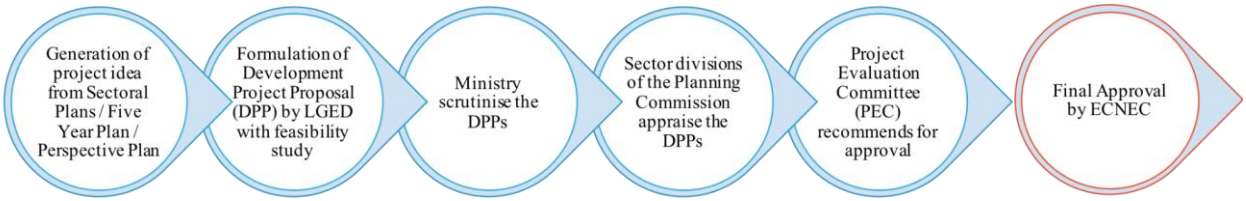


Figure 16: LGED Development Project Proposal process

5.2.3 Utilise

Utilisation of the structural assets are monitored primarily through inspections, in order to ensure the longer-term reliability and utilisation of the road asset. LGED currently undertakes inspections and collects road inventory and condition data which informs maintenance needs. This aggregated information is essential to inform development of an appropriate maintenance program.

The information collected by LGED through inspections and surveys are critical to understanding the utilisation of the structural road asset. By employing the Multi-Criteria Bridge Rehab Algorithm, a standardised process can be followed to determine the overall structure's condition score by considering various factors such as structural significance, material vulnerability, age, environment, road type and inspection uncertainty. Maintaining clear records of these surveys will provide meaningful insight into the asset's condition history and present utilisation.

The Multi-Criteria Bridge Rehab Algorithm is a useful tool for high-level decision making, determining the maintenance priorities and determining forward works programs for asset repair or rehabilitation. This system is central to ensuring that an asset's operation, maintenance and decommissioning are undertaken to maximise the utilisation of the asset.

Operation

To maximise the time that rural road structural assets remain operable and reliable, LGED performs multi levels of inspections on the structures along the rural road network, as detailed in Section 3.5 above.

Although bridges and culverts have generally been second to pavements in terms of expenditure, bridge condition inadequacies significantly impact the safety and performance of roadway networks. For structural assets to remain operational, maintenance or rehabilitation activities must be planned and coordinated to minimise disruption to road-users and administrative burdens to LGED. This is especially relevant in the case of flooding events or other natural disasters, where alternative routes for road-user safety or safe passing of over-sized vehicles must be prioritised.

Regular inspections and surveys will be integral to identifying priority structural assets in the road network, allocating appropriate maintenance or rehabilitation measures and generating future works programs, to ensure disruptions to road-users are minimised and the operational life of assets is maximised.

The Multi-Criteria Bridge Rehab Algorithm will be particularly useful at this stage to capture condition data collected from inspections and surveys to inform maintenance need and programs. Typical issues that impact the condition of bridges and culverts include (but are not limited to):

Table 16: Common bridge / structures condition defects

Structural Asset	Common Condition Defects
Culverts	Obstructions to inlets, outlets and channels due to floating debris
	Erosion at wing-walls
Bridges	Obstructions, erosion or scour caused by floating debris
	Cracking, spalling and disintegration due to: Shrinkage · Temperature stresses · Moisture absorption · Corrosion · Chemical reactions · Weathering · Poor design · Poor quality-control during construction

The Multi-Criteria Bridge Rehab Algorithm will combine condition data with other important factors to identify the priority of the structural asset and enable informed decision-making regarding the maintenance or repair requirements. In bespoke or extreme cases, the direction of the Upazila Engineer or Executive Engineer may be required to uphold safety of the road network.

Maintenance[10]

The data gathered from the inspections and surveys of the rural structural assets inform the maintenance need and measures required for the asset. Maintenance records are important inputs for the Multi-Criteria Bridge Rehab Algorithm, to understand the structure's history in order to justify forward works programs, funding priorities and rehabilitation works.

Maintenance work is classified according to the timing or frequency as well as the scale or complexity of activities, as follows:

[10] Source: Rural Road Maintenance Technical Implementation Guidelines, May 2018 developed under Technical Assistance for Operationalization of the Rural Road Maintenance Policy

Table 17: LGED Maintenance activities overview for bridges/structures

	Routine Maintenance	Periodic Maintenance	Emergency (Reactive) Maintenance
Frequency	Day-by-day, carried out on a regular, repetitive basis	Carried out at intervals depending on traffic levels, structure type, geographical and weathering conditions.	After flooding or other adverse weather events
Typical Activities	Road safety maintenance e.g. • Sealing cracks • Repairing small defects • Cleaning weep-holes • Clearing culverts	• Small repairs to abutment walls, brick-arch bridges or culvert headwalls • Replacing damaged sections of concrete pipe culverts • Repairing concrete beams exposing steel reinforcement	• Temporary restoration works – reopening safe passage • Permanent restoration works – reinstating undermined components • Emergency off and on structure works
Relative Cost	Generally lowest cost	Higher cost that routine maintenance works – require more technical knowledge, mechanical equipment and materials	Depends on extent of damage and impacts to public safety
Labour	Labour-intensive	Carried out by employing local contractors through open tendering method	Depends on extent of damage and impacts to public safety

Renewal/Rehabilitation

Renewal or rehabilitation is the process required to bring the asset back to the required performance after it has deteriorated. Through consistent record-keeping of maintenance activities and condition information of structures, appropriate capital expenditure can be justified. The Multi-Criteria Bridge Rehab Algorithm provides a platform to enable decision-making that considers these factors, along with other important factors regarding the structure. It can also provide insight into the risk to the structure from climate change or extreme natural disasters, and allow for streamlined processes to be established regarding rehabilitation post-disaster.

5.2.4 Decommissioning

Most road infrastructure assets are rarely decommissioned. However, there are instances when some assets are removed from service. Such instances are likely to include closing bridges or removing street lighting, signs, and barriers.

5.3 Lifecycle Management Plan

Lifecycle Management Plans are beneficial to high value road assets which may require considerable funding, and are high risk and/or seen as critical assets. In some cases, LGED may need to apply complex approaches and, in these circumstances, higher quality data and predictive modelling techniques will often be needed. Where minimal data is available, a more basic or a risk-based approach may be adopted. In light of the current initial development phase of LGED's AMS, LGED may adopt a lifecycle plan approach being a collection of treatments over the entire life of bridge asset class or subgroup, with refinement as systems, practices and AM capability improves.

6. Risk Management

What is risk? Risk is defined as "the effect of uncertainty on objectives".[11]

Why is it important? The notion that the outcome of good management of assets is a balance between the cost of providing the asset performance to an agreed level of risk is a key concept in asset management and contained in ISO55000.

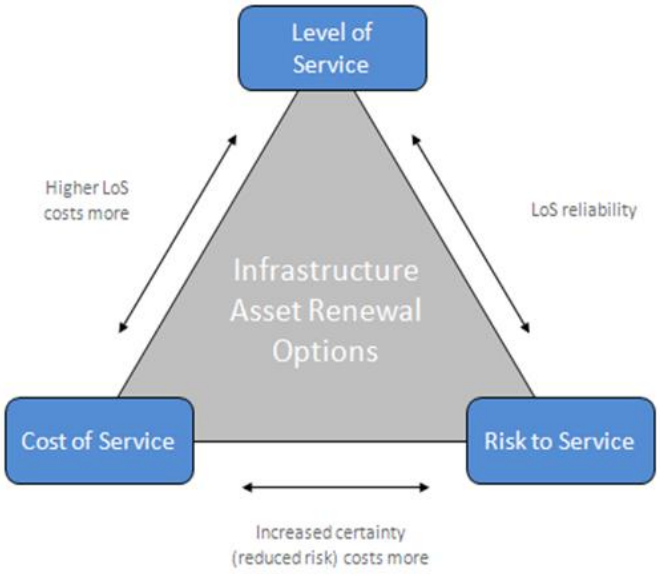


Figure 17: Risk management - ISO 55000 concept

Risk management in an AM context - Risk management is an important enabler for asset management decision making and a key consideration in lifecycle planning and investment planning. Risk management comprises a coordinated set of activities and methods used to monitor and manage potential hazards or events that can affect an organisation's ability to achieve its objectives.

Risk-based approaches enable effective decision making regarding the performance of, investment in, and implementation of capital and maintenance works programs. Risk can be managed at several levels using a consistent risk framework that enables the comparison of risks across all services.

6.1 Risk Management

Risk management is defined as the coordinated activities to direct and control an organisation with regard to risk (ISO31000). Its purpose is to create and protect value.[12] Managing risk is iterative and assists organisations in setting strategy, achieving objectives and making informed decisions.

[11] ISO55001 and ISO 31000: 2009
[12] ISO 31000:2018

Risk management supports the AM approach adopted for making decisions through the asset management planning and lifecycle processes. Fundamentally, applying and incorporating risk management will assist asset managers to make better decisions.

Risk management is an integral part of the overall activities and processes of managing assets throughout their lifecycle. LGED is committed to the management of risk as an integral part of its asset management activities, focussing on understanding and managing risks to ensure LGED meets its Asset Management Objectives.

Risk Management Framework

The purpose of a risk management framework is to assist LGED in integrating risk management into significant activities and functions[13], which in the context of this AMP is the management of bridge assets throughout their lifecycle. Risk framework development encompasses integrating, designing, implementing, evaluating and improving risk management across LGED.

Figure 18: ISO 31000: 2018 Risk Framework components

Incorporating a risk management framework

A risk management framework can be used in several applications, with the framework tailored to suit that context. For example:

- At organisational-level, to inform organisational strategy and investment;

[13] ISO 31000:2018

- At project-level, to manage time, cost, quality of a project being delivered;
- At an operational level, for ongoing management of assets (e.g., asset inspections, defect notifications and how works are prioritised).

The IAM (UK) suggests that the "criticality" of different types of assets can be utilised to assist in determining the asset types for which a risk -based management approach would offer significant value. This is illustrated here:

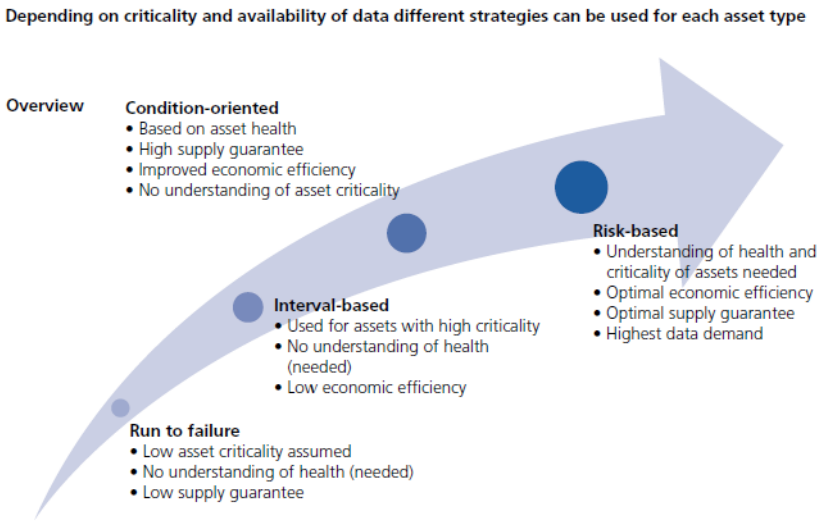


Figure 19: IAM SSG Risk Assessment and Management, Page 19

Incorporating a risk-based management approach to the lifecycle planning and decision making, where deemed to offer significant value, will help LGED to:

- Increase the likelihood of achieving objectives;
- Improve identification of opportunities and threats;
- Effectively allocate and use resources for risk treatment;
- Improve decision making regarding the performance of, investment in, and implementation of capital and maintenance works programs. Risk Management process

The risk management process, as shown in the figure below, involves the systematic application of policies, procedures and practices to the activities of:

- Communicating and consulting,
- Establishing the context
- Assessing,
- Treating
- Monitoring and reviewing,
- Recording and reporting risk.

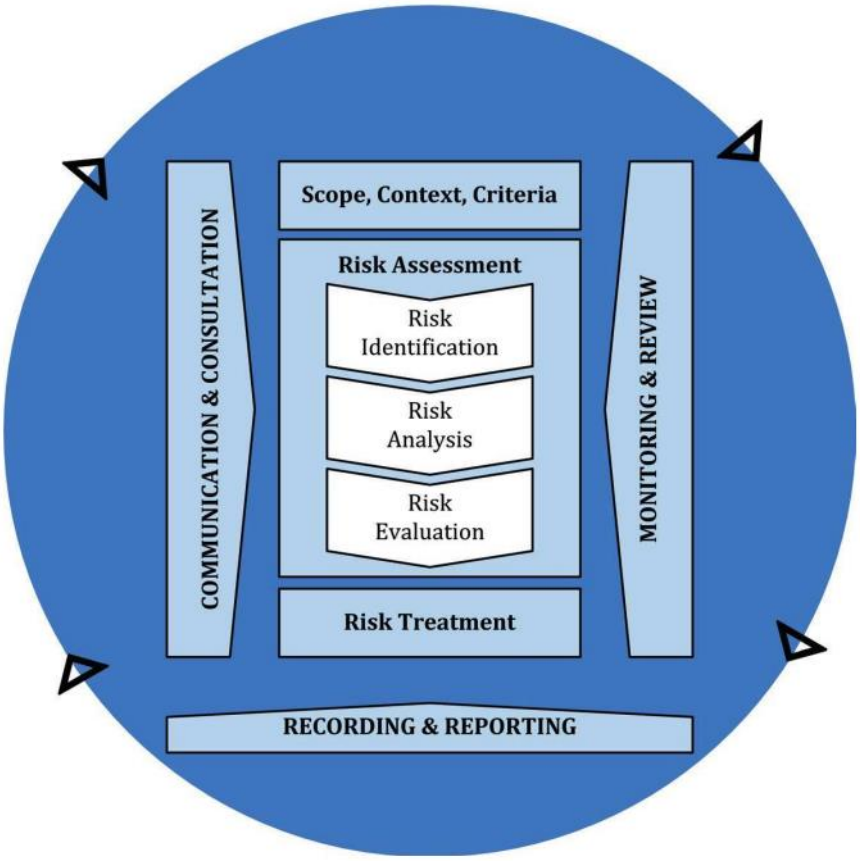


Figure 20: Figure 20: ISO 31000: 2018 The risk management process.

Appendix A provides a detailed outline of each of the components of LGED's risk management process.

The next sections in this AMP describe at a high-level LGED's progress in developing a Risk Assessment Process, which, when applied, will support and enable LGED to achieve their Asset Management Objectives and ensure the required levels of service for Roads. It is aligned with ISO 31000:20018 and ISO 55001.

6.2 Risk Assessment Process

The risk assessment comprises three steps:

1. **Risk Identification:** the process to identify and describe risks that might help or prevent and organization achieving its objectives.
2. **Risk Analysis:** the qualification and quantification of the risk.
3. **Risk Evaluation**: comparing the results of the risk analysis with the risk criteria to determine where additional action is required.

Risk Identification

Risk identification ensures that a comprehensive list of risks (threats and opportunities) has been prepared and this list forms a basis for the further steps risk assessment. Key risks to LGED's delivery to meet the required LoS and performance of the rural road network have been identified and assessed through consultation. For the purposes of this AMP, LGED has identified eight key risk categories that may affect the condition and performance of road assets and impact the ability to achieve the Levels of Service, and are as following:

Technical	Environmental	Legal	Social
Operational	Financial	Organisational	External

These categories have been further expanded with associated key elements of risk identified and tabled below.

Table 18: Risk categories with associated key elements

Risk Category	Key Risk element description
Technical	• Loss of asset performance or loss of service • Asset or system failure • Inadequate design • Inadequate planning • Inadequate systems capability • Inadequate data and information • Fitness for purpose • Ageing infrastructure • Inadequate maintenance
Operational	• Under or over utilisation • Misuse of infrastructure • Overloading • Inadequate safety measures • Insufficient skills and capacity in workforce • Delays in contracts completion • Poor work / delivery planning and quality management • Operator error
Environmental	• Climate change • Flooding • Salinity increase • Drought
Legal	• Loss of rights/license • Change in legislation

Risk Category	Key Risk element description
Financial	• Inadequate funding • Prohibitive O&M costs • Procurement • Unforeseen budget cuts • Contract management • Inadequate investment scheme identification • Corruption
Organisational	• Inadequate resources, skills and knowledge • Loss of reputation • Poor stakeholder management
External	• Political unrest • Availability and quality of construction materials • Availability of consumables • Vandalism • Theft • Terrorism
Social	• Gender exclusive • Change in demand • Change in expectation

The outputs from the risk identification step - the risk description, categories and types - are captured in LGED's Risk Register. (Refer also to Section 6.4 and Appendix A.)

Risk Analysis

The purpose of risk analysis is to comprehend the nature of risk and its characteristics. Risk Analysis involves the qualification and quantification of the risk. It analyses uncertainties, risk sources, consequences, likelihood, events, scenarios, controls and their effectiveness.

Once a risk has been identified, the risk analysis considers the **likelihood** of the event and the nature and magnitude of the **consequence** (e.g., on cost, program, safety etc.). Risk analysis provides an input into the risk evaluation and decision making on which risks need to be treated, and how they will be treated- striving for the most appropriate and cost-effective risk treatment strategies.

Other factors to consider when analysing the risk are:

- Complexity and connectivity
- Time related factors and volatility
- The effectiveness of existing controls
- Sensitivity and confidence levels.

Determining the level of risk is the final step that based on the likelihood rating and consequence rating, and using LGED's Risk Matrix, the level of risk is established. (Refer to Appendix A).

Risk Evaluation

Risk evaluation involves comparing the results of the risk analysis with the risk criteria to determine where additional action is required. The purpose of risk evaluation is to support decisions.[14] Once the consequence and likelihood of each risk item has been determined, a risk rating score can be determined by using a risk matrix.

Potential outcomes of risk evaluation include:

- Do nothing further
- Consider risk treatment options
- Undertake further analysis to better understand the risk
- Maintain existing controls, and
- Reconsider objectives.

6.3 Risk Treatment

Risk treatment involves determining the risk treatment options to be enacted to reduce threats and maximize opportunities. The type and level of response will be determined by risk exposure, considering:

- What needs to be done?
- What can be done?

Each proposed risk treatment or control measure should be evaluated in terms of whole life cost, risk reduction potential and tolerability level. This iterative process involves the following activities:

1. Formulate and select risk treatment options
2. Plan and implement risk treatment
3. Assess effectiveness of risk treatment
4. Decide if remaining risk is acceptable, and
5. If not acceptable, take further action.

The key output from this activity is to develop a Risk Treatment Plan (RTP). The RTP is a detailed plan which includes strategies and actions plans, the cost and benefits of implementing the RTP.

The final step in this activity is to assess the likelihood and consequence of the risk after treatment to determine the residual risk level and to assess if this level is acceptable.

6.4 Risk recording - the Risk Register

The risk management process and its outcomes should be documented and reported through appropriate mechanisms.[15] The purpose of recording and reporting is:

- To communicate risk management activities and outcomes across the organisation,
- Provide information for decision making,

[14] ISO 31000:2018
[15] ISO 31000: 2018

- Improve risk management activities, and
- Assist stakeholder interactions.

The key tool for recording risks is via a Risk Register. The risk register includes the following fields which correlate to specific activities outlined in the documented risk management process. (Refer also to Appendix A)

Table 19: Fields of risk register

Fields of risk register	
Risk reference Number	
Risk Description (Event & Consequence or Cause)	
Risk Category	
Risk Type	
Existing Controls (Directive, Standards, Procedures Processes)	
Effectiveness of Controls	
Initial Likelihood Rating	Risk before treatment
Initial Consequence Rating	
Risk Level	
Risk Treatment Options	
Risk Treatment / Action Plan	
Residual Likelihood Rating	After treatment
Residual Consequence Rating	
Residual Risk Level	
Is Risk Acceptable?	
Risk Owner	
Risk Status	

LGED has undertaken a preliminary risk assessment process where risks have been identified and partially analysed and evaluated in a collaborative workshop environment as part of this inaugural AMP version.

6.5 Risk monitoring and review

The purpose of monitoring and review of risks is to assure and improve the quality and effectiveness of the risk management process, its implementation and outcomes. Monitoring and review should occur across all stages of the risk management process.

Risks can change over time, so it is essential that they are reviewed and monitored. Risk management is an iterative process.

6.6 Critical Assets

Critical assets are those that are essential for supporting the social and business needs of both the local and national economy. The notion of criticality allows LGED to recognise that assets and asset systems have differing importance (value) for operating road network to deliver the required LoS.

Critical assets have a high consequence of failure, but not necessarily a high likelihood of failure. Therefore, these assets are identified separately and assessed in greater detail as part of the asset management planning process. Criticality assessments can be used to prioritise investment in resilience enhancements of existing infrastructure.

Criticality can be assessed by applying broad assumptions about the implications of failure. For example, whether the loss of service of a road would have a significant impact on the local or wider economy or disconnect specific parts of a community. Using this approach initially, simple criteria can be defined to assess the loss of service.

LGED does not currently have an official Critical Assets listing.

7. Approach to Resilience

Focusing only on one part of the asset's lifecycle can lead to silos and ultimately result in reduced resilience of the road network. It is vital that future planning and asset management processes include consideration of resilience in the whole life management of road infrastructure.

LGED's approach to resilience in the context of asset management considers resilience actions that can be taken throughout the entire lifecycle from initial conception and design, through to delivery, operation and maintenance and until eventual decommission or renewal. This approach is aligned with LGED's AM policy that calls for contributing '*to improved resilience and delivering services to current and future generations by managing risk, optimizing performance and managing expenditure on infrastructure assets throughout the whole of asset lifecycle.' (From AM Policy Statement. LGED).*

It should be acknowledged that enhancing resilience doesn't always mean hardening the infrastructure, but rather developing and implementing a range of strategies and measures, from fail-safe to adaptive management through to organisational and social resilience, communication and capacity building.

Within the road industry improving resilience constitutes both (i) increasing the ability of infrastructure to withstand potential threats, and (ii) the capability of the system to rapidly recover from disruptive events. Main components of resilience are 4Rs.

- Resistance : Physical robustness
- Reliability : Ability to operate under a variety of conditions
- Recovery : Respond and recover from disruption
- Redundancy : Spare capacity or diversion routes

Improving resilience to the variety of hazards facing road networks (including structures) requires integration into decision-making at all points of the infrastructure lifecycle. The TRL publication has divided opportunities for increasing consideration of resilience into six areas for action (Figure 21).

The resilience concept goes well beyond the technical aspects. The reasons for this are:

1. Resilience is an outcome - it is the consequence of a series of actions and not an end in itself.
2. Resilience is a 'state of being' - it is inherent in a system, it is the characteristics of a system that result from how the system is planned, designed, constructed, operated and maintained.
3. Resilience is not static - Resilience is the ability to withstand shocks and stresses (Hazards), which are continually changing, so this ability will change depending on how the shocks and stresses change. Similarly, resilience is a characteristic of the system so as the system changes its resilience will also change e.g. the resilience of a road will change if the road is damaged or deteriorates through lack of maintenance.

The resilience approach encompasses a wide range of activities that cannot be 'done once and forgotten', it requires on-going management of the system to ensure it remains resilient.

Resilience is not simply building 'bigger or stronger road assets' - it is about a new approach to preparation and appraisal of infrastructure projects.

Figure 21: Six areas of action for increasing consideration of resilience

(Source: Resilience Primer: Roads – An Industry Guide to Enhancing Resilience: TRL Publication)

8. Work(s) program(s)

The development of work program(s) is key to implementing the life cycle management plan and required processes and activities. The delivery of work programs is the tangible outcome of LGED's asset management approach and planning processes.

The objectives of work programs include:

- Develop effective and efficient work programs for capital investment through Development Project Proposals (DPPs) to meet LGED's approach to asset management and deliver the level of service (Los);
- Identify potential maintenance works as candidate schemes;
- Develop works program of candidate schemes;
- Prioritise and optimise schemes in the work programs to meet funding and budgetary constraints;
- Monitoring of works to ensure it aligns with LGED's approach to asset management.

8.1 Program development process

There are two main work programs which LGED manage and execute within approved budgetary and funding constraints:

1. Investment and Development for new/ capital investments, and
2. Maintenance programs.

For investment and development for new/capital investment the standard procedures is illustrated in Figure 22 below.

Figure 22: Standard approval process of new/capital investment projects

For maintenance program development at a network level Austroads[16] illustrates a process diagram that can be followed by any road agency like LGED: The process shows links between program development, audit and review, program delivery and reporting and communication.

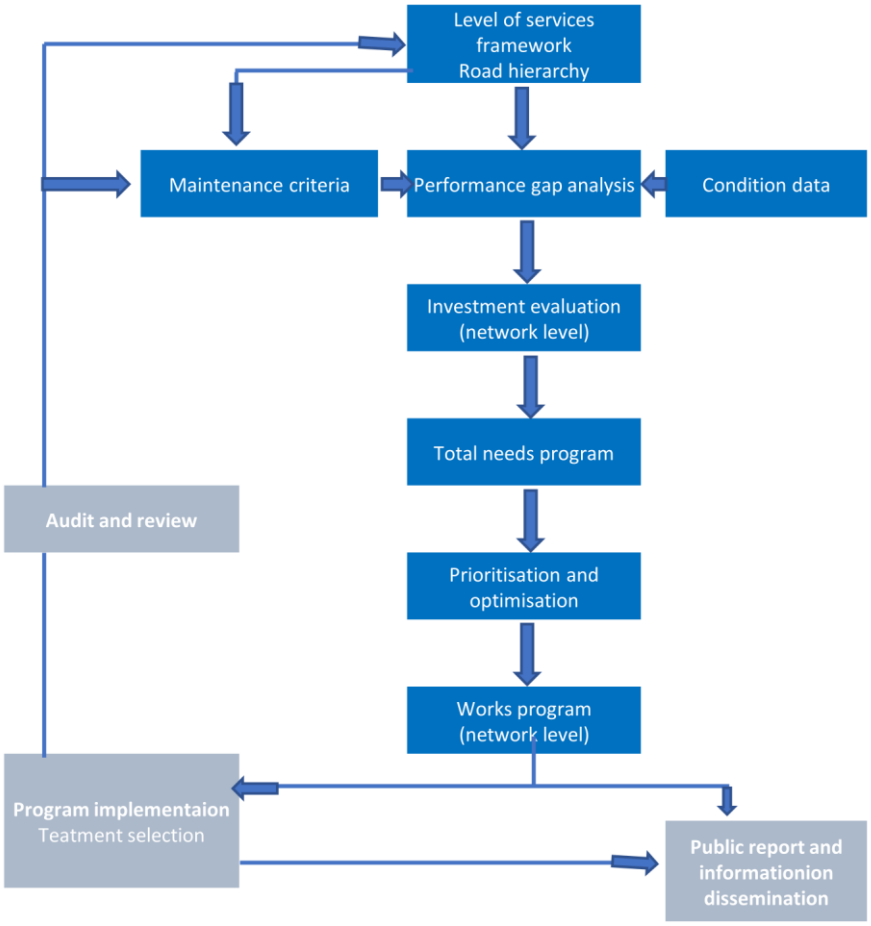


Figure 23: Maintenance Program Development Process and implementation overview

Constructed from: Austroads GAM Part 7, Figure 2.3

8.2 Program evaluation criteria and prioritisation

It is important to have adequate maintenance systems and a viable funding mechanism based on local resources, emphasising local participation and ownership. LGED is making major efforts to improve maintenance efficiency and local participation. The use of labour-based methods in road maintenance further enhances sustainability and affordability. Calculation of economic return should guide the major investment decisions.

In general, planned investment projects are identified as specific projects. New investment interventions (and projects) are planned and prioritized by applying the following criteria:

- Overarching priorities:
    - Improvement should always be on the basis of equity across the country;

[16] Austroads GAM Part 7 Section 2.7 Program Structure

- Route selection will be based on network approach and no scattered road-link should be selected;
- Calculation of economic return always guides the major investment decisions. Sometimes, the decision is made based on qualitative judgement.

In addition, the following general criteria / guidelines also apply:

- The first priority should be to maintain those roads which are functionally important and currently in reasonable condition;
- Routine Maintenance will get more priority over Periodic Maintenance;
- Maintenance of bridges and culverts on Upazila roads and union roads will be considered as critical;
- Upazila roads will get priority over Union roads and Union roads over Village roads;
- Roads developed under Development Partners' financial assistance will get priority;
- Roads having higher traffic volume will receive highest priority;
- Approved bus routes will get special importance;
- Fully developed, end to end passable roads will get more priority;
- Roads connecting the maximum number of ghats and markets, villages and service centres and institutions will be considered as important.

Infrastructure improvements projects which address the following importance aspects require investment plans and include:

- Improvement from earth to paved roads from among the important Upazila Roads, Union Roads;
- Improvement of culverts/bridges to connect the existing gaps to ensure all-weather accessibility to all other rural roads (Union Road and Village Road-A) with some ancillary earth works for spot improvement;
- Improvement of Growth Centres and ghat facilities at Growth Centres located on the bank of inland waterways to facilitate better integration of the rural transport and trading system;
- Construction of Union Parishad Complexes for local socio-economic and governance development will be included under this category of priority.
- Any roads that have past their (10 year) design life.

In the cases where economic return does not govern the selection process, prioritisation of road projects is done through feasibility studies (technical, financial, social, environmental, etc.) and community roads are selected through community consultations. Qualitative judgment may also be used to provide input to the decision-making process.

Planned roads are usually packaged by districts/divisions/regions and included in Development Project Proposals (DPPs) and submitted to higher level (Planning Commission) for consideration and approval. In the process (both at the preparation stage and approval stage) the following factors, among others, are taken into account:

- Contribution of the project in achieving national development goals;
- Alignment with government policies and strategies;

- Linkage with economic growth, productivity, poverty reduction, and social development;
- Balanced development.

8.3 Past Program Achievements

Since this is the inaugural version of the Asset Management Plan, there is no timeframe and physical reference to compare the achievement of the construction, improvement, and maintenance of bridges/culverts on rural road network. In such a case, the timeframe of the 7th five-year plan is taken into account, i.e., 2015-16- to 2019-20.

Table 20: Bridge/culvert Construction - Past programme achievements 2015-16 to 2019-20

	Lengths in Metres						
	FY	2015-16	2016-17	2017-18	2018-19	2019-20	Total
On UZR	Planned	13000	15000	16000	18000	18000	80,000
	Achieved	10479	13080	11551	8421	8739	52,270
	% achieved	81	87	72	47	49	65
On UNR, and VR	Planned	16000	18000	22000	25000	28000	109,000
	Achieved	10691	18920	18500	14616	21791	84,518
	% achieved	67	105	84	58	78	78
Total	**Planned**	**29000**	**33000**	**38000**	**43000**	**46000**	**189000**
	Achieved	**21170**	**32000**	**30051**	**23037**	**30530**	**136788**
	% achieved	**73**	**97**	**79**	**54**	**66**	**72**

UZR: Upazila Road; UNR: Union Road; VR: Village Road

Source: 7th Five Year Plan, and LGED Planning Unit

Table 21: Bridge/culvert Maintenance - Past programme achievements 2015-16 to 2019-20

	Lengths in Metres						
	FY	2015-16	2016-17	2017-18	2018-19	2019-20	Total
On UZR	Planned	4000	4200	4300	1300	600	14,400
	Achieved	3882	4221	4084	1169	487	13,843
	% achieved	97	101	95	90	81	96
On UNR	Planned	1350	720	1400	200	400	4,070
	Achieved	1281	681	1359	151	362	3,834
	% achieved	95	95	97	75	90	94
On VR	Planned	1300	1000	1050	500	400	4,250
	Achieved	1205	927	1000	456	358	3,946
	% achieved	93	93	95	91	89	93
Total	**Planned**	**6650**	**5920**	**6750**	**2000**	**1400**	**22720**
	Achieved	**6367**	**5830**	**6443**	**1776**	**1206**	**21623**
	% achieved	**96**	**98**	**95**	**89**	**86**	**95**

UZR: Upazila Road; UNR: Union Road; VR: Village Road

Source: 7th Five Year Plan, and LGED Planning Unit

8.4 Forward Program Targets

This section outlines forward planned activities to be carried out within the next five Financial Years (2020-21 to 2024-25) relating to road infrastructure assets. During the 8th Five-Year Plan, LGED plans to construct/replace/renew (investment programme) bridge/culvert on various categories of roads spanning a total of 1,65000 metres throughout the country.

Table 22: Bridge/culvert Construction - Forward programme - FY 2020-21 to 2024-25

Lengths in Metres						
FY	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Total**
On UZR, UNR, and VR	28000	31000	33000	35000	38000	165000
Total	**188000**	**31000**	**33000**	**35000**	**38000**	**165000**

UZR: Upazila Road; UNR: Union Road; VR: Village Road

Source: 8th Five Year Plan, and LGED Planning Unit

LGED's plan for the 8th Five-Year Plan period is to keep year-round fit bridge/culverts totalling 1,04,000 metres across the country under maintenance programme (revenue budget).

Table 23: Bridge/culvert Maintenance - Forward programme - FY 2020-21 to 2024-25

Lengths in Metres						
FY	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Total**
On UZR	8000	9000	10000	12000	14000	53000
On UNR	4000	6000	7000	8000	10000	35000
On VR	2000	2500	3000	4000	45000	16000
Total	**14000**	**17500**	**20000**	**24000**	**28500**	**104000**

UZR: Upazila Road; UNR: Union Road; VR: Village Road

Source: 8th Five Year Plan, and LGED Maintenance Unit

9. Financial management and valuation

9.1 Financial planning and management

All infrastructure assets have an initial cost to create them, but that is not the end of it. Ongoing lifecycle costs for utilisation (operation, maintenance and component renewal) are necessary to make sure the assets continue to provide services at the appropriate agreed service levels. Financial planning and management must include not only the initial cost to create the assets but sufficient funding to ensure continued operation and maintenance to affordable service levels.

This section aims to outline the revenues and financial projections for the whole-of-lifecycle management of LGED's road assets portfolio.

The following financial information will be outlined in this section:

- Investment (capital) expenditure requirements for renewals, replacements and new constructions and cost allocations; and
- Maintenance expenditure necessary to address ongoing operations and maintenance to deliver required levels of service.

Collecting the data previously described as condition and performance-based assessments in previous sections will assist LGED to produce the following financial related information:

- Asset Useful life, by adding current age to assessed remaining useful life; and
- Input to assist in calculating Replacement Costs and Asset valuations.

Currently LGED does not collect or maintain the above Information in a systematic and organised manner which is critically needed for financial planning and management purposes. There are opportunities to graduate from the current practices.

9.2 Funding sources

The road infrastructure portfolio of LGED is funded through two distinct sources - one for capital investment that includes new constructions, renewals, and replacements, and the other for operation and maintenance activities.

The capital investment funds are obtained from the national government's development budget through the Annual Development Programme (ADP), which includes the government's own resources and project assistance from development partners. These funds are disbursed according to the Development Project Proposal (DPP) guidelines set by the Planning Commission.

The government's revenue budget determines the annual allocation of maintenance funds for LGED's road infrastructure assets, as decided by the Finance Division. Additionally, investment projects may also cover a portion of the maintenance cost, provided that provisions have been made for the same.

LGED's Rural Road and Bridge Maintenance Policy (2013) outlines several funding sources for the management of road infrastructure assets.:

- Government of Bangladesh Revenue Head;
- Donor funded projects;
- Local Government Institutes (Zila and Upazila Parishads development budget allocations);
- Private Sector Partnerships;
- Land Transfer tax revenues.

Thus far, the maintenance fund has been provided by the government and projects/programs funded by donors. However, other potential options have not yet been explored.

9.3 Financial plans

9.3.1 Investment – Ongoing/past

The financial plan (Investment) for new constructions, renewals, and replacements of bridge/culverts during the 7th Five Year Plan period, as outlined by LGED, is as follows:

Table 24: Financial Plan for Bridge/Culvert construction – Ongoing/past (2015-16 to 2019-20)

	In million Bangladesh Taka (BDT)						
	FY	2015-16	2016-17	2017-18	2018-19	2019-20	Total
On UZR	Planned	8500	9000	9300	9500	9500	45800
	Actual	7650	7080	7000	6000	5650	33380
	%	90	79	75	63	59	73
On UNR, and VR	Planned	8000	9000	11500	13000	15000	56500
	Actual	4450	6010	8800	6620	10400	36280
	%	56	67	77	51	69	64
Total	**Planned**	**16500**	**18000**	**20800**	**22500**	**24500**	**102300**
	Actual	**12100**	**13090**	**15800**	**12620**	**16050**	**69660**
	%	**73**	**73**	**76**	**56**	**66**	**68**

9.3.2 Investment – Forward

The financial plan (Investment) for new constructions, renewals, and replacements of bridge/culverts during the 8th Five Year Plan period, as outlined by LGED, is as follows:

Table 25: Financial Plan for Bridge/Culvert construction – Forward (2020-21 to 2024-25)

In million Bangladesh Taka (BDT)						
FY	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Total**
On UZR, UNR, and VR	33600	37200	39600	49000	57000	216400
Total	**33600**	**37200**	**39600**	**49000**	**57000**	**216400**

9.3.3 Maintenance – Ongoing/past

The finance required to ensure the delivery of the necessary levels of service during the 7th Five Year Plan period for operations and maintenance of bridge/culverts is as follows:

Table 26: Financial Plan for Bridge/Culvert Maintenance - Ongoing/past (2015-16 to 2019-20)

	In million Bangladesh Taka (BDT)						
	FY	2015-16	2016-17	2017-18	2018-19	2019-20	Total
On UZR	Planned	200	170	200	100	100	770
	Actual	180	160	190	110	80	710
	%	88	96	93	111	75	92
On UNR	Planned	120	75	130	65	120	510
	Actual	100	70	120	60	110	470
	%	85	97	94	98	95	93
On VR	Planned	80	80	120	80	110	470
	Actual	70	60	124	66	96	420
	%	88	79	104	83	87	89
Total	**Planned**	**400**	**330**	**450**	**250**	**330**	**1750**
	Actual	**350**	**300**	**430**	**240**	**280**	**1610**
	%	**87**	**92**	**96**	**99**	**86**	**92**

The finance required to ensure the delivery of the necessary levels of service during the 8th Five Year Plan period for operations and maintenance is as follows:

9.3.4 Maintenance – Forward

Table 27: Financial Plan for Bridge/Culvert Maintenance – Forward (2020-21 to 2024-25)

In million Bangladesh Taka (BDT)						
FY	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Total**
On UZR	2000	2200	2200	2500	3000	11900
On UNR	1200	1800	2000	2500	2800	10300
On VR	140	180	240	320	350	1230
Total	**3340**	**4180**	**4440**	**5320**	**6150**	**23430**

10. Management responsibility and interfaces

10.1 Asset management leadership

The Chief Engineer oversees LGED's AMS across the organization supported in the early stages of development by the Asset Management Committee (AMC). The AMC, a standing committee within LGED, is responsible for development, implementation and continuous improvement of all components of the Asset Management System (AMS) in coordination with the relevant LGED leadership persons and functional units.

Although the top management plays the key role, however, the leadership and commitment from all managerial levels is essential for successfully establishing, operating, and improving asset management within the organisation. The following positions within LGED are expected to have significant roles to play in the establishment and implementation of the AMS:

- Chief Engineer
- Additional Chief Engineers
- Superintending Engineers
- Executive Engineers
- Project Directors
- Senior Assistant Engineers/Upazila Engineers
- Assistant Engineers/Upazila Assistant Engineers
- Sub Assistant Engineers

The above group represents the target group demonstrating asset management leadership and commitment by endorsing the AM Policy, SAMP, AM Objectives and by supporting continual improvement through review of performance.

Achieving good leadership requires a certain level of knowledge on the part of leaders and senior decision makers. LGED's Professional Development Strategy is directly linked with and supports LGED's AMS implementation and improvement plan.

10.2 Asset management culture

While the processes and systems are at the core of good asset management, success is only achieved by ensuring right behaviours and attitudes are in place in an organisation. An asset management culture should run throughout LGED as it takes many functions and roles to manage local level infrastructure on a national basis. Introduction of an asset management culture to LGED will require in addition to leadership and commitment,[17] building capability, knowledge and skills throughout the organisation over a period of time.

The principles of asset management will need continual reinforcement to remind existing stakeholders of the benefits, avoid pressure to revert to inefficient methods and to introduce the concepts to new stakeholders, such as new elected leaders and staff.

[17] PIARC Section 1.2.2.1; UKRLG HMEP Part C

10.3 Asset management roles and interfaces

There is no one correct way of defining roles for asset management. However, for consistency and alignment with LGED's Professional Development Strategy (2020), the Institute of Asset Management's (IAM) Competence Framework is referenced and further extrapolated to identify roles. These roles, which are defined in the Institute of Asset Management (IAM) Competences Framework provide guidance on what areas in Asset Management the target groups will be involved with or be responsible for.

Figure 24: Roles in Asset Management[18]

The IAM framework specifically identifies seven (7) roles and associated core competencies,[19] of which four (3, 4, 6, and 7) have specific relevance to the content and processes outlined in this AMP as outlined in Table 21.

Table 28: AM Roles and Core competencies relevant to this AMP

Roles in Asset Management	Core Competences
1. Policy development	N/A AMP *[Refer to LGED AM Policy]*
2. Strategy development	N/A AMP *[Refer to LGED Strategic Asset Management Plan (SAMP)]*
3. Asset Management planning	3.1. Appraise investment options 3.2 Apply whole life cycle costing principles 3.3 Produce business case for creation and/or acquisition of assets 3.4 Plan for contingencies 3.5 Develop and communicate AM plans

[18] AM Competence Framework, Version 3.0, p. 5

[19] IAM Competence Framework, Version 3.0

Roles in Asset Management	Core Competences
4. Implement Asset Management Plans	4.1 Create and acquire assets 4.2 Control operations 4.3 Maintain assets 4.4 Optimize and rationalise assets 4.5 Renew or dispose assets
5. Asset Management capability development	N/A AMP *[Refer to Professional Dev. Strategy and Capability Building Plan]*
6. Risk management and performance improvement	6.1 Appraise and manage risks 6.2 Assure the quality of AM processes 6.3 Monitor and review progress and performance 6.4 Review and audit compliance with legal, regulatory, ethical and social requirements 6.5 Learn from incidents
7. Asset knowledge management	7.1 Define Asset Management information standards 7.2 Specify, select and integrate AM information systems 7.3 Make appropriate AM data available for decision-making *[Refer to LGED Asset Information Strategy]*

11. Further Actions, Opportunities and AMP Improvement Initiatives

The AMP document has identified several additional actions and improvement initiatives. It is important to note that while some activities can start in the short term, the entire process of development, implementation, and integration may take several years.

Immediate	3- 6 months
Short term	6-12 months
Medium term	12-24 months
Longer term	24 months ++

Table 29: Further Actions, Opportunities and AMP Improvement Initiatives

Section	Further Actions and Opportunities	Timeframe
3.1	Review, validate and communicate an agreed appropriate Roads asset hierarchy with the aims to: ● Avoid storing duplicate data ● Ensure efficient and reliable storage and use of the data within RSDMS.	**Immediate**
3.2	Develop improvement initiatives in relation to RSDMS with consideration of the following: ● Incorporating criticality and risk attributes at the appropriate level according to the asset hierarchy; ● The capacity to link data sources to generate the information needed for asset management activities such as life cycle planning, risk management; and ● Improving and streamlining accessibility at all levels.	**Short term**
3.3	Review and update the register of road assets, the hierarchy and components to ensure classification into appropriate segments and component levels.	**Immediate**

Section	Further Actions and Opportunities	Timeframe
3.4	In order to gain a better understanding of function and structural condition of road assets/network, to achieve the required Level of Service, to overcome challenges for improving condition and performance data collection capacity, and to increase reliability of maintenance programs: • Continual review of condition and performance data needs to be undertaken; and • An improvement plan to address current challenges experienced in understanding, recording and analysing road asset condition to support decision making processes along with forward work programs to be developed and maintained.	**Short term**
3.5	In order to improve efficiency of inspection process and to maintain the consistency in interpreting the observed conditions, the following tasks to be integrated in the business process: • Develop a well-designed process that captures as much relevant data as possible in the inspection process and is repeatable to build up long term data; • Ensure operators and field staff are sufficiently trained and knowledgeable to ensure proper and relevant data is collected; • Repeat inspections at sufficient frequencies and intervals to ensure data is fit for planning, maintenance and compliance purposes; and • Ensure the safety of field staff when carrying out inspections through inclusion of process and site inductions and training.	**Medium**
3.6.1	1. Incorporate visual condition assessments based on risk / criticality profile and sampling as a factor in the estimate of remaining useful life of road pavement types. 2. Establish and document how the collection and use of pavement condition data is used in life cycle planning and decision making.	**Long term**

Section	Further Actions and Opportunities	Timeframe
3.6.2	Further actions to improve condition monitoring activities: • A road deterioration model interface to be developed to exchange and make compatible the dataset between RSDMS and HDM-4 as HDM-4's Road Deterioration and Works Effects (RDWE) model is reliable, easy to calibrate with local condition and being used in more than 60 developed/developing countries for the last two decades; • Develop standard specifications and associated test methods to provide a consistent and clear approach to monitoring pavement condition at a network level; • Increase road condition and traffic survey coverage of critical and/or important routes to improve life cycle planning, in particular maintenance activities; and • Identify and gather datasets that support performance measures listed in Section 4. Performance and Levels of Service (evaluated in terms of accuracy, applicability, cost and overall improvement to monitoring process).	**Medium**
3.6.3	To enhance the ability for delivery the reporting in efficient and effective manner, the following register, condition assessment and forward program reports to be appended to this AMP gradually upon the availability of requisite pavement condition data: • A register of surveyed road pavement segments and their components (RSDMS); • Condition assessment rating of pavement and surface asset components and estimate of remaining useful life; and • A summary report on the network which lists forward program schedules and associated expenditure reports.	**Long term**
3.7.1	Carry out further assessment to validate the appropriateness and future relative benefits and value (including costs) in expanding current practices by incorporating the nominated tests mentioned in this section.	**Medium**
3.7.2	Develop strategy and actions to improve the current process of collection and validation to minimise the current challenges and barriers resulting in low compliance.	**Medium**
3.8	Plan to implement improvement initiatives identified in the Asset Information Strategy for improved data quality, management and validation requirements for effective and efficient asset management of LGED's Road Assets.	**Medium**

Section	Further Actions and Opportunities	Timeframe
3.9	To address asset condition monitoring practices for other road related asset types essential in achieving delivery of level of service to users, definition of the following shall be established and documented in future iterations of this AMP: • Condition parameters; • Condition evaluation, monitoring and reporting method(s); • Data collection methods and frequency including applicable condition inspection tier(s); and • Life cycle plans including maintenance strategies.	**Medium**
4.1	• Establish, implement and maintain a Performance Management Framework to monitor and measure the performance and/or condition of assets. • Regular review, evaluation, analysis to be undertaken to understand trends which may become evident over time to inform review and/or update of performance measures and targets for medium- and long-term lifecycle planning of road assets.	**Medium**
4.3	Review and seek to validate the initial Levels of Service, associated Performance Measures and Targets as appropriate and relevant. The review and validation process will include: • Stakeholder(s) engagement to present, • Explore and validate alignment of LoS, • Performance measures and targets - particularly to customers and users' expectations.	**Medium**
4.3	Incorporate LoS and performance management processes into business as usual in an agreed timeframe identifying validation of future LoS.	**Medium**
5.0	Formalise lifecycle management approaches for roads asset classes which identify and incorporate outputs from demand analysis, asset management lifecycle activities and decisions, risks, performance and costs. Processes may include: • Long-term renewal, enhancement, maintenance treatments, volumes and estimates; • Demand management plans to understand how existing assets will meet future demand or how growth impacts the need for new infrastructure assets; • Identification of future funding requirements; • Identification and quantification of associated risks, impact, likelihood and costs;	**Long term**

Section	Further Actions and Opportunities	Timeframe
	• Scenario development and modelling, incorporating non-asset intervention(s.)	
5.1	Develop, document and implement a comprehensive demand analysis process relative and appropriate to the management of rural road assets. The demand process will be an integral input into the development of future work programs, lifecycle plans and expenditure forecasts. Proposed improvements include incorporating the following steps to determine future demand: • Determine factors which drive and/or influence the demand for service; • Complete a forecast to determine demand - i.e., population growth forecasts profiling the population that currently lives in the vicinity; • Assess risks and their impacts on the demand forecast. • Data captured by other government agencies may be utilised to assist in understanding the growth forecasts. The levels of future demands can be proportionately extrapolated to current traffic levels in lieu of transport planning software initially	**Long term**
6.1	Roll out of Risk Management training to build the knowledge, understanding and capability of staff. This will support integrating risk management in asset management practices and transition to business-as-usual supporting informed asset-related decision making.	**Medium**
6.2	Adapt and validate appropriate tools and templates for use in risk assessment processes including: • Control effectiveness categories, • LGED AM Likelihood Table • LGED AM Consequence Table • LGED AM Risk Matrix.	**Medium**
6.4	Develop and maintain a live Risk Register for the management of the rural road's portfolio.	**Medium and Long term**
6.5	Review the Risk register on frequent and regular intervals, or when changes warrant it (e.g., changes to legislation, or available budget or after an extreme event).	**Medium and Long term**
6.5	Develop and document roles and responsibilities in managing risks, identifying officials who will have key roles in implementing risk management. This will be presented in a Responsibility Matrix to be included in the AMP.	**Medium and Long term**

Section	Further Actions and Opportunities	Timeframe
	Develop and integrate risk assessment processes and procedures for asset management activities throughout lifecycle activities. Conduct and document risk assessments to evaluate the impact of hazards on the continued delivery of services to stakeholders.	
6.6	Formalise criteria and identify critical road assets separately which support assessment in greater detail as part of the asset management process. This will allow to target and refine investigative activities, risk assessment, maintenance plans, financial plans to the most crucial areas.	**Medium and Long term**
7.0	Review and revise the relevant organisational policies, strategies, plans, decision making processes, and work culture leading to a new approach to create and maintain road infrastructures. Development of new design standards, specifications, training curricula for road infrastructure planning, supervision and maintenance through the CReLIC (Climate Resilient Local Infrastructure Centre) established within LGED with the support of GCF, KfW and GOB funding. LGED to consider implementation of tangible actions to build up resilience in the road network include: ● Implementation and periodic review of the 'Resilience' LoS and associate indicator; ● Identification and assessment of critical road and bridge assets; ● Assessment and mapping risk and vulnerability to flooding and other natural hazards; ● Prioritise maintenance and renewal interventions in vulnerable areas; ● Development of climate resilience design standards; ● Capacity building for mainstreaming climate resilience; ● Explore use of resilience tools; ● Failure Analysis approach towards build back better mechanisms	**Medium and Long term**
8.1	Develop process flow diagrams using the example provided in this section as a guide to document the process for all program development and implementation in LGED - including capital investment / development programs and maintenance programs. The following inputs and activities should be included: ● Asset information and asset condition data; ● Level of Service hierarchy for roads; ● Performance gap analysis - performance measures, targets and indicators;	**Medium**

Section	Further Actions and Opportunities	Timeframe
	• Demand management; • Risk management and prioritisation; • Life cycle plan (maintenance strategies); • Financial plan (funding or budget restrictions and affordability); • Works delivery or program implementation; • Review and improvement; • Reporting and communication	
8.2	Formalise and document the process and criteria adopted to prioritise investment and work programs. The process and/or criteria should demonstrate alignment to LGED's Asset Management Objectives and AM Policy.	**Medium**
9.1	Further analyse datasets to compile and develop the following specific requirements for inclusion in this section: • Estimated cost of expected future work to implement the investment strategies outlined in the AMP, by asset class, year and work type; • Estimated funding levels to address the costs of future work types, by year; • Identification of anticipated funding sources and funding cycles; • Asset valuation estimates for road type and the needed annual investment to maintain asset value	**Medium and long term**
10.1	Leadership target group and senior decision makers will: • Demonstrate leadership and commitment to enable the implementation of asset management and accountability for processes and activities outlined in this AMP. • support and encourage adoption of decision-making techniques supported by asset management processes and information for appropriate long term investment strategies with consideration of LGED's asset management objectives	**Continuous**
10.2	• LGED leaders, senior decision makers will support and advocate a coordinated view of asset management activities, roles and responsibilities to facilitate translation and embedding of an effective asset management culture. • The appropriate competency required to undertake asset management activities outlined in this AMP will be identified and training provided where necessary. Refer to LGED Professional Development Strategy.	**Continuous**

Section	Further Actions and Opportunities	Timeframe
	• AM culture improvement will be supported and communicated to suppliers, providers and contractors through the introduction of a “closed loop” mechanism to improve accountability. • Introduction of a formal process/system to handover the created assets by the project directors to the proposed asset management unit.	
10.3	Review the asset management roles and confirm key asset management roles and all positions responsibilities, in terms of their functions, accountabilities and authorities and their linkage to described asset management practices and competencies.	**Continuous**

References

The following reference materials were used in the production of this document.

Government of Bangladesh (including LGED specific documents):

- LGED Asset Management Policy (2019);
- LGED Strategic Asset Management Plan (Draft);
- LGED Asset Information Strategy (Draft);
- LGED Professional development Strategy (2020);
- LGED Capability Building Plan (draft);
- LGED Rural Road and Bridge Maintenance Policy (2013)
- Road Design and Pavement Standards of LGED (2019)
- Road Design Standard (Rural Road) (2004)
- LGED Training Manual on Road Maintenance Management (2008)
- LGED Risk Identification and Management Manual (RIMS) Revision D
- Rural Road Maintenance Technical Implementation Guidelines, May 2018 developed under Technical Assistance for Operationalization of the Rural Road Maintenance Policy

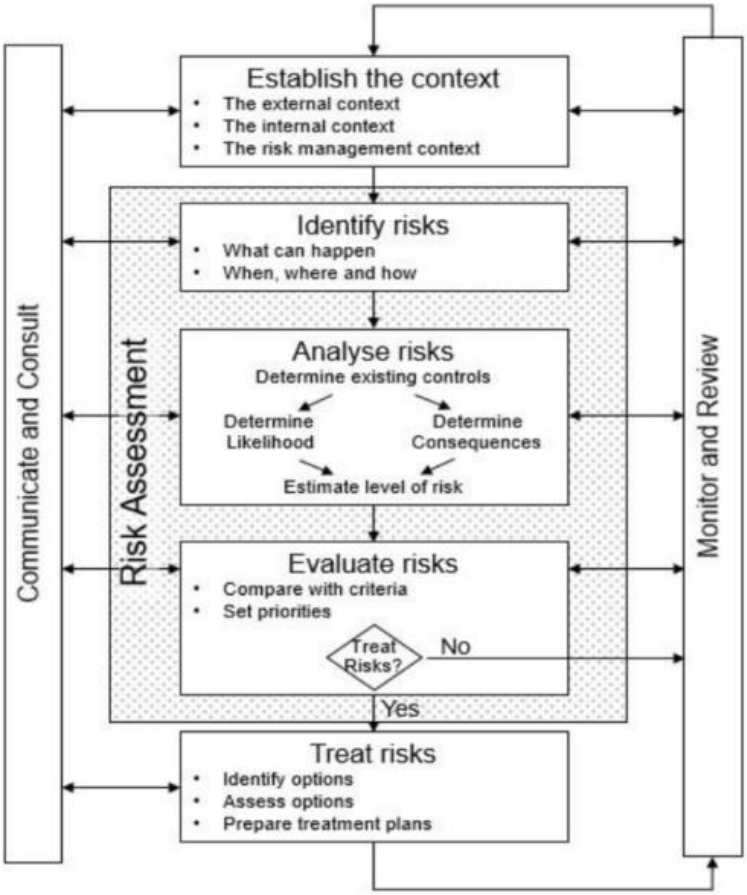
International standards, manuals, and guidelines:

Reference	Title / Source
ISO 55000:2014	Asset Management – Overview, principles and terminology
ISO 55001:2014	Asset Management – Management Systems – Requirements
ISO 55002: 2018	Asset Management - Management Systems - Guidelines for the application of ISO55001
PD ISO / TS 55010: 2019	Asset Management - Guidance on the alignment of financial and non-financial functions in asset management
ISO 31000:2009	Risk Management - Guidelines
Austroads Guides (Various)	Austroads - Guide to Asset Management (GAM) https://austroads.com.au/
UK Roads Liaison Group and HMEP	United Kingdom Roads Liaison Group (UKRLG) and Roads Maintenance Efficiency Programme (HMEP) (2013): Road Infrastructure Asset Management Guidance Document. Department for Transport, London
IIMM, IPWEA	international Infrastructure Maintenance Manual. IPWEA, Institute of Public Works Australasia, 5th Edition, Australia, 2020
PIARC	World Road Association (PIARC) Asset Management Manual - A Guide for Practitioners. https://road-asset.piarc.org/en

Appendix A. LGED Risk Management Framework

This appendix presents a generic risk management framework that is aligned with ISO 31000:2018. The Framework presented builds upon the risk management process developed for LGED projects (termed the LGED RIMS international Project). The outputs of this process are Risk Register and a Risk Action Plan. Templates are included in this appendix for information. Refer to LGED's RIMS Manual (Rev D) for complete details on all process, activities and actions.

Figure A1 - Risk Management Framework after ISO 31000:2018



The aim of risk management in LGED is not to eliminate risks from its projects and programs, rather it is to manage and control risks to optimize the value form the risks. Risk management enables responsible persons to make informed decisions regarding alternative approaches to achieving objectives through implementing effective risk treatment and mitigation measures and actions.[20]

[20] LGED RIMS Manual rev D.

Establish the context

Establishing the risk context involves understanding and documenting the social, cultural, legal, regulatory, economic, and natural environment in which LGED operates. The context allows risk management to be tailored to LGED's needs and circumstances. LGED's risk appetite, i.e., how much risk the organisation is willing to retain, and its risk tolerance, i.e.is the readiness to accept residual risks while still achieving its organisational objectives, need to be understood.

The context of risk assessment is critical for its correct application as well understanding potential limitations in its implementation. Limited data availability and low organisational capability may limit the application of risk management processes.

Possible constraints posed upon the implementation of the mitigation measures should also be considered. These include financial constraints (e.g., limited budgets), workforce constraints (e.g., availability or competency gaps) and environmental constraints (e.g., consideration of the timing of the mitigation measures in the wet season).

Risk Assessment

The risk assessment process consists of three steps:

- Step 1 - Risk identification
- Step 2 - Risk Analysis
- Step 3 - Risk Evaluation

This process has been used to identify and analyse typical risks applicable across the network or portfolio of assets. The same risk evaluation matrix (used to analyse and evaluate the risks) can be adopted to undertake more detailed risk assessments. For example, it can be used to evaluate defects presented in inspection reports to inform prioritisation of activities in the work bank. However, until the detail of inspection reports improves, the application of this risk assessment will be limited to high-level risk assessments. A subsequent reactive safety inspection will then be conducted by an appropriate officer/inspector.

Step 1 - Risk identification

Risk identification should involve a systematic process that considers a range of risk types. The determination of these risks should involve a variety of subject matter specialists, including the previously identified stakeholders.

Risk types can include technical, operational, environmental, legal, financial, organisational, social and external risks.

Step 2 - Risk Analysis

Once an exhaustive list of risks has been defined and agreed by all stakeholders, the risks will be analysed for their likelihood and severity using the tables below.

Table A.1 – Consequence rating table

	Insignificant	Minor	Moderate	Major	Catastrophic
Health and safety	Minor Injury	Multiple minor injuries	Serious injury	Major or multiple serious injuries	Single or multiple fatalities
Environment	No Impact on larger environment. Localized to point source. No recovery required.	Minimal localised environmental impact within site boundaries. Recovery measurable within 1 month of impact.	Moderate harm to local environment with possible wider effects. Recovery timescales greater than 1 month and less than a 1 year	Significant harm to local environment. Recovery greater than 1 year.	Significant harm with widespread effect to environment. Recovery longer than 1 year. Limited prospect of full recovery.
Reputation	Localised temporary impact	Localised, short term impact	Localised, long term impact but manageable	Localised, long term impact with unmanageable outcomes term impact	Long term regional impact
Business Impact	Impact can be absorbed through normal activity	An adverse event which can be absorbed with some management effort	A serious event which requires additional management effort	A critical event which requires extraordinary management effort	Disaster with potential to lead to collapse of the project.

Table A.2 - Risk likelihood table

Rare	Unlikely	Moderate	Likely	Almost Certain
The likelihood of this consequence to occur is highly unlikely to occur	The likelihood of this consequence to occur is unlikely to occur	The likelihood of this consequence to occur is possible to occur	The likelihood of this consequence to occur is likely to occur	The likelihood of this consequence to occur is certain to occur
1-5% chance of occurring until the next inspection or 5 years, whichever is greater	6-20% chance of occurring until the next inspection or 5 years, whichever is greater	21-40% chance of occurring until the next inspection or 5 years, whichever is greater	41-80% chance of occurring until the next inspection or 5 years, whichever is greater	81-100% chance of occurring until the next inspection or 5 years, whichever is greater

Step 3- Risk evaluation

Once the consequence and likelihood of each risk item has been determined, the risk rating score can be determined by using the below matrix.

Table A.3 - Risk evaluation matrix

			Severity				
			Insignificant	Minor	Moderate	Major	Catastrophic
		Score	1	2	3	4	5
Likelihood	Almost Certain	5	Medium 5	Medium 10	Medium 15	High 20	High 25
	Likely	4	Low 4	Medium 8	Medium 12	Medium 16	High 20
	Moderate	3	Low 3	Low 6	Medium 9	Medium 12	Medium 15
	Unlikely	2	Low 2	Low 4	Low 6	Medium 8	Medium 10
	Rare	1	Low 1	Low 2	Low 3	Low 4	Medium 5

Risk Treatment

The risk treatment controls that are presented in this section are appropriate to control the risk to a tolerable level. Mitigation measures should be considered in the below order (in order of risk control effectiveness):

- Eliminate - can the risk be avoided? For example; remove the root cause of deterioration - i.e., reroute river away from the toe of infrastructure.
- Reduce - can the risk be reduced? For example; ensure asset can resist the erosion effects of the river - i.e., installation of scour protection.
- Control - can you adopt administrative controls? For example; control the likelihood of consequence - i.e., monitor the asset regularly and inspect asset after periods of heavy rain/flooding.

Note - above examples are applicable to the risk where a river will erode the bottom of the embankment of a road or bridge.

Using the list of constraints identified earlier in Table A.1, a list of possible mitigation measures should be listed against each risk. The final mitigation measures chosen should be appropriate, achievable within a specific timeframe and provide good financial value.

Some mitigation measures can be addressed more easily and effectively than others, and may alter the order of implementation appropriately. Analysis of the costs of risk reduction against different options will assist in identification of the optimum solution. The action owner responsible for each mitigation measure shall be agreed and identified.

Monitoring and Review

Once the risks have been agreed and mitigation measures proposed, a Risk Action Plan should be drafted to sit alongside the Risk Register with a clear set of actions, risk owners and frequency for monitoring and review.

As LGED's understanding of the risk management approach and LGED's risk tolerance is refined, the approach to risk management, supporting data and conclusions should be re-evaluated. This evaluation should include the re-evaluation of the context of risk management of LGED, including any changes to legislation, business objectives, funding stakeholder expectations and the changing condition of Bangladesh's asset portfolio.

The monitoring and review phase shall audit whether the proposed mitigation measures have been adopted into the management of assets, and understand why measures have not been adopted where appropriate.

The review and re-evaluation phase should investigate the effectiveness of the instigated mitigation measures and propose refinements and/or new mitigation measures where appropriate.

This monitoring and review should be undertaken yearly and by independent personnel.

====== End of document ======