THE GREAT RIFT ECONOMIC DEVELOPMENT CORRIDOR (BIRETWO-ARROR-CHESONGOCH (B126) ROAD AND ASSOCIATED SPUR ROADS




BIODIVERSITY MANAGEMENT PLAN FOR THE PROPOSED ROAD UPGRADING OF BIRETWO - ARROR – CHESONGOCH, NYARU – KIMWARER – KAPKAYO, AND KIMWARER – EMSEA

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Executive Summary

This Biodiversity Management Plan (BMP) has been prepared for the proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County. The project seeks to improve strategic transport connectivity linking rural settlements, agricultural production areas, trading centres, schools, health facilities, and emerging growth nodes within the county. Upgrading the roads to all-weather standard is expected to reduce travel time, improve road safety, stimulate trade, enhance access to markets and services, and contribute to broader socio-economic development. However, the proposed corridors traverse environmentally sensitive escarpment-to-valley landscapes requiring careful integration of engineering design with biodiversity protection and ecosystem management.

The project area is characterized by steep escarpments, rugged valleys, rolling uplands, river crossings, wetlands, clay-rich lowlands, and diverse agricultural landscapes. Biophysical analysis identified significant engineering and ecological constraints associated with slope instability, dense drainage systems, erosion-prone soils, flooding risk, and rainfall variability. High-risk terrain occurs along sections of the Biretwo–Arror–Chesongoch corridor (0+000–12+000, 20+000–30+000, 58+000–70+900), the Nyaru–Kimwarer–Kapkayo corridor (0+000–6+000), and the Kimwarer–Emsea corridor (3+000–14+000). Major drainage crossings and hydrologically sensitive zones require robust culvert sizing, scour protection, erosion control, and maintenance of natural flow paths. These environmental conditions strongly influence both road design and biodiversity distribution.

The study area supports a highly diverse mosaic of ecosystems including riparian corridors, wetlands, woodland remnants, bushland, wooded grassland, rocky escarpments, agroforestry systems, cropland, grazing lands, and settlement mosaics. These habitats provide essential ecosystem services such as water regulation, flood buffering, soil stabilization, pollination, carbon storage, livestock forage, fuelwood supply, and wildlife movement pathways. Riparian systems and valley bottoms were identified as especially sensitive due to their hydrological importance and high biodiversity value, while escarpment vegetation and woodland remnants play a critical role in slope stabilization, carbon storage, and ecological connectivity.

Biodiversity baseline findings indicate that the project area retains substantial ecological value despite long-term human land use. A total of 726 species were recorded across assessed taxonomic groups. Birds were the most species-rich group with 392 species, followed by plants (137 species), mammals (73 species), invertebrates (71 species), reptiles (37 species), and amphibians (16 species). Diversity indices were consistently high, with the combined Shannon–Wiener Index reaching H' = 5.911 and Simpson's Diversity Index reaching 0.996, indicating a biologically rich and relatively balanced landscape. Riparian habitats, mature indigenous trees, wetlands, woodland remnants, and escarpment refugia were identified as biodiversity hotspots requiring priority protection. Species such as Ficus sycomorus were recognized as ecologically significant due to their role in providing fruit, nesting resources, and shade.

The assessment identified several key biodiversity risks associated with road upgrading. During construction, impacts may include vegetation clearance, loss of habitat, disturbance to wildlife, soil erosion, sedimentation of watercourses, dust generation, noise, waste production, pollution from fuels and lubricants, spread of invasive species, and damage to riparian systems. Operational-phase risks include habitat fragmentation, wildlife mortality from vehicle collisions, increased roadside settlement pressure, uncontrolled resource extraction, invasive species spread, altered runoff patterns, and cumulative land-use change associated with improved access. Sensitive impacts are likely where roads intersect wetlands, streams, woodland patches, wildlife movement routes, steep slopes, and areas containing mature indigenous vegetation.

This BMP adopts the mitigation hierarchy of avoid, minimize, restore, and offset residual impacts where necessary. Avoidance measures include route optimization, minimizing widening in ecologically sensitive sections, protecting wetlands, retaining mature trees, and avoiding unnecessary disturbance to riparian corridors and steep slopes. Minimization measures include limiting construction footprints, controlling dust and noise, managing spoil disposal, enforcing contractor codes of conduct, maintaining wildlife passage through culverts and underpasses, and applying erosion and sediment control structures. Restoration measures include regrading disturbed areas, topsoil replacement, native revegetation, borrow pit rehabilitation, and riparian reinstatement. Residual impacts, if significant, should be addressed through compensatory habitat restoration or biodiversity enhancement initiatives.

The report highlights several habitat categories relevant to international safeguard standards such as International Finance Corporation Performance Standard 6. Modified habitats include farmland, settlements, and disturbed road reserves. Natural habitats include woodland patches, riparian vegetation, wetlands, and escarpment ecosystems. Potential critical habitats may include riparian refugia, key wildlife movement corridors, breeding sites, wetlands, and habitats supporting threatened or restricted species. The project should therefore apply enhanced due diligence in sensitive sections, ensure no measurable adverse impact on critical biodiversity values, and maintain ecological connectivity across the landscape.

A biodiversity monitoring and adaptive management framework is proposed to track project performance throughout construction and operation. Key indicators include vegetation recovery, invasive species occurrence, erosion severity, drainage performance, water quality at crossings, wildlife sightings, roadkill incidents, use of crossing structures, riparian habitat condition, and survival of replanted vegetation. Monitoring should be undertaken jointly by the contractor, supervising engineer, Kenya National Highways Authority, relevant regulators, and county agencies, with annual review and corrective action where targets are not met. Community participation and grievance redress mechanisms should be maintained to ensure local concerns are addressed transparently.

In conclusion, the proposed road upgrading project offers major development benefits for Elgeyo Marakwet County but traverses landscapes of high ecological sensitivity and environmental complexity. With proper implementation of this Biodiversity Management Plan, the project can proceed in a manner that safeguards biodiversity, maintains ecosystem services, protects water resources, reduces erosion risk, and sustains ecological connectivity while delivering durable transport infrastructure and long-term socio-economic benefits.

1 Introduction

1.1 Project Overview

The proposed project involves the upgrading of three strategic road corridors within Elgeyo Marakwet County, namely the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road sections. These roads form important transport links connecting rural settlements, agricultural production zones, trading centres, and emerging growth nodes across the county. The project is intended to improve mobility, reduce travel time, enhance road safety, and strengthen access to markets, schools, health facilities, and administrative centres. In addition, the improved road network is expected to support broader regional integration and stimulate socio-economic development through increased trade, investment, and service delivery.

The three road corridors traverse landscapes of high environmental and engineering complexity. The Biretwo–Arror–Chesongoch section crosses steep escarpment terrain, rugged valleys, and transitional lowland areas characterised by high slope variability and dense drainage systems. The Nyaru–Kimwarer–Kapkayo corridor passes through a gradient of upland agricultural areas, gently undulating mid-slopes, and lower agro-pastoral landscapes. The Kimwarer–Emsea section traverses escarpment transition zones with clay-rich soils, high rainfall areas, and numerous drainage channels. These varying biophysical conditions influence road design requirements, construction risks, hydrological processes, and biodiversity distribution along the alignments.

The proposed upgrading works are expected to include improvement of the existing carriageway to all-weather standards, pavement strengthening, widening where necessary, drainage enhancement, slope protection works, bridge and culvert improvements, road safety installations, and associated ancillary works such as borrow pits, campsites, spoil disposal areas, and temporary access routes. Depending on final engineering design, sections of the roads may require geometric realignment, embankment works, retaining structures, and additional stormwater management measures to address terrain and climate-related constraints.

The project area supports a mosaic of natural and modified ecosystems including woodland, bushland, riparian vegetation, wetlands, farmland, settlements, and open grazing lands. These habitats provide important ecosystem services such as soil stabilisation, water regulation, pollination, carbon storage, livestock forage, and wildlife movement pathways. Because the road corridors intersect sensitive ecological zones, drainage systems, and community land-use areas, project implementation requires careful planning to avoid or minimise environmental degradation and biodiversity loss.

This Biodiversity Management Plan has therefore been prepared to guide environmentally responsible implementation of the road upgrading project. It provides a framework for identifying ecological sensitivities, assessing potential impacts, prescribing mitigation measures, and establishing monitoring and adaptive management actions throughout the project lifecycle. The report aligns with applicable Kenyan legal requirements, lender safeguard standards, and good international practice to ensure that infrastructure development proceeds in a manner that conserves biodiversity, maintains ecosystem functionality, and supports sustainable development objectives within the project area.

1.2 Objectives of the Biodiversity Management Plan

1.2.1 Overall Objective

The overall objective of this report is to assess the ecological characteristics and biodiversity of the project area and to develop a spatially explicit, ecosystem-based Biodiversity Management Plan that guides the avoidance, minimisation, mitigation, and monitoring of environmental impacts associated with the proposed road upgrading, while maintaining ecological integrity, habitat connectivity, and long-term ecosystem functionality.

1.2.2 Specific Objectives

1. To characterise the biophysical environment, including topography, soils, hydrology, climate, and land use, and analyse how these factors influence biodiversity distribution and ecosystem processes along the road corridors.
2. To assess biodiversity across key taxa, including plants, invertebrates, birds, mammals, and herpetofauna, with emphasis on species composition, functional groups, and ecological indicators.
3. To identify and evaluate potential direct and indirect impacts of road upgrading on habitats, species, and ecosystem processes, with spatial reference to specific chainage sections.
4. To develop targeted biodiversity management and mitigation measures that maintain habitat integrity, ecological connectivity, hydrological function, and key ecosystem services.
5. To establish a monitoring and adaptive management framework using measurable ecological indicators to track environmental performance and inform timely corrective actions throughout the project lifecycle.

1.3 The Project's Approach to Biodiversity Management

The project adopts a practical and ecosystem-based approach to ensure that road upgrading is implemented in a manner that safeguards biodiversity and environmental sustainability. The strategy integrates engineering design, ecological protection, monitoring, and stakeholder participation across all project phases. Key elements of the approach are summarised below.

- Apply an integrated biodiversity management approach that balances road development with conservation of habitats, ecosystem services, and ecological resilience.
- Use the mitigation hierarchy:
  - Avoid impacts where possible
  - Minimise unavoidable impacts
  - Restore disturbed areas
  - Offset residual impacts if necessary.
- Implement a chainage-based spatial planning approach, with mitigation measures tailored to specific road sections according to ecological sensitivity.
- Prioritise steep slope sections for erosion control, slope stabilisation, and runoff management.
- Protect rivers, streams, wetlands, and valley bottoms by maintaining natural drainage, floodplain connectivity, and water quality.

- Maintain wildlife movement corridors along riparian zones, woodland strips, drainage lines, and escarpment edges.
- Incorporate wildlife crossing measures such as culverts, underpasses, bridge spans, and fauna-friendly drainage structures where needed.
- Conserve important habitats and species, including riparian vegetation, indigenous trees, pollinator habitats, termite mounds, and keystone trees such as *Ficus sycomorus*.
- Enforce strict contractor controls against hunting, trapping, vegetation destruction, and illegal resource extraction.
- Apply invasive species prevention measures through machinery hygiene, controlled material sourcing, rapid rehabilitation, and regular monitoring.
- Establish a monitoring and adaptive management system using indicators such as vegetation recovery, erosion, water quality, wildlife sightings, and habitat condition.
- Assign clear responsibilities to KeNHA, contractors, supervising engineers, regulators, and communities for implementation and compliance.
- Promote community engagement and grievance redress mechanisms to address local environmental concerns and support transparency.
- Ensure the project delivers infrastructure benefits while maintaining biodiversity, ecological connectivity, and long-term environmental sustainability.

1.4 Scope

This study covers the proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County, together with areas likely to be directly or indirectly influenced by project activities. The assessment includes the existing road reserve, sections proposed for widening or realignment, drainage crossing points, borrow areas, spoil disposal sites, contractor camps, material storage areas, and adjacent landscapes where ecological processes may be affected by construction or operation. The scope recognises that road projects can generate impacts beyond the immediate carriageway footprint, particularly through changes in hydrology, slope stability, access, land use, and habitat connectivity.

The study evaluates the biophysical environment along the road corridors, including topography, slope conditions, drainage systems, soil characteristics, rainfall patterns, temperature gradients, and land use. These factors were analysed because they strongly influence engineering risks, erosion potential, vegetation patterns, wildlife movement, and the resilience of ecosystems. Spatial variation along each road alignment was considered through a chainage-based framework to identify sections with distinct environmental sensitivities and management requirements.

The biodiversity component of the study covers terrestrial and freshwater-associated ecosystems, vegetation communities, riparian habitats, wetlands, woodland and bushland areas, agricultural mosaics, and disturbed roadside habitats. Faunal scope includes major taxonomic groups such as mammals, birds, reptiles, amphibians, and ecologically important invertebrates where relevant as indicators of habitat condition. Particular attention was given to wildlife movement areas, riparian biodiversity hotspots, pollinator habitats, keystone species, and habitats of conservation significance that may be vulnerable to road upgrading activities.

The impact assessment scope addresses both construction-phase and operational-phase risks. Construction-related issues include vegetation clearance, excavation, soil disturbance, waste generation, dust, noise, vibration, increased traffic, worker activities, and temporary disruption of drainage systems. Operational-phase issues include habitat fragmentation, wildlife mortality risk, altered runoff patterns, erosion, invasive species spread, roadside development pressure, increased human access, and cumulative land-use change associated with improved transport connectivity. Both direct and indirect impacts were considered.

The study further includes the development of mitigation measures, biodiversity management actions, monitoring indicators, institutional responsibilities, implementation schedules, and adaptive management procedures. Recommendations are aligned with applicable Kenyan environmental legislation, wildlife protection requirements, and relevant international safeguard standards. The scope therefore extends beyond baseline assessment to provide a practical management framework for integrating biodiversity conservation into project planning, construction, operation, and long-term maintenance of the proposed roads.

2 Relevant Policy and Legal Framework

2.1 Policy Framework

The proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors should be guided by national policy instruments that promote environmental sustainability, biodiversity conservation, climate resilience, and responsible infrastructure development. These policies provide the strategic direction for integrating biodiversity considerations into road planning, construction, operation, and maintenance. The following policy framework is most relevant to the Biodiversity Management Plan (BMP).

These policy instruments collectively require that the project incorporates biodiversity conservation into all project phases. This includes avoiding ecologically sensitive areas where feasible, minimising vegetation loss, maintaining wildlife movement corridors, protecting wetlands and riparian systems, restoring disturbed sites, preventing invasive species spread, managing runoff and erosion, and ensuring climate-resilient road design. They also support stakeholder engagement, community participation, and continuous environmental monitoring.

The Biodiversity Management Plan therefore serves as the practical mechanism for translating these national policy commitments into site-specific mitigation, monitoring, and adaptive management measures for the proposed road upgrading project.

Table 2-1: Kenya Policy Framework Relevant to the Biodiversity Management Plan for the Proposed Road Upgrading Project

Policy Instrument	Key Provisions Relevant to BMP
National Environment Policy, 2013	Requires environmental considerations to be mainstreamed into all development sectors; promotes ecosystem conservation, pollution prevention, environmental restoration, and sustainable infrastructure development.
National Biodiversity Strategy and Action Plan (NBSAP) 2019–2030	Calls for conservation of ecosystems and species, reduction of habitat fragmentation, restoration of degraded habitats, control of invasive species, and integration of biodiversity into transport and infrastructure sectors.
Sessional Paper No. 3 of 2009 on National Land Policy	Promotes sustainable land use planning, protection of fragile ecosystems, management of public land, and prevention of land degradation arising from development projects.
National Land Use Policy, 2017	Requires orderly land use planning, protection of environmentally sensitive areas, zoning of infrastructure corridors, and control of unplanned roadside development.
National Wildlife Policy, 2020	Supports conservation of wildlife habitats and corridors, reduction of human–wildlife conflict, community participation in wildlife management, and integration of wildlife concerns into infrastructure development.
Forest Policy, 2014	Promotes protection of forests, riparian vegetation, hilltop and catchment forests, restoration of degraded landscapes, and increased tree cover in development areas.
Wetlands Conservation and Management Policy, 2015	Requires protection of wetlands, floodplains, springs, marshes, and riparian systems; discourages activities that alter hydrology or degrade wetland biodiversity.

National Water Policy, 2021	Supports integrated water resource management, catchment protection, maintenance of environmental flows, prevention of pollution, and sustainable drainage infrastructure.
National Climate Change Policy, 2018	Requires climate-proofing of infrastructure, adaptation to floods, droughts, erosion, and slope instability, and protection of ecosystems that support climate resilience.
National Climate Change Action Plan (NCCAP)	Promotes climate-resilient transport infrastructure, watershed restoration, landscape rehabilitation, and nature-based solutions for adaptation.
National Policy for Disaster Risk Management	Encourages risk reduction for landslides, floods, erosion, and infrastructure vulnerability through early planning and resilience measures.
Kenya Roads Board / Transport Sector Policies	Promote safe, efficient, and sustainable transport systems while integrating environmental and social safeguards into road development projects.

2.2 Legal Framework

The proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors is subject to Kenya's legal framework governing environmental management, biodiversity conservation, land administration, water resources, forests, public roads, occupational safety, and community rights. These laws establish mandatory requirements for project planning, licensing, construction, operation, monitoring, and restoration. The Biodiversity Management Plan (BMP) provides the mechanism through which ecological compliance obligations are translated into practical site-level actions. The following legal instruments are most relevant to the project.

Table 2-2- Legal Framework/Instruments

Legal Instrument	Key Provisions Relevant to BMP
Constitution of Kenya, 2010	Article 42 guarantees the right to a clean and healthy environment. Article 69 requires sustainable exploitation of natural resources, protection of biodiversity, public participation, and environmental restoration. Article 70 provides enforcement remedies for environmental harm.
Environmental Management and Coordination Act (EMCA), 1999 (Revised 2015)	Requires Environmental Impact Assessment (EIA) for road projects; mandates environmental restoration orders, pollution prevention, biodiversity protection, environmental monitoring, and compliance with licence conditions.
Environmental (Impact Assessment and Audit) Regulations, 2003	Requires EIA study, approval before commencement, implementation of Environmental Management Plans, environmental audits, and ongoing compliance reporting.
Wildlife Conservation and Management Act, 2013	Protects wildlife species and habitats; requires conservation of wildlife corridors and migratory routes; prohibits hunting and disturbance of wildlife; provides mechanisms for human–wildlife conflict management.
Water Act, 2016	Protects water resources, riparian reserves, catchments, and water quality; regulates works affecting rivers and drainage systems; requires permits where relevant.
Forest Conservation and Management Act, 2016	Protects public and community forests, indigenous trees, water catchments, and forest biodiversity; regulates tree removal and forest disturbance.

Land Act, 2012	Governs land acquisition, easements, access rights, compensation, and responsible use of land for public infrastructure.
National Land Commission Act, 2012	Provides procedures for compulsory acquisition, public land administration, and land-use oversight relevant to road reserve expansion.
Physical and Land Use Planning Act, 2019	Requires alignment of infrastructure projects with approved land use plans; supports orderly development and protection of environmentally sensitive areas.
Public Roads and Roads of Access Act (Cap 399)	Provides legal basis for declaration, management, protection, and access control of road reserves and public roads.
Kenya Roads Act, 2007	Establishes road authorities including KeNHA; mandates management, development, rehabilitation, and maintenance of classified roads.
Occupational Safety and Health Act, 2007	Requires safe working conditions, hazard prevention, dust/noise control, and worker welfare during construction activities.
Public Health Act (Cap 242)	Addresses sanitation, waste management, nuisance prevention, drainage, dust, and health risks to nearby communities.
County Governments Act, 2012	Supports county participation in planning, natural resource management, and local stakeholder engagement.
Access to Information Act, 2016	Supports transparency, disclosure of environmental information, and informed public participation.

2.3 Regional Commitments

Kenya is a member of several regional institutions and environmental cooperation frameworks that promote sustainable development, biodiversity conservation, climate resilience, and responsible infrastructure planning across East Africa and the wider African region. These regional commitments are relevant to the proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors because they encourage member states to integrate ecological safeguards into development projects, maintain ecosystem connectivity, protect shared natural resources, and reduce environmental degradation. The Biodiversity Management Plan (BMP) contributes to the implementation of these regional obligations through site-specific mitigation, monitoring, and adaptive management measures.

These regional commitments reinforce the need for the proposed road project to be implemented in a manner that conserves biodiversity, protects watersheds, reduces erosion and pollution, maintains wildlife movement pathways, and strengthens resilience to climate variability. They also recognise that infrastructure development should contribute to sustainable regional growth without undermining ecosystem services and community livelihoods. For this project, the BMP supports these commitments through practical measures such as slope stabilisation, drainage management, riparian restoration, invasive species control, wildlife crossing provisions, habitat rehabilitation, and continuous environmental monitoring. In doing so, the project aligns local road development with broader East African and African regional sustainability objectives.

Table 2-3- Regional Commitments Relevant to the Biodiversity Management Plan for the Proposed Road Upgrading Project

Regional Instrument / Commitment	Key Provisions Relevant to BMP
East African Community (EAC) Treaty	Requires Partner States to cooperate in environmental management, conservation of natural resources, sustainable transport systems, and harmonised environmental standards for regional development projects.
Protocol for Sustainable Development of Lake Victoria Basin	Promotes catchment protection, soil conservation, water quality management, biodiversity conservation, and control of land degradation in upstream basins influencing regional watersheds.
EAC Climate Change Policy and Strategy	Encourages climate-resilient infrastructure, watershed restoration, ecosystem-based adaptation, disaster risk reduction, and integration of climate considerations into transport planning.
East African Community Transboundary Ecosystems Management Framework	Supports maintenance of ecological connectivity, conservation corridors, and collaborative management of migratory species and shared ecosystems.
African Union Agenda 2063	Promotes sustainable infrastructure development, environmental stewardship, climate resilience, and protection of Africa's natural capital as part of long-term economic transformation.
African Convention on the Conservation of Nature and Natural Resources (Maputo Convention)	Requires conservation of soil, water, flora, fauna, and ecological processes while ensuring development projects minimise environmental harm.
Intergovernmental Authority on Development (IGAD) Environmental Strategies	Encourages drought resilience, sustainable land management, ecosystem restoration, and climate adaptation in arid and semi-arid regions.
COMESA Environmental and Natural Resources Programmes	Promote sustainable transport corridors, environmental safeguards, biodiversity protection, and natural resource management across regional trade networks.
African Development Bank Integrated Safeguards System (Regional Financing Context)	Requires biodiversity protection, pollution control, climate resilience, stakeholder engagement, and mitigation of environmental impacts for financed infrastructure projects.

2.4 International Agreements and Commitments

Kenya is party to a number of international environmental conventions, treaties, and global commitments that require biodiversity conservation, sustainable development, climate resilience, pollution prevention, and responsible management of natural resources. These international obligations are relevant to the proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors because infrastructure development should be implemented in a manner that does not undermine ecosystems, species conservation, water resources, or community well-being. The Biodiversity Management Plan (BMP) provides the project-level mechanism for translating these global commitments into practical mitigation, monitoring, and adaptive management actions.

These international agreements collectively require that the project integrates biodiversity conservation into infrastructure delivery, avoids unnecessary ecological degradation, protects wetlands and watercourses, maintains wildlife movement pathways, reduces land degradation, and improves resilience to climate change. They also reinforce the importance of stakeholder engagement, fair labour practices, and sustainable resource use. For the proposed road project, the BMP operationalises these commitments through measures such as avoidance of sensitive habitats, riparian protection, slope stabilisation, erosion control, invasive species management, wildlife crossing opportunities, habitat restoration, environmental monitoring, and adaptive management during construction and operation. By aligning with these global frameworks, the project demonstrates commitment to internationally recognised principles of environmentally sustainable infrastructure development.

Table 2-4:International Commitments Relevant to the Biodiversity Management Plan for the Proposed Road Upgrading Project

International Agreement / Commitment	Key Provisions Relevant to BMP
Convention on Biological Diversity (CBD), 1992	Requires conservation of biological diversity, sustainable use of ecosystems, restoration of degraded habitats, prevention of biodiversity loss, and mainstreaming biodiversity into sectoral development planning.
Kunming–Montreal Global Biodiversity Framework, 2022	Calls for reduction of habitat loss, restoration of degraded ecosystems, control of invasive species, protection of ecological connectivity, and integration of biodiversity into infrastructure planning.
Convention on International Trade in Endangered Species (CITES)	Requires protection of listed wildlife species from illegal exploitation; relevant to preventing poaching risks and disturbance of protected fauna during project implementation.
Ramsar Convention on Wetlands, 1971	Requires wise use and protection of wetlands, floodplains, marshes, riparian systems, and ecological functions associated with water bodies.
United Nations Framework Convention on Climate Change (UNFCCC)	Requires climate-responsive development planning, adaptation to climate risks, and reduction of vulnerability of infrastructure and ecosystems.
Paris Agreement, 2015	Supports climate-resilient infrastructure, ecosystem-based adaptation, carbon sequestration through restoration, and sustainable land management.
United Nations Convention to Combat Desertification (UNCCD)	Promotes land degradation neutrality, soil conservation, vegetation restoration, erosion control, and sustainable management of dryland landscapes.
Convention on Migratory Species (CMS / Bonn Convention)	Encourages conservation of migratory species, movement routes, dispersal areas, and habitat connectivity.
UN Sustainable Development Goals (SDGs)	Particularly SDG 9 (Infrastructure), SDG 13 (Climate Action), SDG 15 (Life on Land), SDG 6 (Clean Water), and SDG 11 (Sustainable Communities).
ILO Core Labour Standards	Relevant to ethical labour practices, safe working conditions, and prevention of illegal or exploitative labour practices during construction.
UN Declaration on the Rights of Indigenous Peoples / Human Rights Principles	Supports participation, consultation, equitable treatment, and protection of communities affected by development projects.

2.5 International Standards and Guidelines

2.5.1 African Development Bank Integrated Safeguards System (ISS), 2023

The proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors must align with the African Development Bank (AfDB) Integrated Safeguards System (ISS), 2023. The ISS establishes mandatory requirements for identifying, assessing, mitigating, monitoring, and managing environmental and social risks throughout the project lifecycle. It ensures infrastructure development contributes to sustainability while minimizing adverse impacts on biodiversity, ecosystems, communities, and human well-being.

By adopting an integrated risk-based approach, the framework emphasizes climate resilience, social inclusion, stakeholder engagement, and adaptive management. It recognizes that linear infrastructure can generate significant direct, indirect, induced, and cumulative impacts if ecological considerations are omitted from project planning, design, construction, and operation.

This framework is highly relevant because the road corridors traverse ecologically sensitive escarpment systems, riparian zones, wetlands, woodland patches, agricultural mosaics, wildlife movement areas, and erosion-prone landscapes within Elgeyo Marakwet County. The project has the potential to alter biodiversity, ecological connectivity, hydrological systems, slope stability, and community livelihoods. Consequently, this Biodiversity Management Plan (BMP) has been prepared to fulfill AfDB requirements and integrate conservation into all project phases.

The ISS comprises several Environmental and Social Operational Safeguards (ESOSs). The safeguards most relevant to this BMP include:

- **ESOS1:** Environmental and Social Assessment
- **ESOS3:** Resource Efficiency and Pollution Prevention and Management
- **ESOS4:** Community Health, Safety and Security
- **ESOS5:** Land Acquisition, Restrictions on Land Use and Involuntary Resettlement
- **ESOS6:** Biodiversity Conservation and Sustainable Management of Living Natural Resources
- **ESOS10:** Stakeholder Engagement and Information Disclosure

Among these, ESOS6 serves as the primary international safeguard basis for this plan. It specifically governs habitat protection, ecosystem services, ecological connectivity, invasive species control, and the restoration of degraded ecosystems.

The ISS mandates the application of the mitigation hierarchy as its central operational principle:

1. **Avoid:** Prevent impacts wherever feasible, particularly within high-conservation-value habitats.
2. **Minimize:** Reduce the scale of disturbance and degradation where impacts are unavoidable.
3. **Restore:** Rehabilitate disturbed ecosystems to regain ecological functionality.
4. **Offset:** Address significant, residual impacts through compensatory restoration mechanisms.

Because impacts extend beyond the immediate road reserve, the BMP adopts a landscape-scale, ecosystem-based approach. The assessment accounts for a full spectrum of risks across the wider Kerio Valley and escarpment landscape:

- **Direct Impacts:** Vegetation clearance, habitat loss, wildlife disturbance, erosion, sedimentation, and construction-related pollution.

- **Indirect Impacts:** Increased settlement pressure, agricultural expansion, fuelwood extraction, and the spread of invasive species driven by improved road accessibility.
- **Induced Impacts:** Long-term land-use transformation and economic development stimulated by the transport infrastructure.
- **Cumulative Impacts:** Environmental pressures arising from the interaction of this project with other existing or planned regional developments.

Furthermore, the ISS requires infrastructure to incorporate climate resilience and ecosystem-based adaptation. Because these corridors are vulnerable to erosion, flooding, landslide risks, and extreme rainfall, the BMP integrates slope stabilization, drainage control, riparian restoration, and the protection of watershed vegetation cover into the engineering considerations.

To support communities that depend heavily on local ecosystem services (such as water supply, grazing land, and flood regulation), the ISS requires meaningful stakeholder engagement. Affected communities must be consulted throughout the project lifecycle, with concerns addressed via effective grievance redress mechanisms and participatory monitoring.

Finally, the framework mandates continuous environmental monitoring and adaptive management. Monitoring data will trigger corrective actions to address emerging risks or unforeseen ecological shifts. To execute this, the BMP establishes a monitoring framework with specific indicators tracking vegetation recovery, invasive species spread, erosion severity, water quality, wildlife movement, and wildlife-vehicle collisions.

Ultimately, alignment with the ISS ensures that this project avoids net ecological degradation, rehabilitates auxiliary sites like borrow pits, and reflects international good practice for sustainable infrastructure development.

2.5.1.1 Environmental and Social Operational Safeguard 6 (ESOS6): Biodiversity Conservation and Sustainable Management of Living Natural Resources

ESOS6 establishes specific operational mandates to ensure that project activities protect and conserve biodiversity, maintain ecosystem services, and sustainably manage living natural resources. This safeguard applies to all projects that affect or depend on these resources, requiring a precautionary approach to resource management. For the proposed road upgrading project, ESOS6 dictates stringent compliance pathways across several critical areas:

- **Habitat Classification and Requirements**

The safeguard categorizes habitats based on their ecological sensitivity and imposes differentiated management requirements for each:

- **Modified Habitats:** Areas containing alterations to the natural percentage of species. Project activities must minimize further degradation and implement restoration measures where technically feasible.
- **Natural Habitats:** Areas composed of viable assemblages of plant and animal species of largely native origin. The project may only proceed if no viable alternative locations exist, and if mitigation measures ensure no net loss of biodiversity.
- **Critical Habitats:** High-biodiversity-value areas, including protected reserves, habitats of endangered species, and unique ecosystems. Under ESOS6, the project cannot be implemented

in critical habitats unless there are no measurable adverse impacts on the criteria that qualify the area as critical, and a net gain in biodiversity is demonstrably achievable.

- **Key Operational Mandates for the Road Corridors**

To fulfill ESOS6 requirements within the ecologically diverse Elgeyo Marakwet and Kerio Valley landscapes, the project must implement the following operational controls:

- **Invasive Alien Species (IAS) Control:** Project activities must prevent the introduction or spread of invasive plant and animal species. The BMP enforces strict sanitation protocols for construction machinery and mandates the eradication of colonized alien flora along the road reserves.
- **Management of Living Natural Resources:** Any extraction of natural materials or use of local biotic resources must follow sustainable management practices, ensuring local communities do not lose access to vital non-timber forest products or grazing assets.
- **Protection of Ecosystem Services:** Since local communities rely on watershed stability, soil retention, and natural flood regulation, construction actions must not degrade these services. Special attention is directed toward maintaining riparian buffer zones and protecting natural hydrological flows.

2.5.1.2 ESOS6 Compliance Matrix for Road Corridors

To ensure systematic adherence to the African Development Bank's requirements, Table 2.X maps the specific operational triggers of ESOS6 to the corresponding engineering and environmental management actions mandated within this Biodiversity Management Plan (BMP).

Table 2-5: ESOS6 Compliance and Mitigation Mapping Matrix

ESOS6 Core Requirement	Project Risk & Application Context	Mandated BMP Action / Compliance Pathway
Precautionary Approach	Uncertain ecological impacts within the sensitive escarpment and riparian zones.	Implementation of continuous, participatory ecological monitoring; immediate halting of works if unforeseen wildlife corridors or rare species are detected.
No Net Loss / Net Gain	High-biodiversity-value areas across Elgeyo Marakwet County face residual degradation.	Enforcement of strict clearing limits within road reserves; mandatory 1:1 revegetation for natural habitats, and targeted offset programs to achieve net gain in critical zones.
Invasive Species Management	Earthworks and soil movement facilitate the spread of aggressive alien flora (e.g., *Prosopis juliflora* or *Lantana camara*).	Mandatory vehicle wash-down stations at construction boundaries; regular post-construction eradication sweeps; exclusive use of certified native seed mixes for slope stabilization.
Protection of Ecosystem Services	Siltation of wetlands, disruption of community water catchments, and increased soil erosion risks.	Demarcation of 30-meter riparian buffer zones; installation of silt fences and sediment traps; restriction of heavy machinery near active hydrological channels.

Sustainable Resource Management	Potential over-exploitation of local woodland patches for construction timber or fuelwood.	Absolute prohibition of wood sourcing from local forests; mandatory procurement of commercial, certified timber; provisioning of alternative energy sources for worker camps.

2.5.1.3 Borrow Pit and Quarry Rehabilitation Requirements

The exploitation of material source sites (borrow pits and quarries) presents severe localized risks to biodiversity, including habitat fragmentation, steep-slope safety hazards, stagnant water hazards, and accelerated soil erosion. Under ESOS6, these ancillary facilities are treated with the same compliance rigor as the primary road alignment. The project must execute the following time-bound rehabilitation protocol:

- **Progressive Rehabilitation:** Extraction activities must follow a phased approach. Re-vegetation and contouring must begin on exhausted sections of a borrow pit while extraction continues in active zones, rather than delaying all restoration until decommissioning.
- **Topsoil Management:** Before extraction, the top 30–50 cm of organic topsoil must be stripped and stockpiled separately in low, aerated mounds (not exceeding 2 meters in height) to maintain soil microbe viability. This soil must be protected from erosion and reused exclusively for final site resurfacing.
- **Geotechnical Stabilization:** Quarry faces and borrow pit walls must be sloped back to a safe gradient (maximum 1:2 or 1:3 depending on material stability) to prevent landslides, facilitate safe wildlife movement, and eliminate trapping hazards.
- **Drainage and Vector Control:** Final profiling must ensure positive drainage to prevent the formation of permanent, stagnant water pools, which present drowning risks to wildlife and disease-vector breeding grounds for local communities. Where integration into local hydrology is beneficial, sites may be converted into managed community water pans with lined, gradual banks.
- **Revegetation and Ecological Succession:** Resurfaced areas must be scarified to loosen compacted subsoil, covered with stockpiled topsoil, and planted with indigenous grasses, pioneering shrubs, and deep-rooted trees native to the Elgeyo Marakwet ecosystem to catalyze natural ecological succession.

2.5.1.4 Alignment of the Biodiversity Management Plan with Applicable AfDB Environmental and Social Operational Safeguards

While this Biodiversity Management Plan (BMP) is primarily prepared to meet the requirements of Environmental and Social Operational Safeguard 6 (ESOS6): Biodiversity Conservation and Sustainable Management of Living Natural Resources, its implementation also contributes to compliance with several other safeguards under the African Development Bank (AfDB) Integrated Safeguards System (ISS), 2023.

Table 2-6 summarises the Environmental and Social Operational Safeguards relevant to the proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors and outlines how the BMP supports their implementation. Detailed requirements relating to social safeguards, land acquisition, labour management, and cultural heritage are addressed through complementary project instruments, including the Environmental and Social Impact Assessment (ESIA), Resettlement Action Plan (RAP), Stakeholder Engagement Plan (SEP), Labour Management Procedures (LMP), and associated Environmental and Social Management Plans (ESMPs).

Table 2-6: Summary of ESOS Relevant to the Proposed Project

ESOS	Title	Triggered?	How This BMP Addresses the ESOS
ESOS1	Assessment and Management of Environmental and Social Risks and Impacts	**YES** – Road upgrading requires assessment of direct, indirect, cumulative, and climate-related impacts.	Chapter 4 (summary of biodiversity surveys), Chapter 5 (potential adverse impacts), Chapter 6 (mitigation), Chapter 7 (monitoring). Incorporates mitigation hierarchy and climate resilience (e.g., drainage design for increased rainfall intensity).
ESOS2	Labor and Working Conditions	**YES** – Construction workforce exposed to occupational and environmental risks.	Worker training on biodiversity protection (M-CC-04); prohibition of hunting/trapping wildlife; contractor HSE plans; inclusion of SEA/SH prevention measures.
ESOS3	Resource Efficiency and Pollution Prevention and Management	**YES** – Construction activities involve earthworks, materials use, and potential pollution.	Sediment control (M-BC-08, M-KE-03); dust suppression (M-BC-14); spill prevention and hazardous material management; invasive species waste disposal (M-BC-11).
ESOS4	Community Health, Safety, and Security	**YES** – Risks to communities from traffic, construction activities, and human-wildlife conflict.	Human-wildlife conflict early warning system (M-CC-01); land-use advisory (M-CC-02); traffic calming and signage (M-NK-07, M-BC-13).
ESOS5	Land Acquisition, Restrictions on Land Use, and Involuntary Resettlement	**YES** – Road widening may require land acquisition and affect livelihoods.	Addressed in a separate Resettlement Action Plan (RAP). BMP complements RAP through land-use advisory measures and biodiversity-related livelihood considerations.
ESOS6	Biodiversity Conservation and Sustainable Management of Living Natural Resources	**YES** – Project affects natural habitats, wildlife corridors, wetlands, and riparian ecosystems.	Core focus of this BMP. Includes mitigation hierarchy (avoid, minimize, restore, offset); no net loss approach (M-BC-01 to M-BC-15); protection of critical habitats (M-KE-01 to M-KE-06); wildlife crossings (M-NK-02); protection of threatened species; compensatory planting.
ESOS7	Vulnerable and Underserved Groups	**YES** – Presence of pastoralists and rural communities with	Inclusive stakeholder engagement; targeted consultation; integration with RAP livelihood restoration measures;

		limited access to services.	land-use advisory (M-CC-02) considers vulnerable groups.
ESOS8	Cultural Heritage	**PARTIALLY** – Potential impacts on culturally significant sites (e.g., sacred trees, burial sites).	Protection of culturally important species such as *Ficus sycomorus* (M-KE-06); chance finds procedures; community consultation. Detailed assessment addressed in separate cultural heritage study.
ESOS9	Financial Intermediaries	**NO** – Project is not implemented through financial intermediaries.	Not applicable.
ESOS10	Stakeholder Engagement and Information Disclosure	**YES** – Project affects multiple stakeholders requiring continuous engagement.	Grievance mechanism (Section 6); participatory approaches in early warning system (M-CC-01) and land-use advisory (M-CC-02); ongoing consultation processes.

The Biodiversity Management Plan serves as a key implementation tool for operationalising the AfDB safeguard requirements at the project level. It translates the principles of biodiversity conservation, ecosystem protection, and sustainable land management into site-specific mitigation measures, monitoring indicators, and adaptive management actions applicable during the planning, construction, operation, and maintenance phases of the road project. Through alignment with the AfDB safeguard framework, the project demonstrates commitment to environmentally sustainable infrastructure development and strengthens its compliance with international financing requirements.

2.5.2 Equator Principles

The Equator Principles (EPs) are an internationally recognised risk management framework adopted by financial institutions to identify, assess, and manage environmental and social risks in major development projects. They are widely applied in project finance for infrastructure investments such as roads, energy, mining, ports, and large-scale transport corridors. Although not a law, the Equator Principles are highly influential because many international banks and lenders require compliance before financing projects. Their relevance to the proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors lies in ensuring that the project is planned and implemented in accordance with global good practice for environmental sustainability, biodiversity protection, and community safeguards.

The Equator Principles are aligned closely with the IFC Performance Standards and the World Bank Environmental, Health and Safety Guidelines. For this project, they reinforce the need for robust environmental and social due diligence, including assessment of biodiversity impacts, land acquisition risks, labour conditions, pollution control, climate resilience, stakeholder consultation, and long-term environmental management.

A key requirement under the Equator Principles is the preparation of an Environmental and Social Impact Assessment (ESIA) and supporting management plans such as the Biodiversity Management Plan (BMP). These documents should identify project risks, assess alternatives, prescribe mitigation measures, and establish monitoring systems throughout the project lifecycle. For the proposed roads, this means the BMP should clearly address slope instability, erosion, riparian disturbance, wildlife movement barriers, invasive species spread, community safety, and induced land-use change resulting from improved access.

The Equator Principles also require application of the mitigation hierarchy, meaning impacts should be avoided where feasible, minimised where unavoidable, rehabilitated after disturbance, and offset only as a last resort. This is particularly relevant to sensitive habitats along the project corridors such as escarpment vegetation, wetlands, river crossings, woodland patches, and movement routes used by wildlife or livestock.

Another important requirement is stakeholder engagement and information disclosure. Communities affected by construction impacts, land take, traffic disruption, flooding risk, or ecological change should be consulted in a transparent and timely manner. The project should maintain an accessible grievance redress mechanism allowing concerns to be raised and resolved efficiently.

The Equator Principles also place emphasis on independent monitoring and compliance reporting. Where projects are financed under EP frameworks, lenders often require regular reporting on implementation of environmental and social commitments. For this road project, monitoring may include vegetation restoration success, erosion control effectiveness, water quality at drainage crossings, road safety performance, biodiversity indicators, and contractor compliance.

Climate change considerations are increasingly embedded within the Equator Principles. Infrastructure projects are expected to consider physical climate risks such as extreme rainfall, flooding, slope failure, heat stress, and changing hydrological regimes. For the proposed roads, this means incorporating resilient drainage design, slope protection, and long-term maintenance planning under changing climatic conditions.

In practical terms, alignment with the Equator Principles strengthens the credibility and bankability of the proposed road upgrading project. It demonstrates that biodiversity and environmental risks are being proactively managed and that the project is consistent with internationally accepted sustainable finance standards.

Equator Principle Requirement	Key Provision	Relevance to Proposed Road Project	Recommended BMP Response
Environmental and Social Review	Assess environmental and social risks before financing approval.	Road corridors cross sensitive ecological and community landscapes.	Prepare robust ESIA and BMP with site-specific mitigation.
Applicable Standards	Apply IFC Performance Standards and EHS Guidelines.	International lenders may require global safeguards.	Align BMP with IFC PS6, pollution control, labour and safety standards.
Mitigation Hierarchy	Avoid, minimise, restore, offset residual impacts.	Vegetation loss, habitat fragmentation, erosion risks likely.	Prioritise route optimisation, footprint

			control, restoration, habitat recovery.
Management Plans	Implement environmental and social management plans.	Need operational controls during construction and operation.	Implement BMP, monitoring plans, contractor environmental plans.
Stakeholder Engagement	Conduct meaningful consultation and disclose information.	Communities may be affected by land take, traffic, water, and ecological change.	Maintain consultation process and grievance redress mechanism.
Biodiversity Protection	Manage impacts on habitats, species, and ecosystem services.	Riparian zones, escarpments, woodland patches, wildlife movement areas present.	Habitat screening, crossing structures, restoration, invasive species control.
Pollution Prevention	Prevent contamination, dust, noise, waste, and sedimentation.	Construction activities create environmental risks.	Dust suppression, waste management, spill prevention, erosion control.
Climate Risk Management	Consider physical climate risks and resilience.	High rainfall, flooding, slope instability, changing runoff patterns.	Climate-resilient culverts, slope stabilisation, adaptive maintenance.
Monitoring and Reporting	Track compliance and performance during implementation.	Need evidence of mitigation effectiveness.	Monitor vegetation recovery, erosion, biodiversity, safety, drainage function.
Independent Review	External review may be required for financed projects.	Large infrastructure projects often undergo lender review.	Maintain auditable records, transparent reporting, compliance evidence.

3 Approach and Methodology

3.1 Overview

The Biodiversity Management Plan (BMP) for the proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors was developed using an integrated ecosystem-based and risk-informed assessment approach. The methodology combined field-based biodiversity surveys, biophysical assessments, geospatial analysis, stakeholder consultations, ecological risk evaluation, and safeguard review in order to establish a comprehensive understanding of biodiversity conditions and potential project impacts within the project influence area.

The methodological approach was designed to align with the requirements of the African Development Bank (AfDB) Integrated Safeguards System (ISS), 2023, particularly Environmental and Social Operational Safeguard 6 (ESOS6) on Biodiversity Conservation and Sustainable Management of Living Natural Resources. The assessment further incorporated principles of the mitigation hierarchy, ecosystem-based management, ecological connectivity conservation, climate resilience, adaptive management, and sustainable infrastructure planning.

The study recognised that road infrastructure projects can generate both direct and indirect ecological impacts extending beyond the immediate road reserve. Consequently, the assessment considered the broader landscape context including escarpments, riparian systems, wetlands, woodland remnants, agricultural mosaics, wildlife movement areas, grazing lands, drainage systems, and settlement interfaces that may be influenced during construction and operation of the proposed roads.

The methodology integrated both qualitative and quantitative approaches to biodiversity assessment and environmental risk evaluation. Data collection focused on establishing baseline ecological conditions, identifying environmentally sensitive areas, assessing biodiversity patterns across taxa, evaluating ecosystem services, determining ecological connectivity, and identifying biodiversity risks associated with road upgrading activities.

3.2 Study Area Delineation

The study covered the proposed upgrading corridors of:

- Biretwo–Arror–Chesongoch;
- Nyaru–Kimwarer–Kapkayo; and
- Kimwarer–Emsea roads,

including areas likely to be directly or indirectly affected by project activities.

The assessment considered:

- the existing road reserve;
- proposed widening and realignment sections;
- drainage crossings;
- borrow pits;
- spoil disposal areas;
- contractor camps;
- material storage sites;
- temporary access roads; and
- adjacent ecological systems potentially affected by hydrological, erosional, or land-use changes associated with the project.

The study area was further stratified into ecologically distinct sections based on:

- topography;
- slope characteristics;
- vegetation type;
- hydrology;
- land use;
- ecological sensitivity; and
- biodiversity characteristics.

A chainage-based spatial assessment framework was adopted to enable identification of environmentally sensitive sections requiring targeted mitigation and monitoring measures.

3.3 Literature Review and Secondary Data Collection

Secondary information relevant to biodiversity and environmental management within the project area was reviewed prior to field investigations. The review included:

- previous ESIA studies;
- biodiversity reports;
- ecological literature;
- vegetation maps;
- geological and soil information;
- hydrological datasets;
- climate records;
- land use and land cover information;
- wildlife occurrence records;
- road engineering information;
- conservation planning documents;
- regional ecological studies; and
- national biodiversity databases where available.

Relevant policy, legal, and safeguard frameworks were also reviewed including:

- the Constitution of Kenya;
- EMCA;
- Wildlife Conservation and Management Act;
- Forest Conservation and Management Act;
- Water Act;
- National Biodiversity Strategy and Action Plan;
- AfDB ISS 2023;
- IFC Performance Standards;
- Convention on Biological Diversity;
- Ramsar Convention; and
- other applicable international biodiversity frameworks.

The literature review informed:

- identification of ecological sensitivities;
- selection of biodiversity indicators;
- field survey design;
- risk assessment criteria; and
- development of mitigation and monitoring measures.

3.4 Biophysical Environment Assessment

Assessment of the biophysical environment was undertaken to understand environmental conditions influencing biodiversity distribution, ecosystem processes, engineering risks, and ecological sensitivity along the road corridors.

The assessment included:

- topography and slope characteristics;
- geology and geomorphology;
- soil characteristics;
- hydrology and drainage systems;
- wetlands and riparian systems;
- rainfall and climatic variability;
- erosion susceptibility;
- flood-prone areas;
- land use and land cover; and
- vegetation structure.

Field observations were supplemented using:

- topographic maps;
- satellite imagery;
- digital elevation models (DEMs);
- hydrological maps; and
- GIS spatial analysis.

Slope-sensitive sections, escarpments, wetlands, drainage crossings, and erosion-prone landscapes were mapped and categorized according to ecological and engineering sensitivity.

3.5 Biodiversity Assessment Methodology

3.5.1 General Biodiversity Survey Approach

Biodiversity surveys were conducted to assess species composition, habitat characteristics, ecological condition, biodiversity hotspots, ecosystem services, and ecological connectivity within the project influence area.

The surveys focused on:

- flora;
- mammals;
- birds;
- reptiles;
- amphibians;
- ecologically important invertebrates; and
- habitat features of ecological significance.

Sampling locations were selected using a stratified ecological approach to ensure representation of major habitat types and environmental gradients occurring along the proposed road corridors.

Survey areas included:

- riparian corridors;

- wetlands;
- escarpments;
- woodland patches;
- grazing areas;
- agricultural mosaics;
- disturbed roadside habitats; and
- valley-bottom systems.

Field data collection incorporated:

- direct observations;
- transect surveys;
- opportunistic sightings;
- habitat assessments;
- photographic documentation;
- GPS location recording; and
- ecological condition assessment.

3.5.2 Survey Design and Sampling Effort

To ensure that the biodiversity baseline is scientifically robust, auditable, and reproducible, the biodiversity surveys were designed to provide representative coverage of the principal habitat types and ecological features occurring within the project's area of influence. Survey methods were selected based on the target taxonomic groups, habitat characteristics, ecological sensitivity, and accessibility of survey locations. The assessment combined primary field surveys, review of secondary information, and local ecological knowledge obtained through stakeholder consultations to establish a comprehensive biodiversity baseline.

Sampling locations were selected using a stratified ecological approach to ensure representation of the major habitat types and environmental gradients along the B122, B124 and B126 road corridors. Survey coverage included riparian corridors, wetlands, escarpments, woodland patches, grazing areas, agricultural mosaics, disturbed roadside habitats, and valley-bottom systems. Field observations were supplemented by photographic documentation, GPS location recording, habitat assessments, and ecological condition assessments.

Table 3-2 summarises the survey design, sampling effort, equipment used, identification procedures, and data quality assurance measures adopted for each biodiversity component.

Table 3-2: Summary of Biodiversity Survey Design

Biodiversity Component	Survey Period/Season	Sampling Locations and Spatial Coverage	Survey Method	Sampling Effort	Equipment Used	Species Identification and Verification	Data Quality Assurance
Flora and Vegetation	9–24 December 2025 (Wet Season)	Representative habitats along B122, B124 and B126,	Habitat assessments, vegetation observations, opportunistic	A transect walks of 500m were use in each habitat.	GPS receiver, digital camera, field	Standard botanical field guides, KEFRI publications	Photographic records, daily review of field notes

Biodiversity Component	Survey Period/Season	Sampling Locations and Spatial Coverage	Survey Method	Sampling Effort	Equipment Used	Species Identification and Verification	Data Quality Assurance
		including riparian areas, wetlands, woodlands, agricultural land and disturbed habitats	species recording	Search around the drainage intersections. And opportunistic observations were used.	notebook	, IUCN Red List where applicable	
Mammals	9–24 December 2025 (Wet Season)	Woodland, riparian, escarpment and valley habitats	Direct observations, indirect signs (tracks, dung, burrows), opportunistic sightings and stakeholder information	A transect walks of 500m were use in each habitat. Local accounts in each habitat. Camera traps. Opportunistic observations were used.	GPS receiver, binoculars, digital camera	Standard mammal field guides, IUCN Red List, consultation with KWS where necessary	Cross-checking with local ecological knowledge and photographic verification
Birds	9–24 December 2025 (Wet Season)	Representative habitats across the project corridor	Visual observations, point counts/opportunistic observations (as applicable)	5 Point counts within the 500m Transect walks of were use in each habitat. Opportunistic observations on drainage intersections.	Binoculars, GPS receiver, digital camera	East African bird field guides and IUCN Red List	Photographic verification and validation of unusual records
Reptiles	9–24 December 2025 (Wet Season)	Rocky outcrops, riparian areas, escarpments and disturbed habitats	Timed visual encounter surveys and opportunistic observations	Timed visual encounter surveys (30 minutes) on the 500m	GPS receiver, digital camera	Standard reptile identification guides	Photographic verification and habitat confirmation
Amphibians	9–24 December 2025 (Wet Season)	Streams, wetlands, riparian habitats and seasonal water bodies	Timed visual encounter surveys and opportunistic observations	Timed visual encounter surveys (30 minutes) on the 500m	GPS receiver, digital camera	Standard amphibian field guides	Verification through habitat association and photographic records
Ecologically Important Invertebrates	9–24 December 2025	Representative terrestrial and riparian habitats	Sweep netting, Opportunistic survey.	Sweeping of 100m transect	Sweep nets, GPS receiver	Standard identification guides	Photographic verification

Biodiversity Component	Survey Period/Season	Sampling Locations and Spatial Coverage	Survey Method	Sampling Effort	Equipment Used	Species Identification and Verification	Data Quality Assurance
	(Wet Season)				, digital camera	where applicable	

3.5.3 Secondary Data Sources

Primary field surveys were supplemented by a review of relevant secondary information to improve the completeness of the biodiversity baseline and verify species occurrence within the project area. The review included published literature, government reports, biodiversity databases, satellite imagery, and conservation planning documents. Key information sources included:

- International Union for Conservation of Nature (IUCN) Red List of Threatened Species;
- Kenya Wildlife Service (KWS) reports and species records;
- National Museums of Kenya publications and database
- Kenya Forestry Research Institute (KEFRI) publications;
- National Biodiversity Strategy and Action Plan (NBSAP);
- relevant peer-reviewed scientific literature;
- land cover and satellite imagery, and;
- other relevant government and institutional reports.

3.5.4 Stakeholder and Local Ecological Knowledge

Local ecological knowledge was obtained through stakeholder consultations undertaken during the biodiversity field surveys. Information was collected through key informant interviews, community meetings, and informal discussions with local communities, village elders, community leaders, livestock herders, Kenya Wildlife Service officers, County Government representatives, and other knowledgeable resource users.

Discussions focused on:

- wildlife occurrence and seasonal movement patterns;
- human–wildlife conflict hotspots;
- environmentally sensitive habitats;
- vegetation changes;
- ecosystem services;
- culturally important species;
- flooding and erosion; and
- historical changes in biodiversity within the project area.

The information obtained was used to validate field observations, supplement secondary information, identify environmentally sensitive areas, and improve understanding of ecological processes that may not have been captured during the field survey period.

3.5.5 Data Quality Assurance and Limitations

Field observations were recorded using GPS-enabled devices and supported by photographic documentation where appropriate. Species identifications were undertaken using standard taxonomic references and verified against recognised conservation databases and published literature. Field data were reviewed daily to ensure completeness, consistency, and positional accuracy before incorporation into the biodiversity database.

The principal limitations of the biodiversity assessment are presented in **Section 3.16**, including constraints related to seasonal variability, accessibility, detectability of cryptic species, and the reliance on rapid assessment methods for selected taxa.

3.6 Vegetation and Flora Assessment

Vegetation assessments were undertaken to characterize:

- vegetation communities;
- habitat structure;
- floristic composition;
- ecological condition;
- dominant species;
- invasive species occurrence; and
- ecologically important plant species.

Field surveys involved:

- systematic vegetation observations;
- habitat characterization;
- species identification;
- recording of indigenous and exotic species;
- identification of mature indigenous trees;
- mapping of riparian vegetation; and
- assessment of ecologically important species such as Ficus sycomorus.

Vegetation types were classified according to:

- dominant structural characteristics;
- ecological function;
- moisture regime; and
- land-use influence.

Particular attention was given to:

- riparian vegetation;
- escarpment vegetation;
- woodland remnants;
- wetlands;
- erosion-sensitive areas; and
- disturbed habitats vulnerable to invasive species colonization.

Invasive species presence, abundance, and distribution were also documented to support development of invasive species management measures.

3.7 Mammal Assessment

Mammal surveys focused on identifying:

- species occurrence;
- habitat use;
- movement pathways;
- signs of wildlife activity; and
- areas of potential human-wildlife interaction.

Assessment methods included:

- direct visual observations;
- identification of tracks and footprints;
- dung observations;
- feeding signs;
- burrows;
- vocalizations;
- roadkill observations; and
- community interviews where relevant.

Special emphasis was placed on:

- wildlife movement corridors;
- riparian movement pathways;
- escarpment refugia;
- grazing interfaces; and
- areas of known wildlife movement or human-wildlife conflict.

Potential roadkill hotspots and wildlife crossing areas were identified to inform design of mitigation measures such as fauna-friendly culverts, underpasses, signage, and speed control interventions.

3.8 Bird Assessment

Bird surveys were conducted because avifauna are important ecological indicators reflecting habitat condition, ecosystem integrity, and landscape connectivity.

Bird assessments involved:

- direct observation;
- point counts;
- opportunistic sightings;
- identification by calls and vocalizations; and
- habitat-based observations.

Surveys were undertaken across different habitat types including:

- riparian systems;
- wetlands;
- woodland patches;
- open savanna;
- agricultural landscapes; and
- settlement mosaics.

The assessment documented:

- species richness;
- relative abundance;
- habitat associations;
- ecological guilds;
- migratory species; and
- species of conservation concern.

Particular attention was given to:

- riparian bird diversity;
- wetland-associated species;
- raptors;
- pollinator-associated species; and
- areas potentially vulnerable to disturbance during road construction.

3.9 Invertebrate Assessment

Invertebrate surveys focused primarily on ecologically important groups serving as indicators of ecosystem condition and ecological functionality.

Assessment targeted:

- butterflies;
- dragonflies;
- bees;
- pollinators;
- termites; and
- other conspicuous invertebrate groups.

Field methods included:

- direct observation;
- opportunistic recording;
- habitat-based searches; and
- photographic identification.

Special consideration was given to:

- pollinator habitats;

- wetland-associated invertebrates;
- termite mound distribution;
- riparian ecological function; and
- habitat disturbance sensitivity.

Termite mound occurrence was assessed because of its importance in:

- soil turnover;
- ecosystem productivity;
- infiltration processes; and
- semi-arid ecological functioning.

3.10 Herpetofauna Assessment

Reptile and amphibian assessments focused on:

- species occurrence;
- habitat use;
- wetland associations;
- riparian systems; and
- microhabitat conditions.

Assessment methods included:

- visual encounter surveys;
- opportunistic sightings;
- habitat inspections;
- observations near wetlands and drainage systems; and
- recording of basking and sheltering sites.

Sensitive habitats including wetlands, riverbanks, moist refugia, and rocky escarpment areas were specifically assessed due to their importance for reptile and amphibian diversity.

3.11 Ecosystem Services Assessment

An ecosystem services assessment was undertaken to evaluate the ecological and socio-economic functions provided by ecosystems within the project area.

The assessment considered:

- water regulation;
- erosion control;
- flood attenuation;
- slope stabilization;
- pollination;
- carbon storage;
- forage provision;
- fuelwood supply;

- microclimate regulation; and
- biodiversity support functions.

The analysis integrated:

- field observations;
- land-use patterns;
- vegetation condition;
- hydrological characteristics; and
- community dependence on natural resources.

The assessment supported identification of ecologically sensitive areas and informed development of mitigation measures aimed at maintaining ecosystem functionality and resilience.

3.12 Ecological Connectivity Assessment

Ecological connectivity assessment focused on identifying:

- wildlife movement pathways;
- riparian linkages;
- escarpment corridors;
- wetland connections;
- drainage-linked habitats; and
- landscape connectivity patterns.

The assessment integrated:

- field observations;
- habitat continuity analysis;
- topographic interpretation;
- hydrological mapping; and
- evidence of wildlife movement.

Potential barriers to movement associated with road upgrading were identified, including:

- widened carriageways;
- embankments;
- drainage modifications; and
- increased traffic.

The assessment informed recommendations for:

- wildlife crossings;
- culvert sizing;
- fauna-friendly drainage structures;
- connectivity protection; and
- road safety interventions.

3.13 GIS and Spatial Analysis

Geographical Information Systems (GIS) and spatial analysis were used extensively to support biodiversity assessment and environmental sensitivity mapping.

Spatial datasets included:

- satellite imagery;
- topographic maps;
- digital elevation models;
- drainage networks;
- land use data;
- biodiversity observation points; and
- infrastructure alignments.

GIS analysis supported:

- habitat mapping;
- ecological sensitivity assessment;
- slope analysis;
- drainage characterization;
- chainage-based risk identification;
- biodiversity hotspot identification; and
- mapping of critical and sensitive ecological areas.

Spatial analysis further supported identification of:

- riparian systems;
- wetlands;
- escarpment sections;
- wildlife movement areas;
- erosion-prone landscapes; and
- areas requiring targeted mitigation measures.

3.14 Biodiversity Risk and Impact Assessment

Potential biodiversity impacts associated with the project were assessed for both construction and operational phases.

The assessment considered:

- direct impacts;
- indirect impacts;
- induced impacts; and
- cumulative impacts.

Potential impacts evaluated included:

- vegetation clearance;

- habitat fragmentation;
- erosion and sedimentation;
- disturbance to wildlife;
- pollution;
- invasive species spread;
- hydrological alteration;
- roadkill;
- slope instability;
- wetland disturbance; and
- long-term land-use change.

Risk assessment incorporated:

- ecological sensitivity;
- likelihood of occurrence;
- impact magnitude;
- spatial extent;
- duration;
- reversibility; and
- significance of affected biodiversity features.

A chainage-based risk framework was used to identify high-risk sections requiring enhanced mitigation and monitoring.

3.15 Stakeholder Consultation and Community Engagement

Stakeholder consultations were undertaken to obtain local ecological knowledge and understand community interactions with biodiversity and ecosystem services.

Consultations included engagement with:

- local communities;
- government agencies;
- conservation stakeholders;
- local leaders;
- land users; and
- other relevant institutions.

Discussions focused on:

- wildlife movement;
- human-wildlife conflict;
- flooding;
- erosion;
- water resources;
- vegetation changes;
- ecosystem services;

- culturally important species; and
- environmentally sensitive areas.

Stakeholder input contributed to:

- identification of biodiversity concerns;
- validation of field observations;
- understanding ecosystem service dependence; and
- development of locally relevant mitigation measures.

3.16 Data Analysis

Biodiversity data were analyzed using descriptive ecological methods and biodiversity indices to assess:

- species richness;
- species abundance;
- habitat condition;
- ecological diversity; and
- ecosystem characteristics.

Analysis included:

- species richness calculations;
- Shannon–Wiener Diversity Index;
- Simpson's Diversity Index;
- comparative habitat assessment; and
- ecological interpretation of species distribution patterns.

Spatial analysis outputs were integrated with biodiversity findings to identify:

- biodiversity hotspots;
- sensitive habitats;
- ecological corridors;
- erosion-prone sections; and
- areas requiring priority management intervention.

3.17 Development of Mitigation and Monitoring Measures

Mitigation and monitoring measures were developed based on:

- field findings;
- biodiversity sensitivity;
- ecosystem service importance;
- risk assessment outcomes;
- ecological connectivity considerations;
- stakeholder input; and
- AfDB ISS 2023 safeguard requirements.

Mitigation measures were structured according to the mitigation hierarchy:

- Avoid;
- Minimise;
- Restore; and
- Offset where necessary.

Monitoring indicators were developed to assess:

- vegetation recovery;
- erosion severity;
- invasive species occurrence;
- wildlife movement;
- roadkill;
- riparian habitat condition;
- drainage functionality; and
- restoration effectiveness.

The monitoring framework incorporates adaptive management principles to ensure that mitigation measures are revised and strengthened where monitoring indicates inadequate environmental performance.

3.18 Limitations of the Study

The biodiversity assessment was undertaken within the available study timeframe and seasonal conditions prevailing during field surveys. Some ecological processes and species distributions may vary seasonally, particularly for migratory birds, amphibians, flowering plants, and wet-season-dependent fauna.

Accessibility challenges associated with steep escarpment terrain, dense vegetation, weather conditions, and remote landscapes also limited access to some sections of the project area.

Despite these limitations, the combination of field surveys, spatial analysis, stakeholder engagement, literature review, and ecosystem-based assessment provided a sufficiently robust baseline for identification of biodiversity sensitivities, ecological risks, and development of appropriate biodiversity management measures for the proposed road upgrading project.

4 Biodiversity Overview and Ecological Significance of the Project Area

4.1 Landscape Characteristics and Habitat Diversity

The proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors traverse a biologically diverse escarpment-to-valley landscape within Elgeyo Marakwet County. The project area contains a mosaic of natural, semi-natural, and human-modified habitats including riparian corridors, wetlands, woodland remnants, bushland, wooded grassland, rocky escarpments, agroforestry systems, croplands, grazing lands, and settlement landscapes. Strong environmental gradients associated with elevation, rainfall, slope, soils, and land use create varied ecological niches that support a broad range of flora and fauna across the landscape. Overall, the project area can be considered an ecologically important multifunctional landscape where biodiversity persists alongside agricultural production and rural settlement.

The diversity of habitats within the project area is directly relevant to the proposed road upgrading because different ecosystems exhibit varying levels of ecological sensitivity and vulnerability to construction and operational impacts. Road widening, excavation, drainage modification, borrow pit development, and vegetation clearing may affect habitat integrity, ecological connectivity, and ecosystem functionality if sensitive habitats are not properly identified and managed. The landscape heterogeneity also implies that mitigation measures must be spatially targeted according to local ecological conditions and environmental risk levels.

4.2 Species Richness and Taxonomic Diversity

A total of 726 species were recorded across the assessed taxonomic groups, indicating very high overall biodiversity within the project area. Birds were the most species-rich group with 392 species, demonstrating the importance of the area for resident, migratory, riparian, woodland, cliff-associated, and farmland bird communities. Plants recorded 137 species, reflecting substantial botanical diversity across woodland, riparian, bushland, grassland, and cultivated habitats. Mammals (73 species) and invertebrates (71 species) also contributed significantly to overall biodiversity, while reptiles (37 species) and amphibians (16 species) confirmed the presence of both dryland and wetland ecological systems. Combined herpetofauna richness reached 53 species, demonstrating the ecological complementarity of rocky uplands, bushland, wetlands, and stream habitats.

The high species richness recorded within the project area demonstrates that the proposed road corridors traverse ecologically valuable landscapes containing diverse habitats and functioning ecological systems. Construction activities may result in vegetation loss, disturbance to wildlife, habitat fragmentation, and alteration of sensitive ecosystems if not properly controlled. The presence of diverse taxonomic groups further indicates the need for integrated biodiversity management measures addressing multiple habitat types and ecological processes throughout project implementation.

4.3 Biodiversity Indices and Ecological Stability

Diversity indices indicate that the project area supports relatively stable and well-balanced biological communities. The Shannon–Wiener Diversity Index (H’) was highest for the combined multi-taxa dataset (H’ = 5.911) and for birds (H’ = 5.484), confirming strong habitat heterogeneity and high species turnover across the landscape. Plants (H’ = 4.228) and invertebrates (H’ = 4.007) also recorded high diversity values, reflecting structurally complex vegetation and functioning ecological processes such as pollination and nutrient cycling. Simpson’s Diversity Index values were consistently high, ranging from 0.742 for amphibians to 0.996 for the combined taxa, indicating low dominance by individual species and relatively even species representation across most taxonomic groups.

High biodiversity index values indicate that the ecological systems within the project area remain relatively functional and resilient despite ongoing human land use. Disturbance associated with road upgrading may alter habitat structure, reduce ecological connectivity, and disrupt ecological processes such as pollination, seed dispersal, nutrient cycling, and wildlife movement. These findings therefore support the need for application of the mitigation hierarchy, protection of ecologically sensitive habitats, minimization of unnecessary vegetation clearing, and long-term biodiversity monitoring throughout construction and operation.

4.4 Critical Habitats and Ecologically Sensitive Areas

The most important biodiversity habitats identified within the project area include riparian corridors, wetlands, woodland remnants, escarpment cliffs, rocky outcrops, and farm-tree mosaics. Riparian systems function as biodiversity hotspots supporting birds, amphibians, reptiles, mammals, invertebrates, and moisture-dependent flora, while also providing ecological connectivity across the landscape. Woodland remnants and mature indigenous trees, including species such as Ficus sycomorus, provide nesting sites, fruit resources, shade, carbon storage, and refuge habitats for wildlife. Escarpment habitats support specialised flora, raptors, reptiles, and cliff-associated species, while wetlands and valley bottoms are critical for amphibians, aquatic insects, and water birds.

These habitats are highly relevant to the proposed road upgrading because they are ecologically sensitive and vulnerable to vegetation clearance, sedimentation, erosion, drainage alteration, pollution, and habitat fragmentation. Construction activities near riparian corridors, wetlands, escarpments, and woodland remnants may significantly affect ecological integrity if appropriate mitigation measures are not implemented. The findings therefore support prioritization of habitat protection, riparian buffer management, ecological connectivity conservation, slope stabilization, and habitat restoration measures within sensitive sections of the project corridors.

4.5 Existing Environmental Pressures and Ecological Threats

Despite the high biodiversity value of the landscape, the project area is already subject to environmental pressures associated with cultivation expansion, grazing intensity, tree cutting, settlement growth, invasive plant species, habitat fragmentation, and localized wetland disturbance. These pressures have contributed to degradation of some habitats and increased ecological vulnerability within modified sections of the landscape.

Road upgrading may intensify existing environmental pressures if vegetation clearing, poorly designed drainage systems, erosion, wildlife barrier effects, and uncontrolled access are not adequately managed. Improved accessibility may also stimulate settlement expansion, increased resource extraction, and further land-use change. Sensitive sections are particularly associated with steep escarpments, major drainage crossings, wetlands, woodland remnants, and areas containing mature indigenous trees. These findings therefore demonstrate the importance of integrating biodiversity conservation, erosion control, drainage management, invasive species control, and ecological connectivity measures into project planning and implementation.

4.6 Ecological Importance of the Project Landscape

Overall, the project area represents a high-value multifunctional biodiversity landscape in which natural ecosystems and human livelihoods are closely interconnected. The high species richness and diversity values demonstrate that biodiversity remains substantial despite long-term land use and increasing human pressure across the landscape. Riparian systems, wetlands, woodland patches, mature indigenous trees, escarpment habitats, and ecological corridors collectively contribute to ecosystem functionality, biodiversity persistence, watershed protection, and community livelihoods.

The ecological significance of the project landscape demonstrates that biodiversity management should form a central component of project planning, construction, operation, and maintenance. Protection of riparian habitats, wetlands, woodland remnants, mature trees, and ecological connectivity should therefore be prioritized within the Biodiversity Management Plan. Additional measures including restoration of disturbed areas, invasive species management, erosion control, ecological monitoring, and adaptive management will be essential to ensure that the proposed road upgrading proceeds in a manner consistent with biodiversity conservation and sustainable landscape management objectives.

4.7 Summary of biophysical baseline assessment

4.7.1 Topography and Terrain Characteristics

The proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors traverses a highly variable escarpment-to-valley landscape characterised by steep escarpments, dissected valleys, rugged hillslopes, rolling uplands, and valley-bottom systems. The most challenging terrain conditions occur along Biretwo–Arror–Chesongoch at chainages 0+000–12+000, 20+000–30+000, and 58+000–70+900, along Nyaru–Kimwarer–Kapkayo at 0+000–6+000, and along Kimwarer–Emsea at 3+000–14+000. These sections are characterized by steep slopes and unstable terrain conditions that increase susceptibility to erosion, slope instability, difficult excavation, and earthwork complications.

Topographic conditions are directly relevant to the proposed road upgrading because steep terrain may require extensive cut-and-fill operations, retaining structures, slope stabilization measures, and engineered drainage systems. Without appropriate mitigation, these activities may trigger landslides, excessive soil erosion, vegetation loss, sedimentation of waterways, and long-term slope instability. The identified escarpment sections therefore represent environmentally sensitive construction zones requiring specialized engineering design, controlled excavation practices, and intensive erosion control measures.

4.8 Hydrology and Drainage Systems

The project area contains numerous rivers, streams, seasonal drainage channels, wetlands, and valley-bottom systems that influence runoff concentration and hydrological connectivity along the road corridors. Major drainage crossings requiring robust culverts, bridges, and scour protection measures occur around chainages 3+800–5+200, 16+000–18+800, 31+500–39+700, 60+100–65+900, and 68+700–70+300 along the Biretwo corridor. Additional hydrologically sensitive sections occur at 0+000–5+000 on the Nyaru–Kimwarer–Kapkayo road and 2+500–15+500 on the Kimwarer–Emsea corridor, where dense runoff channels and converging catchments create elevated flood and erosion risks.

Hydrological systems are highly relevant to the proposed project because road embankments, poorly designed drainage systems, and uncontrolled runoff may obstruct natural flow paths, increase flooding, accelerate erosion, and destabilize surrounding ecosystems. Construction activities near drainage crossings may also increase sedimentation, degrade riparian habitats, and reduce water quality downstream. These findings demonstrate the need for climate-resilient drainage systems, adequately sized culverts and bridges, scour protection structures, runoff dissipation measures, and protection of riparian corridors throughout project implementation.

4.9 Soil Characteristics and Geotechnical Constraints

Soil conditions within the project area range from relatively stable loams to highly problematic clayey and very clayey soils. The most problematic soil conditions occur at chainages 37+000–42+000 and 58+000–66+000 on the Biretwo–Chesongoch corridor, 14+000–30+800 on the Nyaru–Kapkayo section, and 2+500–8+500 along Kimwarer–Emsea. These sections are characterized by high clay content, poor drainage, waterlogging susceptibility, compaction risks, and weak subgrade conditions.

Soil characteristics are directly relevant to the proposed road upgrading because unstable clay-rich soils may increase risks of pavement failure, embankment instability, waterlogging, and structural deterioration of road infrastructure. Construction activities in these sections may also generate excessive sedimentation and erosion if soils are left exposed during rainfall events. The findings therefore support the need for soil stabilization, subgrade improvement, controlled moisture management, engineered fill materials, and appropriate erosion and sediment control measures during construction and operation.

4.10 Rainfall Patterns and Climatic Conditions

Rainfall distribution across the project area varies considerably due to topographic gradients and escarpment influences. The highest rainfall conditions occur within upper escarpment sections including chainages 0+000–5+000 along the Biretwo and Nyaru corridors, and sections 7+500–12+000 and 16+000–19+000 along Kimwarer–Emsea. These areas experience elevated runoff generation, increased slope saturation, and heightened erosion susceptibility during heavy rainfall events. In contrast, lower elevation sections toward Chesongoch, Kapkayo, and Emsea experience warmer climatic conditions associated with higher evapotranspiration rates, dust generation, reduced vegetation moisture, and vegetation stress.

Climatic variability is highly relevant to the proposed road upgrading because high rainfall zones increase risks of erosion, slope instability, flooding, drainage failure, and sediment transport during construction and operation. Conversely, hotter and drier lower sections may experience dust generation, vegetation degradation, and increased susceptibility to surface instability. These findings demonstrate the importance of incorporating climate-resilient engineering design, drainage systems, erosion control measures, dust suppression, and revegetation programmes into project implementation.

4.11 Environmental Sensitivity Hotspots

The assessment identified several environmental hotspots where multiple biophysical constraints converge. These hotspots are generally characterized by combinations of steep slopes, major drainage crossings, clay-rich soils, high rainfall intensity, unstable terrain, and ecologically sensitive riparian systems. Such conditions significantly increase vulnerability to erosion, slope failure, flooding, sedimentation, vegetation disturbance, and infrastructure instability.

Environmental hotspots represent the highest-risk sections for both engineering performance and biodiversity conservation during project implementation. These areas will require chainage-specific mitigation measures including slope stabilization, climate-resilient drainage systems, erosion and sediment control structures, soil improvement measures, riparian buffer protection, revegetation, and careful construction management. Prioritization of these sensitive sections within project planning and monitoring will be critical to minimizing environmental degradation and ensuring long-term infrastructure resilience.

4.12 Overall Biophysical Significance of the Project Area

Overall, the proposed road corridors traverse environmentally sensitive escarpment-to-valley landscapes where topography, drainage systems, soils, rainfall patterns, and ecological conditions strongly influence environmental risk levels. The interaction between steep terrain, concentrated runoff, unstable soils, and ecological sensitivity creates significant challenges for road upgrading and long-term infrastructure sustainability.

The biophysical baseline conditions demonstrate that the proposed project requires an integrated environmental management approach combining engineering design, biodiversity conservation, hydrological management, erosion control, and climate resilience measures. The findings therefore provide the basis for development of targeted mitigation measures, chainage-specific environmental management interventions, ecological monitoring, and adaptive management throughout the construction and operational phases of the proposed road project.

4.13 Summary of Agro-Ecological Baseline Assessment

4.13.1 Overview of Agro-Ecological Conditions

The proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors traverse a highly heterogeneous agro-ecological landscape within Elgeyo Marakwet County. Strong altitudinal gradients, escarpment geomorphology, rainfall variability, soil diversity, and land-use intensity create distinct production zones across the project area. The landscape transitions from cool and moist escarpment highlands through sub-humid mid-slopes to warmer lower valley environments and drier agro-pastoral lowlands. These environmental gradients influence crop suitability, livestock production systems, vegetation cover, settlement density, and vulnerability to land degradation.

The agro-ecological variability within the project area is directly relevant to the proposed road upgrading because environmental conditions influence engineering requirements, land-use sensitivity, erosion risks, drainage behaviour, and ecological vulnerability along different road sections. Understanding agro-ecological patterns is therefore important for development of location-specific mitigation measures, climate-resilient infrastructure design, and sustainable land management interventions during project implementation.

4.14 Highland and Escarpment Mixed Farming Zones

The upper highland and escarpment margin zones, particularly around sections of Biretwo and Nyaru, are characterised by relatively higher rainfall, cooler temperatures, steep terrain, and generally productive loamy soils. These areas support intensive smallholder agriculture dominated by maize, beans, potatoes, vegetables, and mixed agroforestry systems incorporating trees for shade, fodder, fuelwood, and soil conservation. Farm sizes are generally small to medium, while settlement density is comparatively high due to favourable climatic and agricultural conditions.

Despite their agricultural productivity, these highland zones are highly susceptible to erosion, gullying, landslides, and declining soil fertility where cultivation extends onto fragile hillsides and steep escarpments.

These upper escarpment farming zones are highly relevant to the proposed road upgrading because construction activities involving excavation, slope cutting, vegetation clearing, and drainage modification may significantly increase erosion and slope instability risks. Road development may also affect farm terraces, riparian buffers, and agroforestry systems if construction footprints are not carefully controlled. These findings support the need for slope stabilization, runoff management, erosion control structures, and protection of terraced farming systems and riparian vegetation during project implementation.

4.15 Transitional Mid-Slope Mixed Farming Zones

The mid-altitude transitional zones, including parts of Kimwarer, Chop, Tumeiyo, Arror, and surrounding rolling landscapes, represent mixed farming environments where rainfall remains moderate and temperatures are warmer than the escarpment crest. These areas support maize–bean farming systems, sorghum, millet, horticulture in suitable pockets, poultry production, dairy cattle, and small ruminants. Agroforestry remains important, although tree cover tends to be more fragmented compared to the upper highlands.

Soils within these transitional landscapes range from loamy to clayey textures, and agricultural productivity depends strongly on seasonal rainfall patterns and drainage conditions. The areas are also experiencing increasing pressure from cultivation expansion, grazing competition, and fuelwood extraction.

The transitional mid-slope zones are particularly relevant to the proposed project because they are highly responsive to infrastructure improvement and may experience accelerated agricultural intensification and settlement growth following road upgrading. Increased accessibility may contribute to vegetation loss, land fragmentation, and pressure on natural resources if not properly managed. These areas therefore require integrated land-use planning, controlled drainage systems, erosion management, and protection of remnant vegetation and agroforestry systems during project implementation.

4.16 Lower Valley and Agro-Pastoral Lowland Zones

Lower valley and warm lowland sections, especially toward Chesongoch, Kapkayo, Emsea, and eastern descending landscapes, are characterised by higher temperatures, lower or more variable rainfall, broader valleys, gentler slopes, and a stronger presence of clayey to very clayey soils. These areas are generally more suited to agro-pastoral systems combining drought-tolerant cropping with livestock production.

Common crops include sorghum, millet, pigeon peas, cowpeas, green grams, and opportunistic maize cultivation during favourable seasons. Livestock production involving goats, sheep, cattle, and donkeys forms an important livelihood component. Natural vegetation is generally dominated by open bushland, grassland, and scattered drought-tolerant trees adapted to moisture stress conditions.

These landscapes experience relatively higher agricultural risk due to rainfall variability, periodic dry spells, runoff concentration, and water scarcity.

The lower agro-pastoral zones are highly relevant to the proposed road upgrading because infrastructure improvements may significantly enhance market access for livestock and dryland agricultural produce. However, improved accessibility may also increase risks of rangeland degradation, overgrazing, vegetation clearing, and uncontrolled land conversion if environmental safeguards are not implemented. The clay-rich soils within these areas may further create engineering challenges associated with waterlogging, subgrade instability, and surface deterioration. These findings support the need for climate-resilient road design, controlled runoff management, rangeland protection measures, and sustainable land-use planning.

4.17 Riparian Corridors, Valley Bottoms, and Wetland Systems

Riparian corridors, valley bottoms, and localized wetland environments occur across all agro-ecological zones and form highly productive micro-environments within the project area. These systems support irrigated horticulture, fodder production, tree growth, domestic water access, and dry-season grazing activities. In addition to their livelihood importance, these areas provide critical ecosystem services including groundwater recharge, sediment trapping, biodiversity refugia, flood attenuation, and microclimate regulation.

Riparian and wetland systems are highly relevant to the proposed road upgrading because they are frequently intersected by the road corridors and are particularly sensitive to drainage alteration, sedimentation, erosion, flooding, and vegetation disturbance. Inadequate culvert sizing, poorly designed bridge crossings, or obstruction of natural flow connectivity may result in flooding, channel incision, wetland degradation, and loss of productive valley-bottom soils. These findings therefore support the need for careful drainage design, maintenance of hydrological connectivity, riparian buffer protection, and wetland-sensitive construction practices.

4.18 Agro-Ecological Zonation and Land Capability

From a land capability perspective, the project area can broadly be classified into four agro-ecological zones:

- humid to sub-humid highland mixed farming zones;

- sub-humid transitional mid-slope mixed crop–livestock zones;
- semi-humid to semi-arid lower agro-pastoral zones; and
- riparian and valley-bottom high-productivity micro-zones.

Each zone possesses distinct opportunities and constraints associated with rainfall reliability, soil texture, slope conditions, water availability, vegetation cover, and market accessibility. This zonation also aligns closely with biodiversity patterns across the landscape, where upper slopes retain remnant woodland and escarpment vegetation, transitional zones support farmland mosaics and secondary habitats, and lower zones contain dryland bushland and grazing ecosystems.

Agro-ecological zonation is highly relevant to the proposed project because it provides the basis for environmentally sensitive road planning and chainage-specific mitigation design. Different zones require different approaches to erosion control, drainage management, biodiversity conservation, slope stabilization, and livelihood protection. The zonation framework further supports integration of climate resilience, sustainable agriculture, ecosystem protection, and land capability considerations into project implementation.

4.19 Overall Agro-Ecological Significance of the Project Area

Overall, the project area represents an escarpment-to-lowland production continuum where livelihoods are highly adapted to environmental gradients and ecological variability. Agricultural production systems, grazing practices, settlement patterns, and ecosystem functions are closely linked to topography, rainfall, soil conditions, and water availability across the landscape.

The agro-ecological significance of the project area demonstrates that road upgrading has the potential to strengthen agricultural value chains, reduce transport constraints, improve market access, and enhance access to social services across multiple production zones. However, sustainable project outcomes will depend on integrating agro-ecological realities into project planning, design, construction, and operation. This includes implementation of erosion control measures in upper highlands, drainage management within valley bottoms, climate-smart land management in transitional farming zones, and rangeland protection measures within drier agro-pastoral landscapes.

4.20 Vegetation Types

4.20.1 Overview of Vegetation Characteristics

The proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors traverse a highly diverse vegetation landscape within Elgeyo Marakwet County. Vegetation distribution within the project area is strongly influenced by altitude, rainfall variability, slope conditions, soil characteristics, and human land use. The landscape transitions from moist escarpment highlands through cultivated mid-slopes and woodland mosaics to warmer valley-bottom and lower dryland environments. This environmental variability creates distinct vegetation zones that support biodiversity conservation, watershed protection, slope stabilization, grazing resources, and local livelihoods.

Vegetation characterization is directly relevant to the proposed road upgrading because different vegetation zones exhibit varying ecological sensitivities and responses to disturbance. Road widening, vegetation clearing, drainage modification, and construction activities may alter vegetation structure, ecological connectivity, slope stability, and ecosystem functionality if not carefully managed. Understanding vegetation distribution is therefore essential for ecological sensitivity assessment, mitigation planning, restoration design, and biodiversity conservation throughout project implementation.

4.21 Upland Woodland and Agroforestry Vegetation

The upper escarpment and highland zones are characterised by relatively dense woody vegetation, mixed montane bushland, secondary woodland, and agroforestry mosaics. In areas receiving higher rainfall and cooler temperatures, vegetation includes indigenous trees, planted woodlots, hedgerows, and mixed farm trees associated with cultivated landscapes. Remnant woodland patches and steep uncultivated slopes often retain native shrubs, climbers, grasses, and tree species adapted to moist upland conditions.

These upper vegetation zones perform important ecological functions including:

- water catchment protection;
- erosion control;
- microclimate regulation;
- carbon storage; and
- provision of habitat for birds, pollinators, and small mammals.

However, many of these habitats have experienced fragmentation due to cultivation expansion, settlement growth, and fuelwood harvesting.

The upper woodland and agroforestry zones are highly relevant to the proposed road upgrading because construction activities involving excavation, slope cutting, vegetation removal, and drainage modification may destabilize slopes, increase erosion, and fragment remnant woodland habitats. Removal of indigenous trees and agroforestry vegetation may further reduce ecological connectivity and watershed protection functions. These findings support the need for minimizing vegetation clearing, protecting mature indigenous trees, maintaining riparian buffers, and implementing slope stabilization and revegetation measures within escarpment sections.

4.22 Mid-Slope Mosaic Farmland–Bushland Systems

The mid-slope transitional zone is dominated by a mosaic of farmland vegetation, wooded grassland, bushland remnants, scattered trees, hedgerows, and fallow vegetation. This zone represents one of the most structurally heterogeneous vegetation systems within the project area because natural vegetation has been partially modified through long-term agriculture and grazing activities.

Trees are commonly retained around farms, homesteads, stream lines, and rocky outcrops, while open areas support seasonal grasses, herbs, shrubs, and regenerating secondary vegetation. Vegetation within this zone provides:

- fodder resources;
- fuelwood;
- shade;
- pollinator habitat;
- soil protection; and

- ecological transition between upland woodland and lower dryland ecosystems.

Although habitat fragmentation is relatively common, the mosaic nature of land cover still supports moderate biodiversity where tree cover and riparian vegetation remain intact.

The mid-slope mosaic vegetation systems are directly relevant to the proposed road upgrading because they are highly susceptible to fragmentation, vegetation degradation, and settlement expansion following infrastructure improvement. Construction activities may reduce vegetation cover, increase edge effects, and disrupt ecological corridors if tree cover and riparian vegetation are not retained. The findings therefore support integration of vegetation retention measures, controlled construction footprints, roadside revegetation, and restoration of disturbed farmland and bushland interfaces.

4.23 Lower Dry Woodland and Shrub–Grassland Systems

Lower valley and warmer lowland sections are characterised by open bushland, dry woodland, shrubland, wooded grassland, and semi-arid grass-dominated vegetation. Tree density is generally lower compared to upper elevations, with vegetation dominated by drought-tolerant shrubs, scattered woody species, perennial grasses, and annual herbs responding to seasonal rainfall patterns.

These lower vegetation systems are important for:

- grazing and browsing;
- fuelwood collection;
- dryland ecosystem productivity; and
- wildlife movement across lowland landscapes.

Vegetation cover within these zones is highly dynamic and strongly influenced by rainfall variability, livestock pressure, fuelwood harvesting, and localized cultivation. In degraded sections, vegetation transitions into sparse shrubland or heavily grazed grassland with exposed soils and increased erosion susceptibility.

The lower dryland vegetation systems are highly relevant to the proposed road upgrading because disturbance of already fragile semi-arid vegetation may accelerate land degradation, reduce grazing productivity, and increase erosion and dust generation. Improved road access may also intensify fuelwood extraction, settlement expansion, and rangeland pressure. These findings support the need for controlled vegetation clearing, restoration of disturbed dryland vegetation, invasive species management, and protection of grazing landscapes during project implementation.

4.24 Riparian and Wetland Vegetation Corridors

Riparian corridors, wetlands, valley bottoms, and drainage lines form distinct vegetation sub-zones that cut across all elevation bands within the project area. These areas often support denser and greener vegetation than surrounding uplands because of higher soil moisture availability.

Common vegetation types include:

- riverine trees;
- thickets;

- reeds;
- sedges;
- moisture-loving grasses;
- climbers; and
- fertile cultivation strips.

Riparian vegetation performs critical ecological functions including:

- stream bank stabilization;
- flood attenuation;
- groundwater recharge;
- sediment trapping;
- shade provision; and
- habitat connectivity for wildlife.

These areas are among the most ecologically sensitive vegetation zones within the project landscape.

Riparian and wetland vegetation corridors are highly relevant to the proposed road upgrading because they are frequently intersected by road crossings, culverts, bridges, and drainage infrastructure. Disturbance of these systems may increase sedimentation, flooding, bank erosion, hydrological disruption, and habitat fragmentation. The findings therefore support priority protection of riparian vegetation, maintenance of hydrological connectivity, wetland-sensitive drainage design, erosion control, and restoration of disturbed riparian habitats.

4.25 Rocky Escarpment and Cliff Vegetation

Rocky escarpments, cliffs, and shallow-soil outcrops support specialised vegetation communities adapted to drought, shallow rooting conditions, wind exposure, and unstable substrates. These habitats commonly contain hardy shrubs, succulents, tuft grasses, climbers, and stunted woody species adapted to harsh environmental conditions.

Although these habitats may appear less densely vegetated compared to woodland systems, they are ecologically important because they:

- support specialised flora and fauna;
- stabilize slopes;
- reduce erosion risk; and
- function as ecological refugia within the escarpment landscape.

Escarpment vegetation is directly relevant to the proposed road upgrading because slope cutting, blasting, excavation, and uncontrolled runoff may destabilize these fragile habitats and significantly delay vegetation recovery. Disturbance of escarpment vegetation may further increase erosion, landslide susceptibility, and sediment transport into downstream ecosystems. These findings support the need for minimized excavation, slope stabilization, controlled blasting practices, and restoration of disturbed escarpment vegetation using locally adapted native species.

4.26 Human-Modified and Disturbed Vegetation

Human-modified vegetation is widespread around settlements, trading centres, cultivated areas, and existing road edges. This vegetation includes planted trees, ornamental species, live fences, roadside weeds, invasive plant species, ruderal herbs, and secondary regrowth vegetation.

Some modified vegetation provides useful ecosystem services such as:

- shade;
- pollinator resources;
- wind protection; and
- localized soil stabilization.

However, heavily disturbed areas may also function as entry points for invasive species spread and habitat simplification.

Human-modified vegetation is relevant to the proposed road upgrading because construction disturbance may further increase invasive species spread, vegetation degradation, and habitat simplification if disturbed areas are not properly rehabilitated. Roadside disturbance may also facilitate colonization by invasive species along transport corridors. These findings support the need for invasive species management, rapid revegetation of exposed surfaces, roadside landscaping, and restoration using locally appropriate native species.

4.27 Overall Vegetation Significance of the Project Area

Overall, the project area supports five broad vegetation zones:

- upland woodland and agroforestry vegetation;
- mid-slope mosaic farmland–bushland systems;
- lower dry woodland and shrub–grassland systems;
- riparian and wetland vegetation corridors; and
- rocky escarpment specialised vegetation.

These vegetation systems reflect the strong escarpment-to-lowland ecological gradient of the landscape and are directly linked to biodiversity conservation, hydrological regulation, slope stability, ecosystem resilience, and community livelihoods.

The vegetation significance of the project area demonstrates that vegetation management should form a central component of road planning, construction, and operational management. Road upgrading should therefore prioritize retention of riparian vegetation, mature indigenous trees, woodland remnants, and erosion-sensitive escarpment vegetation. Restoration of disturbed areas using locally appropriate native species, combined with invasive species control and ecological monitoring, will be critical for maintaining ecological functionality and long-term environmental sustainability throughout the project lifecycle.

4.28 Flora

4.28.1 Forests

The proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors traverse a landscape in Elgeyo Marakwet County where forests occur mainly as fragmented upland woodland patches, riverine forest strips, escarpment thickets, farm forest mosaics, and localized secondary regeneration rather than extensive continuous closed-canopy forest. Historical land conversion for agriculture, settlement expansion, fuelwood extraction, and grazing pressure has reduced forest continuity in many sections, resulting in a mosaic of remnant tree cover embedded within cultivated and grazing landscapes. Despite this fragmentation, forested habitats within the project area remain ecologically important for watershed protection, biodiversity conservation, climate regulation, soil stabilization, and livelihood support.

The most prominent forest-related habitats occur in the upper escarpment and highland sections, particularly around Biretwo, Nyaru, and adjoining elevated terrain where higher rainfall, cooler temperatures, and deeper soils support denser woody vegetation. These areas contain patches of upland woodland, secondary forest regrowth, and tree-rich agroforestry landscapes where indigenous and planted species occur together. Forest cover in these zones often persists on steep slopes, ridgelines, rocky areas, and land less suitable for cultivation. Such forests play a critical role in intercepting rainfall, enhancing infiltration, reducing runoff velocity, and minimizing landslide or erosion risk on steep terrain. They also provide habitat for birds, small mammals, pollinators, reptiles, and other forest-associated biodiversity.

Along drainage lines, streams, and valley bottoms, riverine forests and riparian woodland strips are present throughout much of the project area. These forests are often narrow but highly valuable ecological corridors composed of moisture-dependent trees, shrubs, climbers, and dense understory vegetation. Riparian forests stabilize stream banks, trap sediments, regulate water temperature, improve water quality, and provide movement routes and refuge for wildlife. They are particularly important in landscapes where surrounding natural vegetation has been reduced. Road crossings at rivers and seasonal streams may therefore pose disproportionate impacts if clearing, culvert placement, or altered hydrology degrades these forest strips.

Mid-slope and transitional areas such as Kimwarer, Arror, and sections toward Kapkayo support mixed woodland–farmland mosaics rather than distinct forest blocks. In these areas, tree cover is scattered across farms, homesteads, grazing lands, fallows, and rocky outcrops. Trees may occur as boundary plantings, live fences, shade trees, woodlots, or retained indigenous individuals. Although structurally fragmented, this mosaic tree cover performs many forest-like functions including carbon storage, pollinator support, wind reduction, fuelwood supply, fodder provision, and habitat stepping stones for wildlife moving across agricultural landscapes.

Lower valley and warmer sections toward Chesongoch and Emsea are generally less forested and dominated more by open woodland, bushland, and shrubland systems. Here, tree density is lower and forest formations are mostly confined to riparian zones, rocky refugia, and protected local patches. Vegetation is adapted to drier conditions, with drought-tolerant woody species occurring in discontinuous stands. These dry woodland formations remain important for grazing shade, browse resources, erosion control, and resilience under variable rainfall conditions.

From a conservation perspective, forests in the project area are significant not because of large continuous canopy blocks, but because of their functional value in a human-modified escarpment landscape. Key forest priorities include steep slope woodlands that protect fragile soils, riparian forests that sustain water systems, mature indigenous trees that provide nesting and feeding resources, and woodland linkages that maintain ecological connectivity. Fragmentation increases vulnerability to further degradation, invasive species encroachment, overharvesting, and edge effects. Road upgrading could intensify these pressures if access increases and vegetation clearing is not controlled.

Overall, forests within the project area can be categorized into five main types: (i) upland escarpment woodland and secondary forest patches, (ii) riparian and riverine forests, (iii) agroforestry and farm forest mosaics, (iv) dry lower-elevation woodland patches, and (v) regenerating secondary woody vegetation. Although spatially fragmented, these forest systems are strategically important for biodiversity, hydrology, slope stability, and community livelihoods. The project should therefore prioritize avoidance of unnecessary forest clearing, retention of mature trees, protection of riparian forests, controlled access to sensitive wooded areas, and restoration planting using locally appropriate native species.

4.28.2 Floral Species Distribution

4.28.2.1 Biretwo – Arror - Chesongoch Plants

This section is most strongly indicated by the dominance of disturbance-tolerant shrubs and invasive/exotic taxa typical of road edges, homesteads, fallows, and overgrazed sites. Asteraceae occur widely here as classic "pioneer" weeds that quickly colonize bare soils created by grading, borrow pits, and traffic, including *Ageratum conyzoides, Chromolaena odorata, Vernonia popeana, Xanthium strumarium,* and *Cirsium vulgare*. These species occur particularly in open sunny microsites, freshly disturbed soil, and along drainage outlets where sediment accumulates. Their ecology is linked to rapid seed production, wind dispersal, and strong competitive ability after disturbance, which make them early dominants following roadworks if topsoil is not managed.

Fabaceae occur as a major structural and functional family in this section, represented by dryland thorny trees and shrubs (Vachellia nilotica, V. seyal, V. etbaica, V. oerfota, V. hockii, V. elatior; Senegalia mellifera, S. senegal, S. laeta, S. brevispica) as well as herbaceous nitrogen-fixing pioneers (Crotalaria spp., Vigna spp., Sesbania keniensis, Senna obtusifolia, S. occidentalis, S. siamea). Woody acacias occur on well-drained soils, grazing lands, and savanna/wooded grassland edges where browsing pressure shapes regeneration, while Senna and Crotalaria occur in disturbed ground, fallows, and road verges. This family's ecological role is important for soil nitrogen inputs, forage/browse resources, and habitat structure, but it also includes aggressive invaders such as Prosopis juliflora, which form dense thickets, suppress understory plants, and alter water use and fire regimes if not controlled.

Apocynaceae in this section is strongly represented by drought-adapted, disturbance-tolerant shrubs (Calotropis procera, Calotropis gigantea), ornamental/escaped taxa (Catharanthus roseus), and succulent dryland taxa (Adenium obesum). These occur on hot exposed sites, shallow or compacted soils, and abandoned ground, and their latex and chemical defenses reduce herbivory, allowing them to persist as road-edge dominants. Where grazing is high and competing grasses are reduced, Calotropis often expand.

Cactaceae and Asparagaceae indicate dry, degraded, and frequently disturbed habitats. Opuntia spp. (O. elatior, O. ficus-indica, O. lasiacantha) and Agave (Agave angustifolia, A. sisalana) occur around homesteads, fences, and eroded slopes where their succulent physiology and vegetative propagation allow persistence. These taxa often increase following disturbance and should be treated as invasion-risk indicators along the corridor.

Solanaceae (*Solanum campylacanthum*, *S. hastifolium*, *S. villosum, S. scabrum*, S. *aculeastrum, Datura stramonium*) occur widely in disturbed soils, grazing lands, and farm margins, with some species being toxic or nuisance weeds. Their ecology is linked to bird-dispersed fruits and rapid colonization, meaning they expand following clearing unless revegetation is prompt.

Several wetland and riparian indicators in this broader section suggest local drainage-line habitats where water persists seasonally or permanently. Araceae (Pistia stratiotes) and Onagraceae (Ludwigia stenorraphe) occur in slow-moving water, pools, or swampy drains, while Vitaceae (Cissus quadrangularis, Cyphostemma adenocaule) occur on rocky slopes and thickets, often as climbers or succulent vines tolerant of dry conditions.

4.28.2.2 Nyaru – Kimwarer – Kapkayo Road Plants

This section is indicated by many dryland woody taxa and succulent/rocky-habitat plants, typical of warmer, more open vegetation where road widening create strong edge effects. Fabaceae again be dominant structurally through Vachellia and Senegalia spp., providing canopy and thorny thicket habitat. These woody legumes occur as scattered trees, bushland patches, and regeneration in grazed landscapes. Where Vachellia nilotica and V. seyal occur, they indicate heavier soils and drainage-line influence, while V. etbaica, V. oerfota, V. elatior, and Senegalia mellifera indicate drier bushland and more strongly disturbed grazing systems.

Asphodelaceae (*Aloe turkanensis, Aloe amicorum, Aloe tugenensis* listed as *Aloe archeri* in the genus/species columns) occur on rocky slopes, shallow soils, and well-drained ground. Their ecology is tightly linked to drought tolerance, slow growth, and specialized pollination, and they are vulnerable to physical removal, quarrying, and changes in runoff concentration that can cause localized erosion around rock habitats.

Selaginellaceae (*Selaginella kraussiana, S. yemensis, S. phillipsiana*) and bryophyte/liverwort components (Pottiaceae: Pseudocrossidium; Meteoriaceae: Papillaria; Ricciaceae: Riccia) suggest microhabitats with episodic moisture, shaded rock faces, seepage zones, or humid microsites near drainage lines and shaded gullies. These taxa are sensitive to dust deposition and hydrological changes; they decline where drainage is altered and fine sediments bury microhabitats.

Lamiaceae occur as aromatic herbs and *shrubs (Leucas hirundinaris, Premna resinosa, Plectranthus barbatus, Endostemon camporum, Ocimum spp.*). These plants typically occur in open woodland, rocky ground, and disturbed margins, often responding strongly to light availability and soil disturbance. They can be important for pollinators, and the family often rebounds after disturbance if soil is stable.

Rhamnaceae (*Ziziphus/Zizyphus spp., Lasiodiscus marmoratus*) occur in thickets and dry woodland edges, often on well-drained soils. *Ziziph*us shrubs/trees are important for birds and browsing mammals through fruit provision and thorny refuge structure, meaning their removal reduce food availability and nesting/roosting cover along the corridor.

Euphorbiaceae occur across dry and disturbed habitats (Euphorbia heterospina subsp. baringoensis; Euphorbia hirta; Acalypha; Tragia; Dalechampia; Ricinus communis). Many members are disturbance-adapted, with latex and chemical defenses that allow them to persist under grazing. Euphorbia and Ricinus frequently occupy eroding cut slopes and disturbed soil, acting as early colonizers but also indicating instability and degradation.

Poaceae form the matrix in open landscapes, with species such as *Hyparrhenia hirta, Loudetia simplex, Brachiaria ambigens, Melinis repens, Trisetopsis angusta,* and multiple "Gramineae" records. These grasses represent a mix of grazing-tolerant and disturbance-associated taxa; their ecological role is essential for soil cover, infiltration, and erosion control. Where grasses are removed and topsoil is lost, invasive forbs and shrubs increase rapidly.

4.28.2.3 Kimwarer – Emsea Road Plants

This section is indicated by the presence of families and genera characteristic of moister environments and forest/riverine systems. Podocarpaceae (Afrocarpus falcatus) strongly suggests highland or moist forest influence, typically occurring in cooler, wetter zones and often associated with remnant forest patches or planted/managed stands. This taxon is sensitive to fragmentation and edge effects; road widening increases drying at edges, introduce invasive weeds, and reduce regeneration if not buffered.

Orchidaceae (*Angraecum erectum, Polystachya adansoniae, Tridactyle furcistipes*) indicates specialized habitats such as moist woodland/forest edges, riverine trees, and shaded microhabitats. Orchids are highly vulnerable to habitat disturbance because they depend on specific microclimates and symbiotic fungi; dust, canopy opening, and tree removal will reduce their survival. Their occurrence implies that parts of this section retain higher structural complexity and microhabitat stability than the drier sections.

Rubiaceae (*Psychotria punctata, Anthospermum herbaceum, Heinsenia diervilleoides, Oxyanthus spp.*) is typical of understory shrubs and herbs in moist woodland and forest edges, and often indicates shaded habitats with more stable soils. These taxa decline where understory is cleared, drainage is redirected, or repeated maintenance keeps the verge open.

Annonaceae (Artabotrys spp., Lettowianthus stellatus) and Sapotaceae, Strombosiaceae (Strombosia), Violaceae (Rinorea brachypetala), Cannabaceae (Celtis), Rutaceae (Vepris nobilis, Vepris uguenensis, Zanthoxylum), Loganiaceae (Strychnos), Olacaceae and Icacinaceae all point to woodland/forest or riverine vegetation components. These families are associated with fruiting trees and lianas that support birds and mammals through food resources and cover, meaning their presence indicates habitat value beyond simple road-edge shrubland. Disturbance tends to simplify these habitats, replacing them with generalist weeds and grasses.

Balsaminaceae (Impatiens sodenii) and ferns (Aspleniaceae: Asplenium spp.; Pteridaceae: Aleuritopteris/cheilanthoid taxa) indicate moist shaded sites, seepage zones, and riparian edges. These occur where humidity remains relatively high and soils remain moist. Such habitats are particularly sensitive to altered drainage, increased sunlight exposure, and sedimentation; small changes in water routing can eliminate these microhabitats.

Aquatic and wet-riparian indicators (*Ludwigia stenorraphe*) further confirm that some areas in this section include slow water, stream margins, and wet drains. Where culverts, side drains, or diversions concentrate flow, these habitats shift upstream/downstream, causing loss at some points and new colonization at others, with knock-on effects for associated invertebrates and amphibians (even if not listed here).

4.28.3 Invasive Species

The proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County traverse a landscape comprising cultivated land, settlements, road reserves, riparian corridors, escarpment slopes, grazing areas, and disturbed open ground. Such environments are often susceptible to invasion by aggressive non-native or opportunistic plant species, particularly where repeated disturbance, soil exposure, overgrazing, drainage alteration, and movement of vehicles or livestock create favourable conditions for colonisation. Although the baseline report did not include a dedicated invasive species survey, habitat conditions observed within the project area indicate that several invasive and potentially invasive plant species are already present or are likely to occur. These species are of concern because they can suppress native vegetation, reduce forage quality, obstruct drainage systems, increase management costs, and undermine ecological restoration efforts.

Within the cultivated highland and mid-slope sections of the project area, invasive annual weeds are likely common along road verges, farm margins, settlement edges, market centres, borrow pits, and waste ground. Species such as Bidens pilosa, Tagetes minuta, Parthenium hysterophorus, Datura stramonium, and Ricinus communis are commonly associated with disturbed agricultural landscapes in Kenya and may occur within sections of the corridor. These species establish rapidly on bare soils, produce large seed banks, and compete strongly with crops, grasses, and native herbs. Of particular concern is Parthenium weed, which is highly invasive, causes allergies, reduces pasture productivity, and is difficult to eradicate once established.

Riparian corridors, wetlands, drainage lines, culvert outlets, and valley-bottom environments are particularly vulnerable to invasion due to higher soil moisture, nutrient accumulation, and seed dispersal through flowing water. In these habitats, species such as Lantana camara, Tithonia diversifolia, and Nicotiana glauca are likely to occur in disturbed sections. These species are capable of forming dense monospecific stands that suppress indigenous riparian vegetation, alter natural regeneration patterns, reduce accessibility, and degrade habitat quality for birds, amphibians, pollinators, and other fauna dependent on native vegetation. Their control is often difficult once established in drainage systems and riparian zones.

The lower, warmer, and more open sections toward Chesongoch, Kapkayo, and Emsea are more susceptible to invasion by dryland shrubs and succulent weeds. Species such as Prosopis juliflora may occur in lower valley settlements, riverbanks, and dry disturbed ground where previously introduced. This species forms dense thorny thickets, reduces access to grazing areas, consumes significant soil moisture, and displaces native dryland vegetation. Similarly, Opuntia stricta and related cactus species may establish in degraded rangelands or rocky open areas, where they obstruct livestock movement and reduce usable grazing land.

Some planted species used for woodlots, shade, or boundary planting may also present localized ecological concerns if unmanaged. Dense planting of Eucalyptus spp. near streams, wetlands, or springs may influence water availability and suppress understorey growth, although these species are economically valuable when appropriately located. Careful species selection during roadside landscaping and rehabilitation will therefore be important to avoid introducing species with invasive tendencies or undesirable hydrological effects.

Road upgrading activities may increase the spread of invasive plants through vegetation clearance, importation of contaminated borrow materials, movement of machinery, soil stockpiling, altered drainage, and prolonged exposure of bare ground. Construction camps, spoil disposal sites, culvert outlets, and newly disturbed verges are especially vulnerable to colonisation. If not managed, invasive species may compromise revegetation success, increase maintenance requirements, obstruct drainage channels, and reduce ecological quality of restored habitats.

It is therefore recommended that the project incorporate invasive species management measures including pre-construction mapping of infestations, cleaning of machinery before entering new sections, sourcing weed-free construction materials, rapid stabilization and revegetation of disturbed areas, periodic monitoring of road reserves and riparian zones, and eradication or containment of priority invasive species where detected. Implementation of these measures will reduce long-term environmental risks and support successful restoration of disturbed sites following construction.

Table 4-1: Existing Invasive Plant Species in the Project Area

Species	Common Name	Occurrence Areas	Key Concerns
Parthenium hysterophorus	Parthenium weed	Roadsides, farms, camps, waste ground	Highly invasive, allergenic, suppresses pasture
Lantana camara	Lantana	Riparian margins, disturbed bushland	Dense thickets, excludes native plants
Tithonia diversifolia	Mexican sunflower	Moist roadsides, drainage lines	Rapid spread, displaces native herbs
Bidens pilosa	Blackjack	Farms, gardens, disturbed soils	Crop weed, prolific seeder
Tagetes minuta	Mexican marigold	Roadsides, cultivation edges	Competitive annual weed
Prosopis juliflora	Mathenge	Lower drylands, riverbanks	Dense thorny invasion, grazing loss
Opuntia stricta	Prickly pear	Dry degraded lands	Injures livestock, obstructs access
Nicotiana glauca	Tree tobacco	Gullies, riverbanks, bare slopes	Colonises eroded disturbed sites

4.29 Fauna

4.29.1 Avi-fauna (Birds)

4.29.1.1 Biretwo – Arror - Chesongoch Birds

Along the Biretwo–Chesongoch road section, woodland and bushland insectivores and generalists occur mainly where remnant shrubs, scattered trees, and rocky escarpment vegetation persist on slopes and along drainage lines. Muscicapidae are represented in woodland edges and rocky habitats where perches and shaded ground layers are available, particularly near escarpment faces and bushy road margins. Cisticolidae are widespread in grassland–shrub mosaics and along disturbed road verges, reflecting variability in grass height and shrub density associated with grazing and cultivation. Macrosphenidae and Malaconotidae occur more locally in denser thickets and bush patches, especially where natural vegetation remains intact on steeper slopes or in less accessible areas. Dicruridae are relatively common due to their tolerance of disturbance, using exposed perches such as trees, fences, and utility poles along the road.

Seed-eaters and open-country birds dominate large portions of this section, particularly in farmland, grazing areas, and settlement zones. Estrildidae and Ploceidae are strongly associated with weedy margins, cultivated fields, and grasslands where seed availability fluctuates seasonally. Passeridae increase in abundance around homesteads and roadside activity, while Fringillidae and Emberizidae occur in open bushland and rocky grasslands where both seeds and insects are available.

Flower and nectar-feeding birds occur patchily along this section, mainly where flowering shrubs and trees are retained on slopes and around homesteads. Sunbirds track flowering phenology and are therefore sensitive to roadside clearing and vegetation removal, particularly on escarpment edges.

Fruit-dependent and large-tree-associated birds are relatively limited in this section due to the generally sparse distribution of mature trees. Where riverine strips or old woodland patches occur, Columbidae and occasional barbets may be present, but Musophagidae and Bucerotidae are less prominent, reflecting reduced canopy continuity.

Predators and scavengers are a conspicuous feature of this landscape. Accipitridae frequently exploit open slopes, escarpments, and grasslands for hunting, while using cliffs and large trees for nesting and roosting. Falconidae are associated with open airspace and rocky features, benefiting from the escarpment topography.

Water and riverine specialists are localized and occur mainly at stream crossings and valley bottoms. Kingfishers, wagtails, and occasional herons appear where surface water persists, but these assemblages are discontinuous and spatially restricted.

Open-air feeders and aerial guild species are strongly represented, particularly swifts and swallows that use cliffs, bridges, and open valleys for nesting and foraging. These birds exploit aerial insect abundance over escarpment slopes and cultivated fields.

Large terrestrial and savanna indicators such as guineafowl and francolins occur in open bushland and farmland margins, while ostrich presence, where recorded, reflects extensive open savanna conditions away from densely settled zones.


a)

b)

c)

d)

e)

f)

Plate 4-1: a) Pallid Harrier (Circus macrourus), (b) White-browed Coucal (Centropus superciliosus), (c) Black-headed Heron (Ardea melanocephala), (d) Common Fiscal (Lanius collaris), (e) Rüppell's starling (Lamprotornis purpuroptera), and (f) Red-cheeked

4.29.1.2 Nyaru – Kimwarer – Kapkayo Birds

The Nyaru–Kimwarer–Kapkayo road section supports a richer and more continuous assemblage of woodland and bushland insectivores and generalists due to greater retention of woody vegetation and riverine strips. Muscicapidae are widely distributed in woodland edges, forest margins, and shaded understorey habitats, indicating relatively intact vertical vegetation structure. Cisticolidae occur across grassland–shrub transitions and along forest edges, reflecting a mosaic of open and semi-closed habitats. Macrosphenidae and Malaconotidae are well represented in dense thickets and riverine bush, where understorey complexity supports insect prey and nesting sites. Dicruridae remain common, particularly along woodland edges and semi-disturbed zones where open perches are abundant.

Seed-eaters and open-country birds are present but more spatially constrained than in the Biretwo–Chesongoch section. They occur mainly around farms, settlements, and cleared patches within the woodland matrix. Ploceidae and Estrildidae exploit seasonal seed availability, while Passeridae are associated with human habitation and infrastructure. Fringillidae and Emberizidae occur in open patches but are less dominant overall due to increased canopy cover.

Flower and nectar-feeding birds are a prominent component of this section, reflecting higher diversity and continuity of flowering trees and shrubs. Sunbirds are widely distributed in woodland, riverine forest edges, and forest–farm interfaces, contributing to pollination processes and responding quickly to changes in vegetation structure.

Fruit-dependent and large-tree-associated birds reach their highest representation in this section. Musophagidae, Columbidae, Ramphastidae, and Bucerotidae indicate the presence of mature trees, fruiting species, and nesting cavities. Hornbills and barbets, in particular, signal the ecological importance of retaining large trees and riverine corridors along this road.

Predators and scavengers occur throughout the section, with Accipitridae using open patches and woodland edges for hunting while nesting in tall trees or cliff features. Falconidae exploit open airspace along valleys and clearings, maintaining trophic balance within the system.

Water and riverine specialists are well represented along rivers and perennial streams. Kingfishers, herons, ibises, and wagtails occur along riparian zones, indicating relatively stable hydrological conditions and intact riverine vegetation. Open-air feeders such as swallows and swifts are common, nesting on bridges, buildings, and cliffs and foraging widely over woodland openings and watercourses.

Large terrestrial and savanna indicators occur mainly in more open peripheral zones, with guineafowl and francolins using woodland edges and cultivated margins.

a)

b)

c)

d)

e)

Plate 4-2: a) Grey Wagtail (Motacilla cinerea), b) Common Fiscal (Lanius collaris), c) Ring-necked Dove (Streptopelia capicola), d) Laughing Dove (Streptopelia senegalensis), and e) Speckled Mousebird (Colius striatus).

4.29.1.3 Kimwarer – Emsea Birds

The Kimwarer–Emsea section is ecologically distinct due to its association with valley bottoms, rivers, wetlands, and floodplain agriculture. Woodland and bushland insectivores and generalists occur primarily in narrow riparian strips and remnant bush patches. Muscicapidae and Malaconotidae are concentrated along riverine thickets, while Cisticolidae dominate grasslands and floodplain margins where vegetation structure varies seasonally. Macrosphenidae are restricted to denser riparian understorey habitats. Seed-eaters and open-country birds are abundant and widespread across floodplain farms, grasslands, and settlement areas. Estrildidae and Ploceidae exploit seasonal seed pulses in cultivated fields and wetlands, while Passeridae thrive around human activity. Fringillidae and Emberizidae occupy open grassland and farmland edges. Flower and nectar-feeding birds occur along riverbanks and homesteads where flowering plants persist, but their distribution is more linear and restricted compared to the Nyaru–Kapkayo section. Fruit-dependent and large-tree-associated birds are largely confined to riparian corridors, where mature trees provide fruit resources and nesting sites. Their presence highlights the ecological importance of maintaining these linear woodland strips within an otherwise open landscape. Predators and scavengers are common over open floodplains, with Accipitridae hunting over grasslands and wetlands and Falconidae exploiting open airspace. These species reflect high prey availability associated with wetland–agricultural mosaics. Water and riverine specialists form the dominant avifaunal group in this section. Kingfishers, herons, ibises, storks, ducks, hamerkop, and wagtails are strongly associated with rivers, wetlands, and floodplain habitats, indicating permanent or seasonal surface water and high aquatic productivity. Open-air feeders are abundant, with swallows and swifts foraging over wetlands, rivers, and cultivated land, often nesting on bridges and nearby structures. Large terrestrial and savanna indicators occur mainly in drier peripheral zones, while guineafowl and francolins use grassland and cultivated margins adjacent to wetlands.

4.29.2 Invertebrate Species

4.29.2.1 Biretwo – Arror - Chesongoch Invertebrate Species

The invertebrate assemblage along the Biretwo–Chesongoch section reflects a predominantly dry to semi-dry landscape characterised by open bushland, rocky slopes, escarpment vegetation, cultivated margins, and localized drainage lines. Butterfly families such as Nymphalidae and Papilionidae are well represented, particularly species of Charaxes, Junonia, Vanessa, Papilio, Danaus, and Belenois. At family level, Nymphalidae are strongly associated with woodland edges, bushland, and rocky habitats where larval host plants and adult nectar sources persist. Charaxes species are especially indicative of mature shrubs and trees and often signal the presence of remnant woody vegetation along escarpment slopes and less disturbed road margins. Papilionidae similarly indicate woodland and bushland mosaics, with adults frequently observed along open tracks and flowering roadside vegetation.

Hesperiidae, represented by Eagris, Celaenorrhinus, Borbo, and Eretis, are characteristic of grassland–bushland interfaces and shaded understorey environments. Their occurrence reflects patchy grass cover interspersed with shrubs, often along road verges and fallow agricultural land. Pieridae, including Belenois and Eurema, dominate more open and disturbed habitats, indicating grassland, farmland, and roadside clearings where herbaceous host plants are abundant.

Pollinator families such as Apidae and Halictidae are consistently present, with Apis, Amegilla, Lipotriches, and Xylocopa reflecting the availability of flowering plants in both natural and modified habitats. Their presence suggests that roadside vegetation, fallows, and homesteads provide important nectar and pollen resources. Syrphidae are diverse and abundant in this section, indicating open habitats with flowering plants and agricultural activity. At family level, syrphids are important pollinators and biological control agents, with larvae often associated with aphid-rich vegetation or decaying organic matter in moist microsites.

Agricultural and disturbance-associated insect families are also prominent. Tephritidae, represented by Dacus, Ceratitis, Parafreutreta, and Xanthorrachista, indicate cultivated areas and the presence of fruiting crops or wild host plants along farms and settlement zones. Pentatomidae and Reduviidae reflect agro-ecosystems and bushland environments, with predatory reduviids indicating functioning arthropod food webs.

Aquatic and semi-aquatic invertebrate families are limited but present where drainage lines occur. Bithyniidae, Planorbidae, and Raninidae reflect localized aquatic habitats such as streams, pools, and slow-flowing channels, while Culicidae indicate standing water in small pools, borrow pits, or poorly drained roadside depressions. Odonate families, including Libellulidae and Coenagrionidae, further reinforce the presence of temporary or permanent water bodies.

Overall, the invertebrate assemblage in this section reflects a dryland escarpment and agro-bushland system, with high representation of generalist butterflies, pollinators, agricultural pests, and disturbance-tolerant taxa, and localized aquatic indicators confined to drainage crossings.


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g)

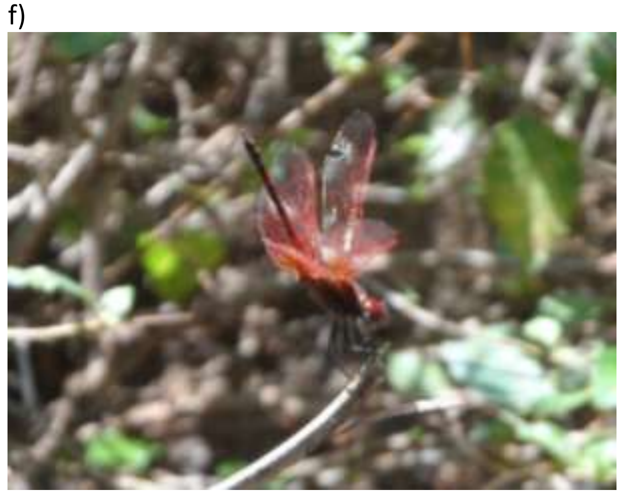
h)


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Plate 4-3: a) Butterflies gathered on the riverbank to puddle, b) Citrus Swallowtail (Papilio demodocus), c) Green-veined Charaxes (Charaxes candiope), d). African Blue Tiger (Tirumala petiverana), e) Guinea-fowl Butterfly (Hamanumida daedalus), f) Com

4.29.2.2 Nyaru – Kimwarer – Kapkayo Invertebrate Species

The Nyaru–Kimwarer–Kapkayo corridor supports the most structurally complex invertebrate assemblage, reflecting greater habitat heterogeneity, including woodland, riverine vegetation, forest edges, and mixed farming systems. At family level, Nymphalidae are diverse and include several Charaxes species, which are strong indicators of mature woodland and forest-edge habitats. Their presence suggests continuity of woody vegetation and availability of larval host trees along this section. Junonia, Neptis, and Vanessa further reflect woodland clearings and semi-shaded habitats.

Papilionidae and Pieridae remain prominent, but their ecological signal differs from the drier sections. In this corridor, these families are more closely associated with woodland–farm interfaces, flowering shrubs, and riparian edges. Hesperiidae are well represented and indicate shaded grasslands, understorey vegetation, and forest margins, reinforcing the presence of structurally layered habitats.

Pollinator diversity is particularly high in this section. Apidae, Halictidae, and Syrphidae occur in large numbers, reflecting high floral diversity and resource continuity. Syrphidae are especially diverse at family level, indicating a mosaic of flowering plants, moist microhabitats, and agricultural systems that support both larval and adult stages. Their presence also signals ecological connectivity between natural vegetation and farmlands.

Predatory and soil-associated invertebrate families such as Formicidae, Reduviidae, and Laelapidae are more evident in this section, reflecting more complex trophic interactions and better-developed soil and litter layers. Ants of the family Formicidae indicate intact soil structure and resource availability, while mites in Laelapidae suggest functioning detrital and soil-faunal systems.

Aquatic and semi-aquatic invertebrate families are well represented due to the presence of rivers and perennial streams. Planorbidae and Bithyniidae indicate slow-moving or standing freshwater habitats, while Culicidae reflect shaded pools and vegetated water bodies. Odonate families are diverse and abundant, indicating good water quality and structurally complex riparian habitats.

Tephritidae remain present but are more evenly distributed across natural and cultivated habitats, reflecting a mix of wild host plants and agricultural crops. Their diversity in this section suggests a landscape where farming and natural vegetation coexist closely.

Overall, the invertebrate assemblage along the Nyaru–Kimwarer–Kapkayo section reflects a woodland–riverine–agricultural mosaic, with high diversity of forest-edge butterflies, pollinators, predators, soil fauna, and aquatic insects, indicating relatively high ecological integrity compared to the other road sections.


a)


b)


c)


d)


e)


f)

Plate 4-4: a) Green-Veined Charaxes (Charaxes candiope), b) Layman (Amauris albimaculata), c) Skimmer Dragonfly Family (Libellulidae), d) Potter Wap (Delta sp.), e) Tiny Grass Blue (Zizula hylax), and f) Round Winged Orange Tip (Colotis euippe).

4.29.2.3 Kimwarer – Emsea Invertebrate Species

The Kimwarer–Emsea section is strongly influenced by valley bottoms, rivers, wetlands, and floodplain agriculture, and this is clearly reflected in the invertebrate assemblage. Aquatic and semi-aquatic families dominate the ecological signal. Planorbidae, Bithyniidae, and Coenagrionidae indicate permanent or seasonal freshwater habitats such as rivers, streams, and wetlands. Libellulidae and other odonate families are particularly abundant and diverse, reflecting open water, emergent vegetation, and good sunlight penetration typical of riverine and floodplain systems.
Culicidae are common in this section, indicating standing water in floodplains, drainage channels, and agricultural landscapes. Their presence highlights the importance of water management and drainage in this corridor. Raninidae and other aquatic-associated taxa further reinforce the dominance of freshwater habitats.

Butterfly families such as Nymphalidae, Pieridae, and Papilionidae are present but are largely associated with riparian vegetation, wet grasslands, and cultivated margins rather than dry bushland or woodland. Danaus, Belenois, Eurema, and Junonia indicate open, sunlit habitats with abundant herbaceous vegetation and flowering plants along floodplain farms and riverbanks.

Pollinator families remain important, with Apidae and Syrphidae exploiting flowering crops, riparian vegetation, and fallow land. Syrphidae diversity suggests a strong link between wetland productivity, flowering plants, and biological control functions within agricultural systems.

Tephritidae are abundant in this section, reflecting intensive agriculture and the presence of fruiting crops and wild host plants in moist environments. Their high diversity indicates strong interactions between farming practices and invertebrate community composition.

Predatory and scavenging invertebrate families such as Formicidae, Reduviidae, and Noctuidae contribute to food-web structure and are associated with both natural wetlands and cultivated areas.

In summary, the Kimwarer–Emsea invertebrate assemblage reflects a wetland–riverine–floodplain agricultural system, dominated by aquatic insects, pollinators, and disturbance-associated taxa, with strong ecological dependence on water availability and riparian vegetation.


a)


b)


c)

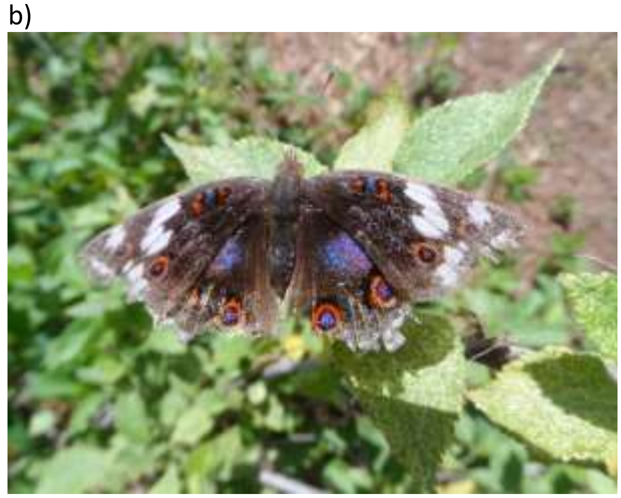

d)

Plate 4-5: a) African Common White (Belenois creona), b) Julia Skimmer (Orthetrum julia) c) Scarlet Tip (Colotis danae), and d) Blue Pansy (Junonia oenone).

4.29.3 Mammal Diversity

4.29.3.1 Biretwo – Chesongoch Mammal Diversity

The mammal assemblage associated with the Biretwo–Chesongoch section reflects a predominantly dry to semi-arid escarpment and bushland landscape, with rocky slopes, open savanna, and scattered woodland. At family level, Bovidae dominate the ecological signal, particularly taxa associated with open grassland, bushland, and rocky terrain, including gazelle-like forms, small antelopes such as Madoqua, and mixed feeders such as Tragelaphus and Kobus. These groups indicate a landscape capable of supporting both grazing and browsing strategies, consistent with a mosaic of grasses, shrubs, and scattered trees. Within this open escarpment system, Elephantidae are also present and represent an important component of the large mammal assemblage, using this section as part of a wider dispersal and seasonal movement landscape rather than as a permanent residence area.

Elephant presence along the Biretwo–Chesongoch road section is closely linked to seasonal rainfall patterns and landscape drainage characteristics. During the wet season, elephants move into the upper escarpment and well-drained bushland areas where soils are firmer and forage availability improves, while avoiding waterlogged lowlands downstream. The open savanna interspersed with woody vegetation provides suitable browsing resources, and the escarpment terrain offers relatively dry movement routes that align with traditional elephant pathways. This seasonal use brings elephants into proximity with cultivated areas, particularly during periods when maize and other crops are present, contributing to crop damage but historically with limited escalation to severe human–wildlife conflict.

Equidae and Giraffidae, where present, further support the interpretation of open savanna and bushland with sufficient forage and visibility, conditions that are also compatible with elephant movement and foraging at a landscape scale.

Carnivore families such as Canidae, Felidae, and Hyaenidae indicate a functional trophic structure within open landscapes, relying on wide hunting ranges and relatively open terrain. The presence of Hyaenidae and large felids suggests the availability of medium to large herbivore prey, including both wild ungulates and, seasonally, elephants that shape vegetation structure and indirectly influence prey distribution through habitat modification.

Small mammal families including Muridae, Gliridae, Hystricidae, and Leporidae reflect rocky habitats, grasslands, and bushland soils, often associated with burrowing or crevice-using species. Procaviidae, including Procavia and Dendrohyrax, are particularly indicative of rocky escarpments and cliff faces, which are characteristic features of this road section and contribute to habitat heterogeneity alongside elephant-modified vegetation patches.

Overall, the mammal assemblage in the Biretwo–Chesongoch section reflects a dry escarpment–savanna system structured around open habitats, rocky refugia, and pastoral land use, with the presence of elephants highlighting the role of this corridor as a seasonal dispersal and movement zone for large megaherbivores within the broader landscape.

Plate 4-6: The African multimammate rat (Mastomys sp.)

4.29.3.2 Nyaru – Kimwarer – Kapkayo Mammal Diversity

The Nyaru–Kimwarer–Kapkayo corridor exhibits the highest ecological complexity in terms of mammal families, reflecting a landscape of woodland, riverine forest, forest edges, and mixed agriculture. Bovidae remain important but shift toward taxa associated with browsing and mixed feeding, including forest-edge and woodland antelopes such as Cephalophus, Tragelaphus, and Pseudotragus, indicating denser vegetation and greater vertical structure.

Cercopithecidae are particularly significant in this section, including genera such as Cercopithecus, Colobus, Chlorocebus, Papio, and Theropithecus. These primates are strongly associated with riverine forest, woodland canopies, forest edges, and gallery forests, and their presence indicates the availability of tall trees, continuous canopy patches, and reliable water sources. Colobus and Cercopithecus, in particular, signal relatively intact woody habitats and ecological connectivity along riparian corridors.

Elephantidae, including Loxodonta use of this landscape as a movement and foraging corridor linking woodlands and riverine systems. Their presence underscores the importance of large-scale connectivity and access to water and woody vegetation.

Bat families such as Pteropodidae, Hipposideridae, Rhinolophidae, Nycteridae, Molossidae, and Vespertilionidae are diverse, reflecting a structurally complex landscape offering roosting sites in trees, caves, riverbanks, and buildings, as well as abundant insect and fruit resources. Fruit bats of the family Pteropodidae indicate the presence of fruiting trees within woodland and riverine habitats.

Rodent diversity is also high, with Muridae, Nesomyidae, Cricetidae, and Spalacidae reflecting varied niches from forest floor and grassland to wetlands and burrowing systems. This diversity points to intact soil structure, litter layers, and vegetation heterogeneity.

In summary, the Nyaru–Kimwarer–Kapkayo section represents a woodland–riverine–forest edge system with strong signals of primates, large herbivores, bats, and diverse small mammals, indicating high ecological value and functional connectivity.

4.29.3.3 Kimwarer – Emsea Mammal Diversity

The Kimwarer–Emsea section is ecologically shaped by valley bottoms, rivers, wetlands, and floodplain systems, and this is clearly reflected in the mammal assemblage. Hippopotamidae are a defining family in this section, indicating permanent water bodies and slow-moving rivers. Semi-aquatic carnivores within Mustelidae, including otter-like taxa, further reinforce the dominance of aquatic and riparian habitats.

Suidae are prominent in this corridor, particularly Potamochoerus and related taxa, which are closely associated with riverine thickets, wetlands, floodplains, and agricultural mosaics. Their presence reflects dense cover, moist soils, and abundant food resources in riparian zones. Bovidae remain important but are dominated by species tolerant of wetter grasslands and floodplain environments, such as Kobus and Tragelaphus.

Primates, particularly Chlorocebus and Papio, are characteristic of this section, exploiting riverine vegetation, farms, and forest edges. Their adaptability reflects a landscape where natural habitats and human land use are closely interwoven. Rodent families such as Muridae, Nesomyidae, and Thryonomyidae are strongly associated with wetlands, tall grasses, and floodplain agriculture, indicating high primary productivity and dense ground cover.

Bat diversity remains high, especially within Vespertilionidae and Pteropodidae, reflecting the abundance of insects, fruiting trees, and roosting sites near water. The presence of Orycteropodidae and Spalacidae indicates friable soils suitable for burrowing, often associated with moist floodplain conditions.

Overall, the Kimwarer–Emsea mammal assemblage reflects a riverine–wetland–floodplain system, dominated by water-dependent mammals, riparian specialists, and adaptable generalists, with strong sensitivity to hydrological changes and land-use modification.

Plate 4-7: Vervet Monkey (Chlorocebus pygerythrus)

4.29.4 Herpetofauna

4.29.4.1 Biretwo - Arror - Chesongoch Herpetofauna

The herpetofauna assemblage along the Biretwo–Chesongoch road section reflects a dry to semi-arid escarpment and bushland environment characterised by rocky slopes, shallow soils, open savanna, and limited surface water. Amphibian diversity in this section is dominated by families tolerant of temporary or seasonal water availability, particularly Bufonidae. Species within Amietophrynus and Poyntonophrynus are well adapted to arid and semi-arid conditions, breeding opportunistically in ephemeral pools formed after rainfall and surviving prolonged dry periods through burrowing or sheltering in rocky crevices. The presence of Ptychadenidae and Pyxicephalidae further reflects reliance on seasonal wetlands and rain-filled depressions rather than permanent aquatic systems.

Reptile families in this section strongly reflect open, rocky, and bushland habitats. Agamidae, including Agama species, are characteristic of rocky outcrops, road embankments, and open ground where basking opportunities are abundant. Scincidae and Lacertidae occupy grassland edges, rocky substrates, and disturbed roadside habitats with loose soils. Lamprophiidae and Colubridae are well represented and indicate structurally heterogeneous bushland with adequate prey availability, particularly small mammals and amphibians. Testudinidae, especially Stigmochelys pardalis, are typical of open savanna and bushland and reflect relatively undisturbed ground surfaces and forage availability. Varanidae, particularly *Varanus albigularis*, indicate dry woodland and savanna environments with sufficient prey and nesting opportunities in friable soils.

Overall, the herpetofauna of the Biretwo–Chesongoch section is indicative of a dry escarpment–savanna system, with species adapted to seasonal moisture, rocky refugia, and open basking habitats, and relatively low dependence on permanent water bodies.


a)


b)

Plate 4-8: a) Leopard Tortoise (Geochelone pardalis) and b) Nile Monitor (Varanus niloticus)

4.29.4.2 Nyaru – Kimwarer – Kapkayo Herpetofauna

The Nyaru–Kimwarer–Kapkayo corridor supports the highest ecological diversity of herpetofauna, reflecting a mosaic of woodland, riverine habitats, wetlands, and forest edges. Amphibian families such as Hyperoliidae, Phrynobatrachidae, Pipidae, and Ptychadenidae are strongly represented, indicating the presence of permanent or semi-permanent water bodies, swampy margins, and moist microhabitats. Hyperolius and Kassina species are closely associated with vegetated wetlands and grassland–water interfaces, while Xenopus species are fully aquatic and signal permanent water bodies such as rivers, ponds, and dams.

Reptile diversity in this section reflects both arboreal and aquatic habitat availability. Chamaeleonidae, including Chamaeleo and Trioceros, indicate structurally complex vegetation with shrubs and trees suitable for arboreal movement and foraging. Colubridae and Lamprophiidae show high diversity, reflecting a range of microhabitats from forest edges and thickets to open woodland. Natricidae and Pelomedusidae are closely linked to rivers, wetlands, and slow-moving waters, indicating strong hydrological connectivity.

The presence of *Varanus niloticus* highlights the importance of large river systems and riparian corridors in this section. Testudinidae and Trionychidae further reinforce the role of stable soils and aquatic habitats along floodplains. Typhlopidae indicate well-developed soils and leaf litter layers, while Viperidae such as Causus resimus are associated with moist grasslands and forest edges.

This assemblage characterises the Nyaru–Kimwarer–Kapkayo section as a key herpetofaunal zone driven by water availability, vegetation complexity, and habitat connectivity.

4.29.4.3 Kimwarer – Emsea Herpetofauna

The Kimwarer–Emsea road section is dominated by riverine, wetland, and floodplain environments, and this is clearly reflected in the herpetofauna composition. Amphibian families with strong aquatic affinities, including Pipidae, Ptychadenidae, Phrynobatrachidae, and Hyperoliidae, are prominent and indicate permanent water bodies, marshes, and seasonally flooded grasslands. Species of Xenopus and Ptychadena are particularly indicative of standing and slow-moving waters, while Phrynobatrachus species reflect moist ground and shallow wetland margins.

Reptile families in this section show a strong aquatic and riparian signal. Varanidae, especially *Varanus niloticus*, are closely associated with rivers and wetlands. Natricidae and Pelomedusidae further emphasise the importance of aquatic habitats, while Trionychidae indicate soft substrates and deeper water bodies. Colubridae and Lamprophiidae remain present but are largely associated with riparian vegetation, floodplain grasslands, and cultivated areas near water.

Testudinidae persist in drier patches within the floodplain mosaic, while Scincidae and Gekkonidae occupy disturbed areas, farms, and settlement edges. The occurrence of Typhlopidae and burrowing reptiles reflects moist, friable soils typical of floodplain environments.

Overall, the Kimwarer–Emsea herpetofauna assemblage represents a water-dependent riverine and wetland system that is highly sensitive to hydrological alteration, drainage modification, and changes in floodplain connectivity.

4.30 *Ficus sycomorus* Distribution along Biretwo – Arror - Chesongoch road

The distribution of *Ficus sycomorus* along the Biretwo–Chesongoch road corridor reflects both its ecological requirements and its long-standing role as a keystone species in dryland and escarpment ecosystems. This species is ecologically adapted to environments with reliable sub-surface moisture, deep alluvial or colluvial soils, and relative long-term landscape stability. Its presence along the corridor therefore marks zones of sustained ecological function, particularly along drainage lines, mid-slopes, and stable interfluves.

From Biretwo trading center through Chesigot and Kabito sublocations, approximately between chainage 0+000 and 6+000, Ficus sycomorus occurs as isolated, mature individuals close to drainage lines and lower mid-slope positions. Ecologically, these trees indicate locations where soil moisture persists below the surface even during the dry season. Their extensive root systems access deep groundwater and bind soil layers, reducing erosion along drainage margins. In this intensively used agro-pastoral landscape, these trees function as refugia for biodiversity, providing shade, nesting sites, and a dependable fruit source that supports birds, bats, and small mammals when other resources are scarce.

Between Songeto and Rimo sublocations, roughly from chainage 7+000 to 13+000, the occurrence of Ficus sycomorus becomes more frequent and spatially coherent. Trees in this section are positioned near ephemeral and seasonal drainage features that recharge during the rainy season but remain relatively dry at the surface. Ecologically, Ficus sycomorus is known for asynchronous fruiting, meaning individual trees may bear fruit at different times of the year. This trait makes them particularly valuable for sustaining frugivorous bird communities across seasons, contributing to seed dispersal and maintaining broader vegetation diversity in the surrounding landscape.

A notable concentration of Ficus sycomorus is observed between chainage 13+000 and 17+000 within Songeto and Rimo sublocations. Here, trees are located on well-drained mid-slopes and stable soils, conditions that allow the species to reach large sizes and long lifespans. Ecologically, these large figs act as structural habitat features, supporting nesting raptors, cavity-nesting birds, and diverse insect assemblages. Their fallen fruits and leaf litter enrich surrounding soils, enhancing nutrient cycling and promoting localized patches of higher vegetation productivity.

Between chainage 21+000 and 24+000, within Anin and Komoigon sublocations, Ficus sycomorus is strongly associated with drainage crossings and moisture-retaining slope breaks along the road alignment. The presence of mature individuals in this section reflects decades of uninterrupted growth, suggesting relative stability of these microhabitats despite surrounding land use. Ecologically, fig trees are well documented as keystone food resources in African landscapes, providing critical forage for birds, primates, ungulates, and bats. In this corridor, they likely support both resident and migratory bird species, especially during periods when other fruiting trees are absent.

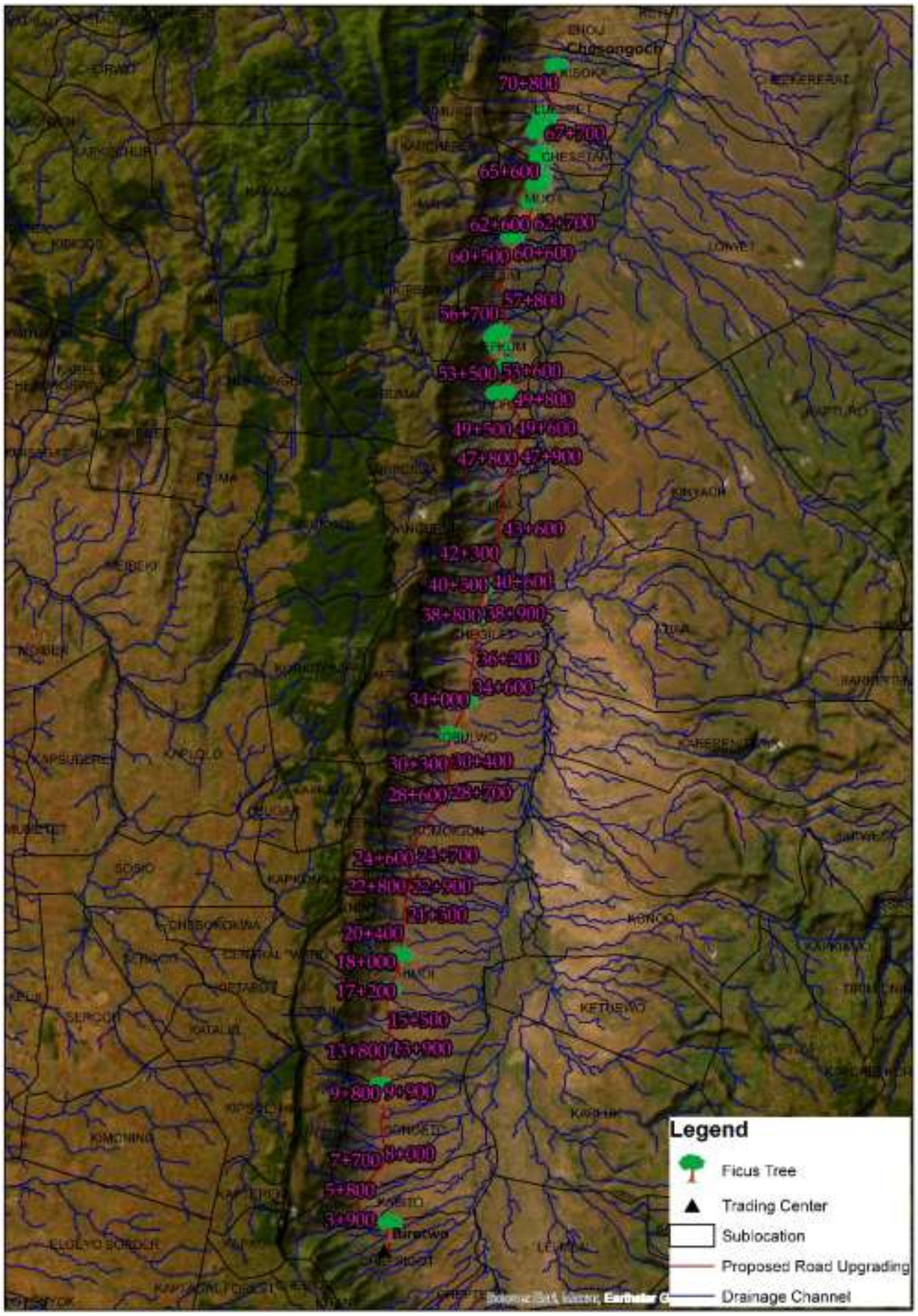
From Komoigon through Kobulwo and Chegilet sublocations, approximately between chainage 24+000 and 36+000, Ficus sycomorus becomes more scattered but remains consistently tied to riparian corridors and gentle slope transitions. In these areas, the trees contribute to bank stabilization and regulation of microclimates along drainage lines. Their dense canopies reduce evapotranspiration and moderate temperature extremes, creating favourable conditions for understory vegetation and soil organisms. This ecological function enhances overall landscape resilience, particularly during prolonged dry periods.

A further cluster of Ficus sycomorus occurs between chainage 37+000 and 40+000 within Chegilet and Koitilial sublocations. These trees occupy mid-slope zones that remain relatively dry and stable during the rainy season, aligning with known wildlife movement routes. Ecologically, figs often act as focal points for animal activity, drawing birds and mammals that in turn facilitate seed dispersal of other plant species. This process supports vegetation regeneration and maintains ecological connectivity across fragmented habitats.

Between chainage 49+000 and 51+000, within Aror sublocation, Ficus sycomorus is present near drainage convergence zones and gently sloping terrain. Here, the trees serve as important dry-season refuges and feeding sites for wildlife moving away from wetter valley bottoms. Their ability to withstand periodic drought while maintaining fruit production underscores their role as a stabilising ecological element in variable climatic conditions.

Further north, from Resim through Mogil, Chesetan, Kukei, Kisoka, and toward Chesongoch trading center, approximately between chainage 51+000 and 70+800, Ficus sycomorus occurrences are fewer and largely restricted to well-established drainage systems. Increased human activity and land modification in this section appear to limit regeneration, making existing trees particularly important. Ecologically, the loss of mature fig trees in such landscapes can result in disproportionate declines in bird and wildlife diversity, given their keystone status.

Overall, the distribution of Ficus sycomorus along the Biretwo–Chesongoch corridor highlights areas of sustained moisture availability, soil stability, and ecological continuity. As a keystone species, Ficus sycomorus supports complex food webs, enhances soil fertility, stabilises drainage systems, and provides critical habitat for a wide range of species. Protecting these trees during road upgrading is therefore essential to maintaining ecosystem function, biodiversity, and ecological resilience along the corridor.


Chesongoch
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7+700
8+000
5+800
3+900
Biretwo
Legend
Ficus Tree
Trading Center
Sublocation
Proposed Road Upgrading
Drainage Channel

4.31 Termite Habitat along Biretwo – Arror - Chesongoch road

The distribution of termite mounds along the Biretwo–Chesongoch road corridor shows a clear spatial pattern linked to terrain position, soil drainage, and vegetation structure, making termites a useful ecological indicator of relatively stable, well-drained environments along the escarpment landscape. Termite mounds are not evenly distributed along the alignment but occur in distinct clusters that correspond with specific chainage sections and sublocations.

Plate 4-9: Termite mound (Macrotermes sp.) nest with tall open-chimney for venting heat generated by colony, in the lowland semi-arid sections of Biretwo-Arror-Chesongoch road.

From Biretwo trading center through Chesigot and Kabito sublocations, approximately between chainage 0+000 and 6+000, termite mounds are sparse and largely absent. This section lies close to wetter valley bottoms and areas with higher drainage density, where soils are periodically waterlogged during the rainy season. Such conditions are generally unfavourable for long-term mound construction, as excessive soil moisture disrupts termite nest stability and ventilation.

Termite mound occurrence increases gradually from Songeto through Rimo sublocations, roughly between chainage 7+000 and 13+000. In this section, mounds begin to appear on gently sloping ground and mid-slope positions where soils are better drained and less prone to seasonal saturation. The presence of termite mounds here indicates improved soil aeration and relatively stable surface conditions compared to downstream low-lying areas.

A notable concentration of termite mounds is observed between chainage 13+000 and 17+000 within Songeto and Rimo sublocations. These mounds are primarily located on interfluves and upper mid-slopes adjacent to the road alignment. The soils in this zone are well-drained and structurally stable, supporting long-term termite colonies. Ecologically, this reflects an environment with moderate disturbance, sufficient organic matter input from surrounding vegetation, and limited prolonged flooding.

Between chainage 21+000 and 24+000, within Anin and Komoigon sublocations, termite mound density increases further and forms a distinct belt parallel to the road. This area corresponds with relatively dry ridges and gently undulating terrain that remains firm during the rainy season. Termite presence here suggests soils with good infiltration capacity and sustained sub-surface moisture balance, conditions that also make these areas attractive to elephants during wet periods. The coincidence of termite mounds and elephant movement corridors highlights the role of termites as indicators of dry-season refugia and structurally resilient landscapes.

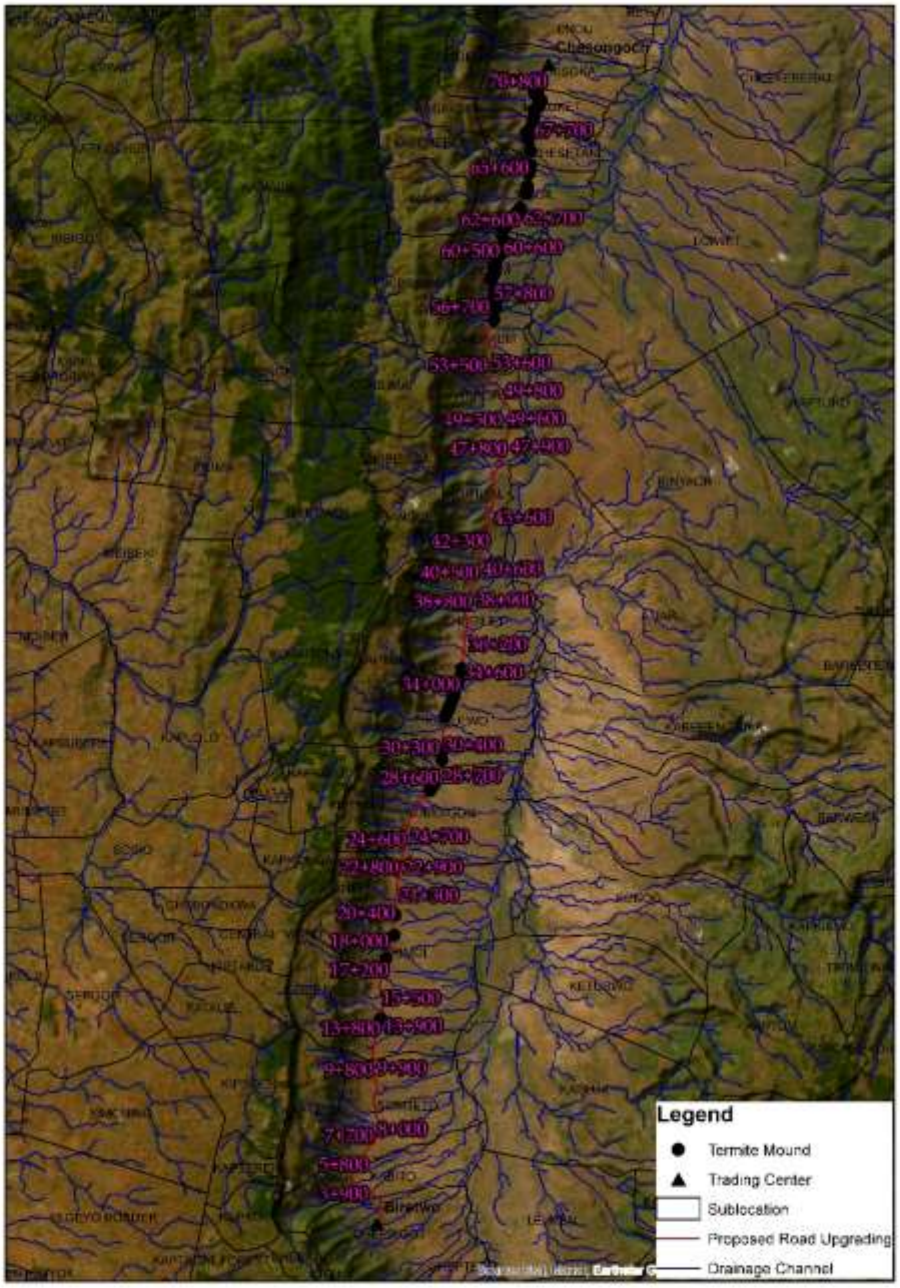
From Komoigon through Kobulwo and Chegilet sublocations, approximately between chainage 24+000 and 36+000, termite mounds remain frequent but are unevenly distributed. They tend to cluster on convex slope positions and away from active drainage channels. This spatial pattern indicates termite avoidance of areas prone to concentrated runoff and erosion, and preference for stable ground where vegetation cover supports continuous organic inputs.

A particularly strong presence of termite mounds is recorded between chainage 37+000 and 40+000 within Chegilet and Koitilial sublocations. In this section, mounds are aligned along mid-slope zones that form transitional areas between steep upstream escarpment faces and gentler downstream terrain. Ecologically, this reflects zones of long-term soil stability, where erosion rates are low enough to allow mound persistence over decades. These areas often support more productive grassland and shrubland vegetation, enhanced by termite-driven soil mixing and nutrient cycling.

Between chainage 49+000 and 51+000, within Aror sublocation, termite mounds occur in well-defined clusters on gently sloping, well-drained ground east of the road alignment. Their presence here indicates relatively dry soil conditions during the rainy season and limited surface waterlogging. This aligns with local observations that both wildlife and livestock favour these areas during wet periods, reinforcing the role of termites as indicators of favourable habitat conditions.

Further north, from Resim through Mogil, Chesetan, Kukei, and toward Chesongoch trading center, approximately between chainage 51+000 and 70+800, termite mounds remain present but become more dispersed. Their distribution follows ridgelines and upper slope positions rather than valley bottoms, reflecting increasing aridity and reduced organic input toward the northern sections. Near Chesongoch, mound density decreases where human activity and land disturbance are higher, suggesting sensitivity of termite colonies to intensive land use.

Overall, termite mounds along the Biretwo–Chesongoch corridor function as reliable ecological indicators of well-drained soils, long-term surface stability, and moderate disturbance regimes. Their spatial coincidence with dry mid-slope zones, elephant dispersal routes, and relatively productive vegetation highlights their role in shaping ecosystem processes such as soil formation, nutrient cycling, and vegetation structure. Areas with high termite mound density therefore represent ecologically resilient landscapes that warrant careful consideration during road upgrading, as disturbance to these zones could disproportionately affect soil function and habitat quality.



3.14. Elephant Dispersal Areas along Biretwo – Arror - Chesongoch road

Elephant dispersal along the Biretwo–Chesongoch road corridor is strongly influenced by seasonal rainfall patterns, slope, and drainage conditions associated with the escarpment landscape adjoining Rimoi National Reserve. During the rainy season, particularly between May and July, elephants are reported to move out of the Reserve and disperse eastwards and southwards across the road alignment, selectively using relatively well-drained and less waterlogged terrain. These movements are most evident along sections of the road that lie close to the escarpment break and traverse moderately sloping ground with good surface drainage.

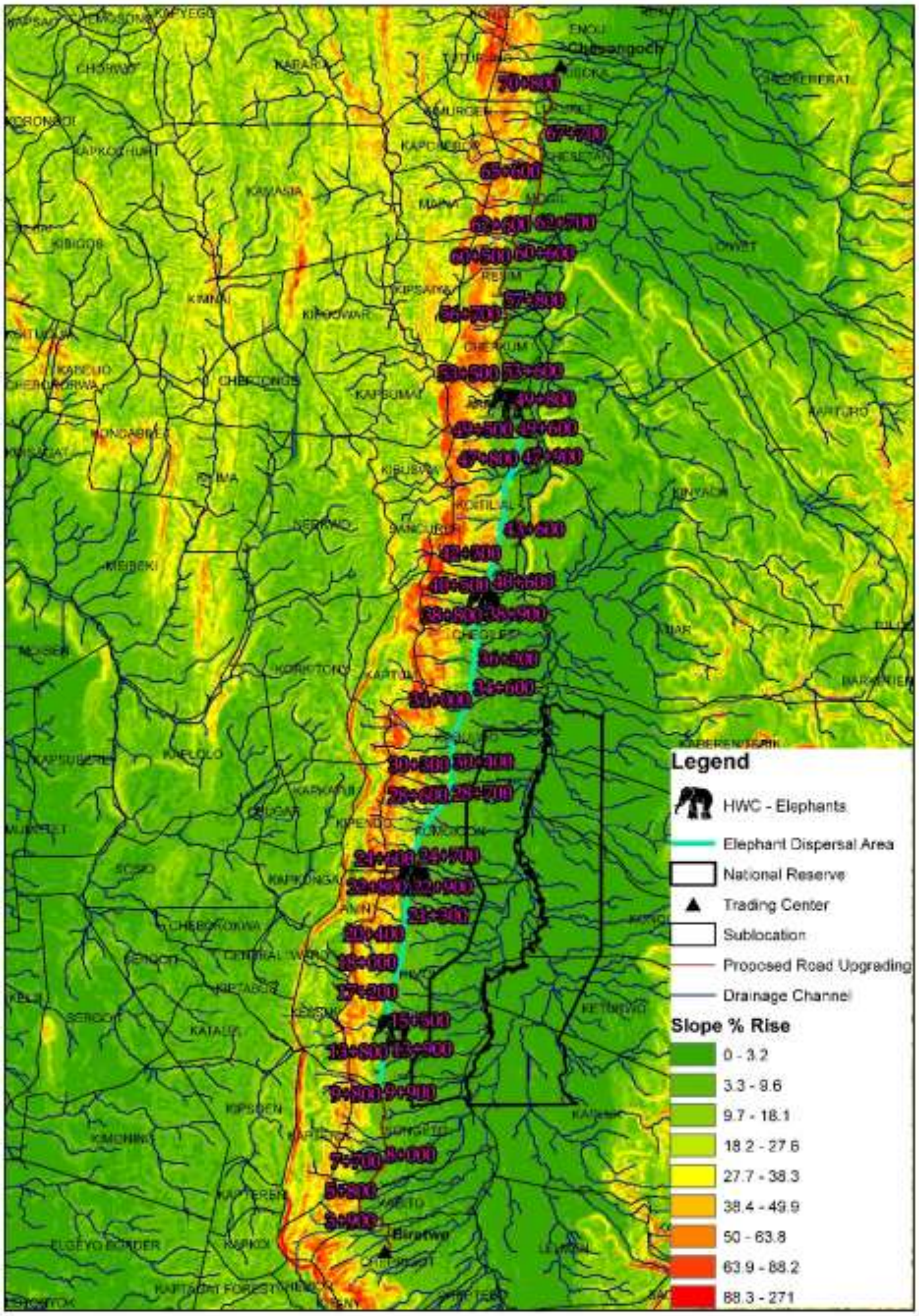
From Biretwo trading center through Chesigot and Kabito sublocations, approximately between chainage 0+000 and 6+000, elephant movement is limited and largely transient. Although this section lies close to the southern extent of the dispersal zone, high drainage density and localized wet conditions downstream during the rainy season appear to discourage prolonged elephant presence. Movements here are mainly associated with passage rather than feeding.

Elephant dispersal becomes more pronounced further north through Songeto, Rimo, and Anin sublocations, roughly between chainage 6+000 and 20+000. In this stretch, elephants are observed to cross the road from the western side, moving away from wetter downstream areas toward relatively drier, gently sloping terrain east of the alignment. The presence of cultivated maize fields during the rainy season coincides with this movement, making these areas attractive for foraging.

Between Komoigon and Kobulwo sublocations, approximately chainage 20+000 to 30+000, the road lies directly within a key dispersal corridor linking Rimoi National Reserve to surrounding community lands. The terrain here is characterised by moderate slopes and relatively well-drained soils compared to the lower-lying downstream areas. During periods of sustained rainfall, elephants appear to preferentially use these drier ridges and mid-slope zones, avoiding waterlogged valley bottoms and saturated drainage corridors.

Further north, through Chegilet, Koitilial, Sangurur, and Aror sublocations, approximately between chainage 30+000 and 50+000, elephant dispersal is frequent and spatially consistent. The alignment in this section intersects multiple known crossing points where elephants move eastwards across the road, following topographic routes that offer firm ground during the rainy season. These dispersal paths correspond with areas of moderate slope and reduced drainage convergence, making them suitable movement routes when lower areas are muddy.

From Resim through Mogil, Chesetan, Kukei, Kisoka, and up to Chesongoch trading center, approximately between chainage 50+000 and 70+800, elephant dispersal continues but becomes more localized. Movements in this section are associated with drier upper slopes and interfluves, particularly where the road runs parallel to drainage lines rather than cutting across them. Elephants tend to avoid the wetter downstream plains during peak rains and instead use these relatively dry zones as movement corridors.



4.32 Human Wildlife Conflict Areas along Biretwo – Arror - Chesongoch road

Human–wildlife conflict along the Biretwo–Chesongoch road corridor is spatially concentrated in specific chainage sections where elephant dispersal routes intersect cultivated land on relatively dry, well-drained terrain during the rainy season. Based on field mapping, community accounts, and the elephant crossing analysis, the most affected sections are between chainage 13+000–17+000, 21+000–24+000, 37+000–

40+000, and 49+000–51+000. These areas consistently experience crop damage during the May–July period when maize is present, although no loss of human life has been recorded.

Between chainage 13+000 and 17+000, within Songeto and Rimo sublocations, human–elephant conflict is recurrent and seasonal. This section lies immediately east of the escarpment edge, where elephants cross the road from Rimoi National Reserve and move onto mid-slope agricultural land. During the rainy season, downstream valley bottoms become wet and muddy, prompting elephants to favour the relatively dry, gently sloping maize fields along this section. The concentration of smallholder farms close to established elephant movement paths results in repeated crop raiding incidents, particularly at night.

The section between chainage 21+000 and 24+000, largely within Anin and Komoigon sublocations, represents one of the most pronounced HWC hotspots along the corridor. Here, the road cuts across a key dispersal route connecting the Reserve to surrounding agro-pastoral landscapes. The terrain consists of well-drained slopes and interfluves that remain firm during periods of high rainfall. Maize cultivation is common in this zone during the long rains, making it highly attractive to elephants moving out of wetter downstream areas. Crop damage in this section is frequent and spatially concentrated, with elephants repeatedly using the same crossing points across seasons.

Between chainage 37+000 and 40+000, within Chegilet and Koitilial sublocations, human–elephant conflict is closely linked to the interaction of slope and drainage patterns. This section lies along a transition zone where steep upstream catchments discharge toward gentler downstream land. During the rainy season, elephants avoid saturated drainage corridors and instead move along drier ridges and mid-slopes adjacent to the road. These routes coincide with cultivated plots, particularly maize fields established on well-drained soils, resulting in localized but persistent crop damage. The predictability of elephant movement in this section makes it a key area of concern.

The section between chainage 49+000 and 51+000, within Aror sublocation, forms another significant HWC hotspot. This area lies close to a convergence of elephant dispersal paths and cultivated land on relatively dry terrain. During periods of sustained rainfall, elephants moving away from wetter lowland areas cross the road at this point and access maize fields situated on gentle slopes. Although settlement density is lower than in southern sections, the presence of seasonal crops within established movement corridors leads to repeated crop losses during the May–July period.

Overall, these four chainage sections represent the core human–elephant conflict zones along the Biretwo–Chesongoch road corridor. They share common characteristics: proximity to elephant dispersal routes from Rimoi National Reserve, relatively dry and well-drained terrain during the rainy season, and the presence of maize cultivation during peak elephant movement periods. These sections should therefore be prioritised for targeted mitigation measures, including early-warning systems, community crop-protection strategies, and road-related interventions that account for predictable elephant crossings.

4.33 Vehicle-Wildlife Collision along Biretwo-Arror-Chesongoch road

Wildlife–vehicle collisions are a major ecological impact of road infrastructure, occurring when animals attempt to cross roads that fragment their natural habitats. These collisions result in substantial wildlife mortality, particularly among large mammals with wide movement ranges, as well as reptiles and birds that use road surfaces for basking, feeding, or scavenging. In many landscapes, roadkill constitutes one of the most significant human-induced causes of wildlife deaths, disproportionately affecting slow-moving species and those with low reproductive rates (van der Ree et al., 2015; Grilo et al., 2020).

Upgrading roads from gravel pavement to tarmac further intensifies collision risks by allowing higher vehicle speeds, increasing traffic volumes, and enabling continuous day-and-night use. Improved surfaces reduce driver reaction time and increase collision severity, while enhanced night-time traffic elevates risks for crepuscular and nocturnal species. Tarmac surfaces also retain heat, attracting reptiles, and road widening, vegetation clearing, and drainage improvements increase habitat fragmentation and wildlife crossing frequency, thereby amplifying mortality rates (Rytwinski et al., 2016; van der Ree et al., 2015).

Temporal factors compound these impacts, as wildlife–vehicle collisions vary by both season and time of day. Collision rates often peak at dusk, night, and dawn when many mammals are most active and driver visibility is reduced. Wet seasons further increase risk through heightened wildlife movement and poor driving conditions, while dry seasons attract animals to roadside resources and warm road surfaces. The interaction between upgraded road characteristics, seasonal wildlife behavior, and night-time or low-light conditions can therefore substantially elevate collision risk unless time-specific mitigation measures are implemented (Ascensão et al., 2019; Grilo et al., 2020).

Plate 4-10: Road kill of a Spotted Owl flying low while returning from morning hunt with a rodent prey

4.34 Biodiversity Indices

4.34.1 Plants

Plant communities showed high taxonomic breadth and strong ecological heterogeneity, with 137 taxa, H' = 4.228, 1−D = 0.967, and J = 0.859. These values indicate a highly diverse flora with relatively low dominance but still with a few strong disturbance-associated and invasive elements shaping the assemblage. The uploaded plant records are especially notable for the prominence of *Opuntia elatior*, *Prosopis juliflora*, *Calotropis procera*, *Calotropis gigantea*, and *Solanum campylacanthum*, which point to a dryland system with a strong disturbance signature, invasion pressure, and drought adaptation. At the same time, the flora contains ecologically important woody legumes such as *Acacia nilotica* subsp. *subalata*, *Acacia mellifera* subsp. *mellifera*, *Acacia senegal var. senegal*, and other dryland acacias that contribute to soil stabilization, nitrogen inputs, browse, and structural habitat. Taxonomic uniqueness is also evident in succulent and xeromorphic taxa such as *Aloe turkanensis*, *Aloe tugenensis*, *Aloe amicorum*, *Caralluma acutangula*, *Caralluma arachnoidea*, and *Huernia keniensis*, which are particularly valuable indicators of dry, rocky, and specialized microhabitats. Functionally, the plant assemblage spans invasive shrubs and cacti, dryland trees and shrubs, forbs, grasses, succulents, climbers, and disturbance-responsive herbs. From an ESIA perspective, this means vegetation management cannot focus only on cover loss; it must distinguish between desirable native dryland structure, invasive expansion by *Prosopis juliflora*, *Opuntia elatior*, *Lantana camara*, and *Chromolaena odorata*, and the conservation of habitat-specialist succulents and woody browse species. The strongest mitigation linkage here is therefore selective clearing control, invasive species containment, and protection of rocky or localized microhabitats supporting taxonomically distinctive succulent flora.

Taxa	Richness (S)	Shannon (H')	Simpson (1–D)	Evenness (J)
Plants	137	4.228	0.967	0.859
Invertebrates	71	4.007	0.972	0.940
Birds	392	5.484	0.994	0.918
Mammals	73	3.337	0.933	0.778
Reptiles	37	3.329	0.953	0.922
Amphibians	16	1.854	0.742	0.669
Herpetofauna combined	53	3.152	0.905	0.794
Multi-taxa overall	726	5.911	0.996	0.897

4.34.2 Invertebrates

The invertebrate dataset yielded 71 taxa, with H' = 4.007, 1−D = 0.972, and a very high J = 0.940, indicating a strikingly even community structure despite moderate total record count. This is a strong ecological signal, because high evenness in invertebrates often reflects a functionally broad assemblage rather than one dominated by a few outbreak species. The uploaded records are dominated by syrphid flies, fruit flies, butterflies, bees, mosquitoes, ants, assassin bugs, and other insects, with prominent taxa including *Melanostoma infuscatum*, *Asarkina eremophila*, *Apis mellifera*, *Belenois creona*, *Eagris sabadius astoria*, *Papilio demodocus*, *Papilio rex*, *Nezara viridula*, *Odontomachus haematodus*, and multiple *Dacus* and *Ceratitis* species. Ecologically, this assemblage captures several functional groups at once: pollinators, flower visitors, herbivores, pests, predators, and decomposer-associated taxa. Taxonomic uniqueness is notable in the butterfly component, including *Papilio rex*, *Charaxes eupale latimargo*, *Charaxes druceanus obscura*, and *Aphnaeus jefferyi*, which suggest habitat mosaics that support visually conspicuous and often habitat-sensitive Lepidoptera. The fruit-fly-rich component, particularly *Dacus* and *Ceratitis*, is also important because it links biodiversity directly to agro-ecological productivity and pest management risk. From an ESIA perspective, the invertebrate results support mitigation centered on maintaining floral resources, avoiding blanket pesticide use, conserving edge vegetation and host-plant diversity, and preventing simplification of habitat structure. Because *Apis mellifera* and butterfly taxa are present alongside crop-affecting fruit flies, the mitigation balance should be ecological intensification rather than chemical control alone.

4.34.3 Birds

Birds were the richest taxonomic group in the uploaded datasets, with 392 species, H′ = 5.484, 1−D = 0.994, and J = 0.918. This combination indicates a very species-rich and broadly even assemblage, consistent with a heterogeneous landscape containing multiple habitat strata and trophic opportunities. The most frequently represented bird species in the records include *Pycnonotus barbatus*, *Lamprotornis purpuroptera*, *Plocepasser mahali*, *Dicrurus adsimilis*, *Terpsiphone viridis*, *Streptopelia capicola*, *Uraeginthus bengalus*, *Colius striatus*, *Turtur chalcospilos*, and *Eurocephalus ruppelli*. These species collectively reflect a mixed system of shrubland, wooded edges, open country, and human-influenced habitat. Taxonomic and ecological distinctiveness is also evident in species such as *Bucorvus abyssinicus*, *Balearica regulorum*, *Apaloderma narina*, *Poicephalus meyeri*, *Bycanistes subcylindricus*, and raptors including *Buteo augur*, *Aquila rapax*, and *Circaetus* species. Functionally, the avifauna includes insectivores, granivores, nectarivores, frugivores, scavengers, and predators, indicating a highly connected trophic network. For ESIA purposes, this richness means the area is sensitive to vegetation removal, nesting disturbance, noise pulses, and the fragmentation of wooded and riparian strips. Mitigation should therefore emphasize retention of structurally diverse vegetation, scheduling of vegetation clearing outside peak breeding periods where feasible, protection of nesting trees and riparian bird habitat, and minimizing prolonged disturbance in habitats likely to support hornbills, cranes, parrots, and raptors.

4.34.4 Mammals

The mammal assemblage recorded 73 taxa, with a Shannon–Wiener diversity index (H′) of 3.337, Simpson's diversity index (1−D) of 0.933, and Pielou's evenness (J) of 0.778. These values indicate moderate species diversity with relatively higher dominance compared to other faunal groups such as birds, reptiles, and invertebrates, suggesting that while species richness is substantial, a subset of taxa exerts stronger ecological influence within the system.

The assemblage is composed entirely of extant species, including representative taxa such as *Cercopithecus mitis, Colobus guereza, Chlorocebus aethiops, Atilax paludinosus, Bdeogale jacksoni, Epomophorus minor, Epomophorus labiatus, Scotoecus hirundo, Scotophilus dinganii, Myotis tricolor, Rhinolophus eloquens, Nycteris hispida, Tachyoryctes ruddi, Procavia capensis,* and *Xerus rutilus*. This composition reflects a functionally diverse mammalian community spanning multiple trophic levels and ecological guilds.

Consistent with patterns observed in other taxa, the mammal community indicates a heterogeneous landscape structure, characterized by a mosaic of woody vegetation, open areas, rocky refugia, and riparian or drainage-linked habitats. Primates such as *Cercopithecus mitis* and *Colobus guereza* are indicative of arboreal and canopy-linked habitats, aligning with bird assemblages that signal vertical vegetation structure. Bat species, including *Scotoecus hirundo, Scotophilus dinganii,* and *Myotis tricolor*, reflect high insect availability and the presence of suitable roosting habitats, paralleling invertebrate diversity patterns that indicate productive trophic interactions. Rodents and small terrestrial mammals further point to soil integrity, ground cover, and microhabitat heterogeneity, reinforcing signals observed in reptile and invertebrate communities regarding habitat complexity and substrate conditions.

In alignment with cross-taxa ecological patterns, the mammal assemblage demonstrates the importance of habitat connectivity, structural diversity, and resource availability in sustaining biodiversity within the project area. The relatively lower evenness compared to other faunal groups suggests localized dominance of certain adaptable or generalist species, which may be associated with anthropogenic influence or habitat modification.

From an ESIA perspective, mitigation measures should therefore be consistent across taxa and focus on maintaining ecological connectivity and habitat integrity. Key actions include preserving riparian and woody corridors, minimizing habitat fragmentation, reducing disturbance in critical foraging and roosting areas (particularly through management of artificial lighting and noise), and protecting key microhabitats such as mature trees, rocky outcrops, and drainage systems. These measures will support not only mammal diversity but also reinforce ecological functions identified across birds, reptiles, and invertebrates, ensuring a coherent, ecosystem-based approach to biodiversity conservation.

4.34.5 Reptiles

The reptile dataset contained 37 taxa, with H′ = 3.329, 1−D = 0.953, and J = 0.922, indicating a fairly diverse and very even reptile assemblage for the number of records available. Frequently occurring taxa include *Crotaphopeltis hotamboeia*, *Hemidactylus angulatus*, *Trioceros bitaeniatus*, *Lycophidion capense*, *Agama lionotus*, *Causus resimus*, *Trachylepis quinquetaeniata*, *Duberria lutrix*, *Dasypeltis scabra*, and *Varanus niloticus*. This combination points to a habitat mosaic containing open basking spaces, rocky refugia, moist microhabitats, edge habitats, and wetland-associated or drainage-associated zones. Taxonomic distinctiveness is visible in species such as *Trioceros bitaeniatus*, which signals structurally complex vegetation, and *Stigmochelys pardalis*, which adds a large-bodied terrestrial reptile component. Ecologically, the reptile assemblage spans insectivores, egg-eaters, small-vertebrate predators, aquatic-edge users, and generalist lizards. For ESIA interpretation, reptiles are especially sensitive to microhabitat loss through clearing, compaction, rock removal, and drainage alteration. Mitigation should therefore include retaining rock piles and coarse shelter features where safe, minimizing unnecessary stripping of edge vegetation, protecting drainage-line vegetation, and designing works to reduce mortality in areas used by monitors, chameleons, tortoises, and snakes.

4.34.6 Amphibians

After correcting the uploaded amphibian file to retain only amphibian families, the amphibian dataset contained 16 taxa, with H′ = 1.854, 1−D = 0.742, and J = 0.669. These are the lowest diversity and evenness values among the assessed groups, showing that the amphibian assemblage is comparatively constrained and more strongly dominated by a few taxa. The strongest dominant is *Amietophrynus regularis*, followed by *Xenopus laevis*, *Phrynobatrachus acridoides*, *Ptychadena mascareniensis*, and *Tomopterna cryptotis*. Additional amphibian taxa include *Amietophrynus xeros*, *Amietophrynus steindachneri*, *Hyperolius marmoratus*, *Hyperolius kivuensis*, *Ptychadena anchietae*, *Ptychadena superciliaris*, *Kassina senegalensis*, and *Xenopus borealis*. Ecologically, this is a water-linked assemblage dominated by widespread toads, aquatic frogs, puddle-breeders, and taxa that respond strongly to hydroperiod and shallow wet habitats. The low evenness suggests that only a subset of amphibian habitats is strongly represented in the uploaded records. From an ESIA standpoint, amphibians are the clearest indicators of hydrological sensitivity. Mitigation should prioritize the protection of seasonal pools, drainage depressions, seepage zones, and low-lying moist habitat; avoid pollution or siltation of shallow water habitats; and maintain small-scale hydrological connectivity rather than focusing only on large drainage channels.

4.34.7 Herpetofauna (Reptiles + Amphibians)

When reptiles and corrected amphibians are combined, herpetofauna reach 53 taxa, with H′ = 3.152, 1−D = 0.905, and J = 0.794. This indicates a reasonably diverse assemblage, but one still more uneven than reptiles alone because amphibian dominance by *Amietophrynus regularis* and a few other wet-associated taxa pulls the distribution toward certain species. The combined herpetofaunal picture is useful because it captures both thermal and hydrological habitat quality: reptiles respond strongly to structural cover, basking, and refuge conditions, while amphibians respond to moisture, hydroperiod, and water quality. The strongest indicator species across the combined group are *Amietophrynus regularis*, *Xenopus laevis*, *Phrynobatrachus acridoides*, *Ptychadena mascareniensis*, *Crotaphopeltis hotamboeia*, *Hemidactylus angulatus*, *Trioceros bitaeniatus*, and *Varanus niloticus*. For ESIA, herpetofauna together provide one of the best early-warning groups for microhabitat degradation, drainage disruption, and edge simplification.

4.34.8 Multi-Taxa Integrated Biodiversity

Across all cleaned uploaded datasets, the combined assemblage produced 726 taxa, H′ = 5.911, 1−D = 0.996, and J = 0.897, indicating very high overall biodiversity and strong cross-taxa balance. This integrated picture is driven by exceptionally rich bird and plant datasets, but it is ecologically anchored by the coexistence of woody dryland flora, invasive and disturbance flora, pollinators, crop-associated invertebrates, diverse birds, bats, primates, reptiles, and amphibians. Particularly important cross-taxa species include *Prosopis juliflora* and *Opuntia elatior* as indicators of vegetation transformation; *Apis mellifera* as a pollination anchor; *Pycnonotus barbatus*, *Lamprotornis purpuroptera*, and *Buteo augur* as avian indicators of trophic structure; *Cercopithecus mitis* and *Colobus guereza* as signals of arboreal structure; and *Amietophrynus regularis* plus *Xenopus laevis* as hydrological indicators. The overall result is a landscape that is biologically rich but internally differentiated, with strong evidence of both ecological value and ecological pressure.

4.35 Functional Diversity and Ecological Roles Across Taxa

The table below presents a functional perspective of biodiversity within the study area by linking major taxa to their ecological roles and representative species. Rather than focusing solely on species richness, it highlights how different organisms contribute to ecosystem processes, structure, and resilience, providing a more process-based understanding of biodiversity.

Plant communities exhibit a wide range of functional groups, including dryland woody legumes, invasive shrubs and cacti, succulents, herbs, grasses, and climbers. Species such as *Acacia nilotica* subsp*. subalata* and *Acacia mellifera* subsp*. mellifera* play a key role in nitrogen fixation and soil fertility enhancement, supporting productivity in nutrient-limited environments. Grasses such as *Hyparrhenia hirta* underpin grazing systems, while climbers like *Cissus quadrangularis* contribute to structural complexity. The presence of invasive species such as *Prosopis juliflora* and *Opuntia elatior* indicates ecological pressure and potential shifts in vegetation dynamics. Overall, plant functional diversity reflects adaptation to semi-arid conditions and forms the foundation for higher trophic levels.

Invertebrate communities represent critical functional groups, including pollinators, herbivores, predators, and decomposer-linked taxa. Pollinators such as *Apis mellifera* and *Amegilla atrocincta* support plant reproduction, while species like *Dacus bivittatus* and *Ceratitis venusta* influence plant and agricultural dynamics as herbivores or pests. Predatory taxa such as *Odontomachus haematodus* regulate invertebrate populations, contributing to ecological balance. This diversity of roles underscores the importance of invertebrates in maintaining ecosystem services such as pollination, nutrient cycling, and food web stability.

Bird assemblages show a broad range of ecological functions, including insectivory, granivory, frugivory, nectar feeding, and predation. Species such as *Dicrurus adsimilis* contribute to insect control, while *Plocepasser mahali* influences seed dynamics. Frugivores like *Poicephalus meyeri* facilitate seed dispersal, and nectarivores such as *Cinnyris venustus* support pollination processes. Raptors such as Buteo augur occupy higher trophic levels and indicate ecosystem health, while wetland-associated species like *Balearica regulorum* reflect the presence of aquatic habitats. This functional diversity highlights birds as key integrators of ecological processes across habitats.

Mammal communities encompass a range of trophic and ecological roles, including primates, bats, rodents, carnivores, and herbivores. Species such as *Cercopithecus mitis* and *Colobus guereza* contribute to seed dispersal, while bats like *Scotoecus hirundo* regulate insect populations. Rodents such as *Praomys jacksoni* influence soil processes and vegetation dynamics, and carnivores like *Bdeogale jacksoni* regulate prey populations. Herbivores such as *Tragelaphus spekii* shape vegetation structure through grazing and browsing. These interactions demonstrate the role of mammals in maintaining trophic balance and ecosystem dynamics.

Reptiles function as microhabitat specialists occupying roles such as basking lizards, arboreal species, predators, and grazers. Species like *Agama lionotus* and *Trioceros bitaeniatus* reflect habitat structure and vegetation complexity, while snakes such as *Crotaphopeltis hotamboeia* and larger reptiles like *Varanus niloticus* contribute to predation and nutrient cycling. Tortoises such as *Stigmochelys pardalis* influence vegetation through grazing. Their functional roles highlight the importance of microhabitat stability and environmental conditions.

Amphibians, represented by aquatic frogs, puddle breeders, and toads, are strongly linked to water availability and quality. Species such as *Xenopus laevis* and *Ptychadena mascareniensis* depend on aquatic and seasonal habitats, making them sensitive indicators of hydrological integrity. Their lower diversity and specialised habitat requirements highlight vulnerability to environmental change, particularly alterations in drainage and moisture regimes.

Table 4-2 presents a summary of high functional diversity across taxa, indicating a well-structured and resilient ecosystem. The presence of multiple functional groups ensures that key ecological processes such as pollination, seed dispersal, predation, and decomposition are maintained. At the same time, the occurrence of invasive species and pest taxa signals areas of ecological pressure. This functional approach provides a strong basis for biodiversity management by identifying critical ecological roles that should be maintained to support ecosystem stability and long-term sustainability.

Table 4-2: Functional Diversity

Taxa	Functional groups represented	Examples
Plants	dryland woody legumes, invasive shrubs/cacti, succulents, herbs/forbs, grasses, climbers	*Acacia nilotica* subsp. *subalata*, *Acacia mellifera* subsp. *mellifera*, *Prosopis juliflora*, *Opuntia elatior*, *Aloe turkanensis*, *Hyparrhenia hirta*, *Cissus quadrangularis*
Invertebrates	pollinators, flower visitors, herbivores/pests, predators, decomposer-linked taxa	*Apis mellifera*, *Amegilla atrocincta*, *Melanostoma infuscatum*, *Dacus bivittatus*, *Ceratitis venusta*, *Odontomachus haematodus*, *Nezara viridula*
Birds	insectivores, granivores, frugivores, nectarivores, raptors, wetland-associated species	*Dicrurus adsimilis*, *Plocepasser mahali*, *Poicephalus meyeri*, *Cinnyris venustus*, *Buteo augur*, *Balearica regulorum*
Mammals	primates, bats, rodents, carnivores, insectivores, small/medium herbivore-associated taxa	*Cercopithecus mitis*, *Colobus guereza*, *Scotoecus hirundo*, *Praomys jacksoni*, *Bdeogale jacksoni*, *Crocidura montis*, *Tragelaphus spekii*
Reptiles	basking lizards, arboreal reptiles, snakes, monitors, tortoises	*Agama lionotus*, *Trioceros bitaeniatus*, *Crotaphopeltis hotamboeia*, *Varanus niloticus*, *Stigmochelys pardalis*
Amphibians	aquatic frogs, puddle breeders, toads, seasonal wetland indicators	*Xenopus laevis*, *Ptychadena mascareniensis*, *Tomopterna cryptotis*, *Amietophrynus regularis*

4.36 Indicator species matrix

The table below presents a set of indicator species derived from the dataset and links each to specific ecological conditions, pressures, and habitat characteristics within the study area. This approach provides a powerful tool for interpreting ecosystem status, as indicator species reflect underlying environmental processes, habitat quality, and disturbance dynamics beyond simple species presence.

Within plant communities, several species highlight contrasting ecological conditions. The presence of *Prosopis juliflora* indicates strong invasion pressure and ongoing vegetation transformation, often associated with disturbed landscapes and altered grazing or land-use regimes. Similarly, Opuntia elatior reflects invasive spread in dryland environments, signalling habitat degradation and reduced native vegetation resilience. In contrast, species such as *Aloe turkanensis* and *Aloe tugenensis* point to the persistence of specialised rocky and xeric microhabitats, indicating areas where natural environmental conditions remain relatively intact. Native woody species including *Acacia nilotica* subsp*. subalata* and *Acacia senegal* var*. senegal* represent stable dryland vegetation structure, contributing to soil stabilisation, browse availability, and ecosystem functionality. Together, these plant indicators reveal a landscape characterised by both ecological resilience and localized disturbance pressures.

Invertebrate indicators reflect key ecosystem processes and interactions with both natural and agricultural systems. Apis mellifera serves as a strong indicator of pollination function and the availability of flowering resources, suggesting the presence of functional plant–pollinator networks. Conversely, the occurrence of *Dacus* and *Ceratitis* species indicates agro-ecological linkages and potential pest pressure, reflecting interactions between natural ecosystems and cultivated landscapes. These taxa highlight the dual role of invertebrates in supporting ecosystem services while also signalling areas of agricultural influence and disturbance.

Bird species provide insights into trophic structure, habitat continuity, and hydrological conditions. The presence of *Buteo augur* indicates a well-established prey base and functioning trophic hierarchy, as raptors are sensitive to changes in prey availability and habitat integrity. *Balearica regulorum* is strongly associated with wetlands and seasonally moist habitats, and its occurrence reflects the presence and sensitivity of these systems to environmental change. Species such as *Poicephalus meyeri* and *Bycanistes subcylindricus* are indicative of woody habitat continuity and structural complexity, suggesting the persistence of tree cover and mature vegetation patches. Collectively, bird indicators demonstrate the importance of maintaining habitat heterogeneity and ecological connectivity.

Mammal indicators further reinforce the role of vegetation structure and resource availability in shaping biodiversity patterns. Arboreal primates such as Cercopithecus mitis and Colobus guereza indicate the presence of continuous tree cover and high-quality forest or woodland habitats. Bat species including *Scotoecus hirundo* and *Scotophilus dinganii* reflect the availability of flying insect prey and suitable roosting or edge habitats, linking mammal presence to both invertebrate abundance and landscape structure. These indicators highlight the interconnected nature of trophic levels and habitat requirements.

Reptile indicators provide insight into microhabitat conditions and environmental stability. *Trioceros bitaeniatus* is associated with shrub and tree structure, as well as stable microclimatic conditions, indicating intact vegetation and minimal disturbance. In contrast, *Varanus niloticus* is linked to wetland and drainage edge environments, reflecting the integrity of aquatic and semi-aquatic systems. These species demonstrate the sensitivity of reptiles to both vegetation structure and hydrological conditions.

Amphibian indicators are particularly important due to their strong dependence on water availability and quality. Species such as *Xenopus laevis* and *Ptychadena mascareniensis* indicate the presence of persistent aquatic and seasonal water bodies, reflecting hydrological stability. *Amietophrynus regularis*, a more disturbance-tolerant species, indicates the ability of some taxa to persist under variable or degraded conditions, particularly during wet seasons. The combination of sensitive and tolerant amphibian species provides insight into both habitat quality and disturbance gradients.

The indicator species framework reveals a landscape with a mixture of intact ecological functions and areas under pressure from invasive species, agricultural influence, and habitat disturbance. The coexistence of sensitive indicators, such as wetland-dependent birds and amphibians, alongside disturbance-tolerant and invasive species highlights spatial variability in ecosystem condition. This approach is particularly valuable for monitoring and management, as it enables targeted interventions based on specific ecological signals, supporting adaptive biodiversity conservation and restoration efforts.

Table 4-3: Indicator Species

Taxa	Indicator species from dataset	What it indicates
Plants	*Prosopis juliflora*	invasion pressure, vegetation transformation
Plants	*Opuntia elatior*	invasive spread, disturbed dryland habitat
Plants	*Aloe turkanensis / Aloe tugenensis*	specialized rocky/xeric microhabitats
Plants	*Acacia nilotica* subsp. *subalata / Acacia senegal* var. *senegal*	dryland woody structure, browse, soil stabilization
Invertebrates	*Apis mellifera*	pollination function, flowering resource availability
Invertebrates	*Dacus* spp. / *Ceratitis* spp.	agro-ecological pest pressure, fruit resource linkage
Birds	*Buteo augur*	trophic structure, prey base
Birds	*Balearica regulorum*	wetland/seasonally moist habitat sensitivity
Birds	*Poicephalus meyeri / Bycanistes subcylindricus*	woody habitat continuity
Mammals	*Cercopithecus mitis / Colobus guereza*	arboreal habitat quality, tree cover continuity
Mammals	*Scotoecus hirundo / Scotophilus dinganii*	flying insect prey base, roost/edge habitat continuity
Reptiles	*Trioceros bitaeniatus*	shrub/tree structure, microclimate stability
Reptiles	*Varanus niloticus*	wetland/drainage edge integrity
Amphibians	*Xenopus laevis / Ptychadena mascareniensis*	aquatic and seasonal water persistence
Amphibians	*Amietophrynus regularis*	widespread disturbance-tolerant wet-season response

4.37 Species Richness and Species Abundance

Species richness (S) represents the total number of species recorded within each taxonomic group and is one of the most direct measures of biodiversity within the project area. The values presented in Table 5 indicate that the proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County support a highly diverse assemblage of flora and fauna distributed across riparian corridors, woodland remnants, bushland mosaics, escarpment habitats, wetlands, agricultural land, and settlement landscapes. A combined total of 726 species was recorded across all taxa, demonstrating that the project landscape is ecologically heterogeneous and of substantial biodiversity importance.

Birds recorded the highest species richness with 392 species, making them the most diverse taxonomic group within the assessment. This high richness reflects the wide range of habitats available to avifauna, including riverine vegetation, woodland patches, cliffs, wetlands, open grassland, farmland mosaics, and settlement tree cover. The result suggests that the project area functions as an important feeding, breeding, roosting, and movement landscape for both resident and seasonal bird species. The avifaunal richness also indicates strong habitat diversity and landscape connectivity across the corridor.

Plants recorded the second highest richness with 137 species, indicating considerable botanical diversity across the project area. This richness is likely driven by environmental gradients in rainfall, soils, slope position, and land use, which create a mosaic of vegetation communities including riparian forest, woodland, bushland, grassland, agroforestry systems, and disturbed roadside flora. High plant richness is ecologically significant because vegetation forms the structural basis for habitat provision, soil protection, nutrient cycling, and food resources for wildlife.

Mammals recorded 73 species, indicating a relatively rich mammalian community despite the human-modified nature of much of the landscape. This likely includes small mammals such as rodents, bats, mongooses, and hares, as well as medium-sized carnivores, primates, and occasional larger species using habitat corridors. The richness suggests that woodland remnants, riparian strips, and mosaic habitats continue to provide important refuge and movement opportunities for mammals.

Invertebrates recorded 71 species, although this value is likely conservative given the typically high diversity and under-sampling of insect groups in rapid assessments. Even so, the result indicates the presence of pollinators, decomposers, aquatic insects, and other ecologically important taxa that contribute to pollination, soil health, decomposition, and freshwater ecosystem functioning. Invertebrate richness is particularly important as an indicator of ecosystem productivity and habitat quality.

Reptiles recorded 37 species, reflecting moderate richness associated with rocky escarpments, bushland, woodland edges, dry grassland, and warm lower elevations. This indicates that the project area provides a variety of thermal and shelter conditions suitable for reptiles such as lizards, snakes, tortoises, and geckos. Amphibians recorded the lowest richness with 16 species, which is expected because amphibians depend on more localized habitats such as wetlands, streams, seasonal pools, springs, and moist riparian environments. Their lower richness likely reflects the limited distribution of permanently wet habitats relative to terrestrial ecosystems.

When reptiles and amphibians are combined as herpetofauna, a total of 53 species was recorded. This demonstrates that the project area supports a meaningful diversity of ectothermic vertebrates across both dryland and wetland ecosystems, with reptiles contributing more strongly in arid and rocky habitats and amphibians concentrated in wetter zones.

In general, the species richness values indicate that birds, plants, mammals, and invertebrates are the principal contributors to biodiversity within the project area, while reptiles and amphibians provide important habitat-specialist diversity. The high total richness confirms that the proposed road corridors pass through an ecologically valuable landscape where riparian protection, woodland retention, wetland conservation, and habitat connectivity should be prioritized during project implementation.

Table 4-4-Species Richness (S)

Taxa	**Species Richness (S)**
Plants	137
Invertebrates	71
Birds	392
Mammals	73
Reptiles	37
Amphibians	16
Herpetofauna combined	53

Multi-taxa overall	726

4.38 Shannon Wiener Diversity Index (H’)

The Shannon–Wiener Diversity Index (H’) values presented in Table 5 indicate generally high biodiversity across the project area, reflecting the wide range of habitats occurring along the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County. The index combines both species richness and relative abundance, and therefore provides an indication of how many species are present and how evenly individuals are distributed among those species. Higher H’ values signify more diverse and ecologically complex communities, while lower values indicate communities with fewer species or stronger dominance by a limited number of taxa. The results demonstrate that the project landscape supports substantial ecological heterogeneity across multiple taxonomic groups.

Birds recorded the highest Shannon diversity value (H’ = 5.484) among the individual taxonomic groups, corresponding with the exceptionally high species richness of 392 species. This suggests that avifaunal communities within the project area are both species-rich and relatively well distributed across habitats such as riparian corridors, woodland remnants, escarpment cliffs, farmland mosaics, and wetlands. The high H’ value confirms birds as one of the strongest indicators of habitat heterogeneity and ecological integrity within the landscape.

Plants also exhibited a high Shannon diversity value (H’ = 4.228) with 137 species recorded. This indicates that vegetation communities across the project area are structurally diverse and composed of numerous tree, shrub, herb, and grass species. The high plant diversity reflects the environmental gradients in soils, rainfall, slope, and land use across the escarpment-to-lowland system, as well as the presence of riparian vegetation, woodland patches, bushland, and agroforestry systems.

Invertebrates recorded a similarly high diversity value (H’ = 4.007) from 71 species, indicating a rich and relatively balanced assemblage of pollinators, decomposers, aquatic insects, and other functional groups. This high value suggests that many habitats within the project area still retain ecological processes such as pollination, nutrient cycling, and freshwater productivity. The very high evenness reported for invertebrates further indicates that abundance is not dominated by only a few species.

Mammals showed a moderate Shannon diversity value (H’ = 3.337) from 73 species. Although species richness is relatively high, the lower H’ value compared to birds and plants suggests that some mammal communities may be dominated by more common generalist species, while larger or more sensitive mammals occur less frequently. This is consistent with landscapes influenced by agriculture, settlements, and fragmented habitat connectivity.

Reptiles recorded a moderate diversity value (H’ = 3.329) from 37 species, indicating a well-represented reptile assemblage across rocky slopes, bushland, woodland edges, and warmer dry habitats. The relatively high evenness suggests that reptile species are fairly evenly distributed rather than strongly dominated by one or two species. Amphibians, by contrast, recorded the lowest Shannon diversity (H’ = 1.854) from 16 species. This lower value likely reflects the localized nature of suitable amphibian habitats, which are largely restricted to wetlands, streams, drainage corridors, and moist valley bottoms. Amphibian diversity is therefore constrained by water availability and habitat fragmentation.

When reptiles and amphibians are combined as herpetofauna, the Shannon diversity increases to H′ = 3.152, showing that the broader herpetological community is moderately diverse when all reptilian and amphibian habitats are considered together. This reflects the complementarity between dryland reptile habitats and wetter amphibian habitats across the project area.

The highest overall diversity was recorded for the multi-taxa dataset (H′ = 5.911) based on 726 total species. This exceptionally high value demonstrates that the project area, when considered as an integrated landscape, supports very substantial biodiversity across flora and fauna. It confirms that the road corridors traverse an ecologically heterogeneous region where multiple habitats collectively sustain a broad range of species.

Table 4-5- Shannon–Wiener Diversity Index (H')

Taxa	Shannon (H')	Interpretation
Plants	4.228	High plant diversity with structurally varied vegetation communities
Invertebrates	4.007	High diversity with strong ecological functional representation
Birds	5.484	Very high diversity; richest vertebrate group and strong habitat indicator
Mammals	3.337	Moderate diversity with some dominance by common species
Reptiles	3.329	Moderate diversity across dryland and rocky habitats
Amphibians	1.854	Low to moderate diversity restricted to moist habitats
Herpetofauna combined	3.152	Moderate diversity across reptile and amphibian habitats
Multi-taxa overall	5.911	Exceptionally high overall biodiversity across the landscape

4.39 Simpsons Diversity Index

The Simpson's Diversity Index (1−D) values presented in Table 5 indicate a generally high level of biodiversity across the project area, reflecting the wide range of habitats traversed by the proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County. Simpson's index measures the probability that two individuals randomly selected from a community belong to different species. Values closer to 1.0 indicate very high diversity with low dominance by any single species, while lower values indicate stronger dominance by fewer species. The results therefore provide an important indication of community balance, ecological stability, and habitat quality across the recorded taxonomic groups.

The highest Simpson diversity value was recorded for the overall multi-taxa dataset (1−D = 0.996), demonstrating exceptionally high biodiversity when all recorded flora and fauna are considered together.

This indicates that the project landscape supports a broad and well-balanced assemblage of species distributed across multiple ecosystems including riparian corridors, woodlands, bushland, wetlands, escarpment habitats, farmland mosaics, and modified settlement areas. The value confirms the ecological significance of the wider landscape and the importance of maintaining habitat heterogeneity.

Among the individual taxonomic groups, birds recorded a very high Simpson value (1−D = 0.994), the highest of all taxa. This suggests that bird communities are not only species-rich but also relatively evenly distributed, with no single species overwhelmingly dominating the assemblage. The wide range of available habitats, including forests, wetlands, cliffs, agricultural areas, and open landscapes, likely contributes to this balanced avifaunal diversity. Birds therefore remain one of the strongest ecological indicator groups within the project area.

Invertebrates also recorded a very high Simpson diversity value (1−D = 0.972), indicating a highly diverse and functionally balanced community of pollinators, decomposers, aquatic insects, and other invertebrate groups. This reflects the presence of flowering vegetation, wetland systems, stream habitats, and productive soils that support a wide range of ecological processes. Plants similarly showed high diversity (1−D = 0.967), confirming that vegetation communities are composed of many species with relatively low dominance by a few taxa. This is consistent with the varied vegetation types described in the report, including riparian woodland, bushland, agroforestry mosaics, and grassland systems.

Reptiles recorded a strong Simpson value (1−D = 0.953), indicating a moderately rich and well-distributed reptile assemblage across rocky escarpments, warm dry slopes, bushland, and woodland edges. Mammals recorded a slightly lower but still high value (1−D = 0.933), suggesting that mammalian diversity remains substantial, although common adaptable species may contribute more strongly to abundance than rarer or larger mammals. This pattern is typical of mixed-use landscapes influenced by farming, settlements, and habitat fragmentation.

Herpetofauna combined (reptiles and amphibians together) recorded 1−D = 0.905, indicating good overall diversity when dryland reptile habitats and wetter amphibian habitats are considered jointly. Amphibians alone recorded the lowest Simpson diversity value (1−D = 0.742), showing comparatively lower diversity and stronger dominance by fewer species. This is consistent with the restricted distribution of amphibians, which depend on wetlands, streams, drainage corridors, and moist microhabitats that are less widespread than terrestrial habitats across the project area.

Table 4-6 - Simpson's Diversity Index (1−D)

Taxa	Simpson (1−D)	Interpretation
Plants	0.967	High vegetation diversity with low species dominance
Invertebrates	0.972	Very high diversity and strong functional balance
Birds	0.994	Exceptionally high diversity; highly balanced assemblage
Mammals	0.933	High diversity with moderate dominance by common species
Reptiles	0.953	High diversity across dryland habitats

Amphibians	0.742	Moderate diversity; stronger dominance by fewer species
Herpetofauna combined	0.905	High combined reptile–amphibian diversity
Multi-taxa overall	0.996	Exceptional overall biodiversity across the landscape

4.40 Ecosystem Services

The proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County traverse a highly diverse escarpment-to-valley landscape that provides important ecosystem services supporting local livelihoods, biodiversity, watershed stability, and climate resilience. These services arise from the interaction of forests, woodlands, riparian corridors, wetlands, grazing lands, agricultural mosaics, soils, and natural drainage systems distributed along the project area. The road alignment therefore passes through environments that are not only biologically valuable but also economically and socially important to surrounding communities. Understanding these services is essential to ensure that road upgrading enhances development benefits while minimizing ecological losses.

A major regulating ecosystem service within the project area is **water regulation and watershed protection**. Upper escarpment vegetation, woodland patches, and farm tree systems help intercept rainfall, increase infiltration, reduce runoff velocity, and stabilize stream flows. Riparian vegetation and wetlands along drainage crossings filter sediments, reduce bank erosion, recharge groundwater, and maintain downstream water availability. These services are especially important in chainage sections with dense drainage networks and steep slopes, where disturbance could increase flooding, gullying, or sedimentation. If properly managed, road drainage systems can be designed to work with these natural hydrological functions rather than disrupt them.

The project area also provides critical **soil protection and erosion control services**. Vegetation cover on escarpment slopes, valley sides, and cultivated hillsides binds soils, reduces splash erosion, and prevents landslides or slope failure. Grasslands, shrublands, and tree root systems are particularly important in steep chainage zones such as the upper Biretwo and Nyaru escarpment sections. Disturbance of these systems through uncontrolled excavation, spoil dumping, or vegetation clearing may reduce slope stability and increase maintenance costs for the road. Retention of vegetation and slope rehabilitation will therefore preserve both ecological and engineering benefits.

Important provisioning services are also present, particularly **food production, fuelwood, fodder, and water supply**. Agricultural lands along the corridors support maize, beans, vegetables, fruits, and mixed farming systems, while lower drier areas support livestock grazing and agro-pastoral livelihoods. Trees provide timber poles, firewood, charcoal substitutes, shade, fruits, and medicinal products. Riparian zones and springs provide domestic water, livestock watering points, and irrigation opportunities. Improved road access may strengthen markets for these products, but degradation of natural resources could reduce long-term productivity if ecosystem services are not maintained.

The landscape also delivers valuable **biodiversity support services**. Woodland remnants, riparian strips, wetlands, cliffs, bushland mosaics, and farm-tree systems provide habitat, nesting sites, forage resources, breeding grounds, and movement corridors for birds, mammals, reptiles, amphibians, and pollinators. The report identifies riparian habitats and escarpment refugia as biodiversity hotspots, meaning these areas contribute disproportionately to ecological resilience and species persistence. Pollinators and beneficial insects supported by natural vegetation also enhance agricultural productivity in nearby farms.

Another key service is **climate regulation and microclimate buffering**. Tree cover and healthy vegetation store carbon, reduce surface temperatures, improve humidity conditions, provide shade for livestock and people, and reduce wind exposure. In cultivated and settlement areas, farm trees and riparian vegetation moderate local climate stress and contribute to resilience under increasing drought and rainfall variability. Maintaining vegetation cover along the road reserve and adjacent landscapes can therefore contribute to climate adaptation and reduced land degradation.

The project area also provides **cultural and social ecosystem services**. Scenic escarpment landscapes, rivers, forest patches, culturally valued trees such as Ficus sycomorus, and traditional grazing or resource-use areas contribute to community identity, heritage, recreation, and educational value. Natural landscapes also support mental well-being and tourism potential where visually attractive scenery is retained. Road upgrading should therefore consider aesthetic quality, mature tree retention, and culturally sensitive natural features.

Table 4-7 - Key Ecosystem Services Along the Proposed Road

Ecosystem Service Category	Key Services in Project Area	Main Sensitive Locations
Regulating	Water regulation, flood buffering, sediment control, climate moderation	Riparian corridors, wetlands, escarpments
Supporting	Habitat provision, pollination, nutrient cycling, biodiversity persistence	Woodland remnants, wetlands, farm mosaics
Provisioning	Crops, livestock forage, fuelwood, fruits, water, medicinal plants	Farms, grazing lands, rivers, agroforestry zones
Cultural	Scenic landscapes, sacred trees, heritage sites, recreation	Escarpments, river valleys, community landscapes

4.9 Critical Habitat Determination

Based on the biodiversity baseline, ecological sensitivity analysis, terrain assessment, and species records contained in the report, the proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County intersect several habitats that qualify as **critical or highly sensitive habitats** from an ecological management perspective. These habitats are considered critical because they support high biodiversity, key ecosystem services, species of conservation importance, wildlife movement, hydrological integrity, slope stability, or limited and irreplaceable ecological functions. While formal designation under International Finance Corporation Performance Standard 6 would require further species-specific verification, the report clearly identifies priority habitats requiring avoidance, minimization, or stringent mitigation.

The most important critical habitats within the project area are **riparian corridors and riverine vegetation systems** associated with rivers, perennial streams, seasonal drainage lines, wetlands, and valley-bottom watercourses. These habitats were repeatedly identified as biodiversity hotspots and are essential for water regulation, sediment retention, groundwater recharge, bank stabilization, and habitat connectivity. They also provide refuge for birds, amphibians, reptiles, invertebrates, mammals, and moisture-dependent flora. Road crossings, culvert placement, embankment construction, and spoil disposal in these areas could cause disproportionate ecological damage if not carefully managed.

A second category of critical habitat comprises **woodland remnants, indigenous tree clusters, and bushland mosaics**, particularly where natural vegetation persists within otherwise modified agricultural landscapes. These habitats support nesting birds, pollinators, mammals, reptiles, and seed dispersal processes, while also maintaining carbon storage and microclimate regulation. Mature indigenous trees, especially keystone species such as Ficus sycomorus, are of special importance because they provide fruit resources, nesting cavities, shade, and localized biodiversity concentration. Removal of such trees would have ecological impacts beyond their footprint.

The report also indicates that **escarpment slopes, rocky outcrops, cliffs, and steep vegetated terrain** represent critical habitats. These areas contain specialized drought- and rock-adapted flora, raptors, reptiles, cliff-nesting birds, and small mammal refugia. They are also crucial for slope stabilization, erosion control, and maintaining natural landscape connectivity across altitudinal gradients. Due to steep terrain, habitat recovery following disturbance may be slow, and road cuts or blasting could result in long-term ecological degradation.

Wetlands, valley bottoms, and seasonally inundated depressions form another critical habitat type. Although spatially localized, these areas are highly productive and support amphibians, aquatic invertebrates, water birds, sedges, reeds, and moisture-dependent plant communities. They also function as natural flood buffers and groundwater recharge zones. Even small wetland areas may therefore have disproportionately high ecological value relative to their size.

The report further suggests the presence of **wildlife movement corridors and habitat linkages**, especially where river valleys, woodland strips, escarpment breaks, and less-settled land connect broader habitat blocks. Large mammals such as African elephant were referenced in movement corridor context, indicating that some sections may facilitate seasonal or occasional fauna movement. These linkages are critical because fragmentation by roads can disrupt access to forage, water, and breeding areas.

Agricultural mosaics containing retained tree cover, hedgerows, and farm woodlots are not always classified as critical habitat in a strict legal sense, but in this landscape, they may function as **modified habitat of high ecological value**, particularly for pollinators, birds, bats, and small mammals. Where such areas form the only remaining connectivity between natural habitats, they should be managed with elevated sensitivity.

Table 4-8- Critical Habitats within the Project Area

Critical Habitat Type	Ecological Importance	Main Threats from Road Works
Riparian corridors / riverine vegetation	Biodiversity hotspots, water regulation, connectivity	Channel blockage, clearing, sedimentation, pollution

Wetlands / valley bottoms	Amphibians, flood buffering, recharge, aquatic biodiversity	Drainage alteration, filling, contamination
Woodland remnants / indigenous tree clusters	Nesting, pollinators, carbon storage, fauna refuge	Tree clearing, fragmentation, access pressure
Keystone trees incl. Ficus sycomorus	Fruit resource, nesting, shade, cultural value	Removal, root damage
Escarpments / cliffs / rocky outcrops	Raptors, reptiles, specialized flora, slope stability	Blasting, slope cuts, erosion
Wildlife movement corridors	Seasonal movement, landscape connectivity	Barrier effects, collisions
Farm-tree mosaics / modified link habitats	Pollinators, birds, stepping-stone habitat	Simplification, tree loss

4.41 Habitats / Ecosystems

The proposed Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors in Elgeyo Marakwet County traverse a highly heterogeneous escarpment-to-lowland landscape containing a wide range of natural, semi-natural, and human-modified habitats. These ecosystems are shaped by strong gradients in elevation, rainfall, slope, soils, drainage, and land use. As a result, the project area supports multiple habitat types of ecological, hydrological, agricultural, and socio-economic importance. The compiled habitats below are derived from the report’s characterization of vegetation, terrain, biodiversity, land use, and ecosystem services.

The most sensitive ecosystems within the project area are riparian corridors, wetlands, valley bottoms, woodland remnants, springs, escarpment rocky habitats, and wildlife connectivity zones. These habitats support high biodiversity, regulate water movement, reduce erosion, and provide critical refuge for species of conservation importance. Disturbance in such areas could generate disproportionate ecological impacts through habitat fragmentation, flooding, sedimentation, or loss of breeding sites.

Moderately sensitive habitats include bushland, wooded grassland, agroforestry systems, grazing lands, and secondary regrowth areas. Although more resilient than wetlands or riparian zones, these habitats remain important for pollinators, reptiles, birds, livestock forage, and ecological connectivity. Poorly managed construction activities could still reduce their ecological value through clearing, dust deposition, invasive species spread, or unrestricted access.

Lower sensitivity habitats include existing settlements, trading centres, and heavily disturbed roadside zones, where natural ecological integrity has already been substantially modified. However, even these areas may contain important planted trees, drainage functions, and urban biodiversity values that should not be ignored.

Table 4-9 - Habitats / Ecosystems within the Project Area

Habitat / Ecosystem Type	General Description	Main Ecological Functions
Riparian corridors / Riverine vegetation	Vegetated zones along rivers, streams, seasonal drainage lines and watercourses	Water regulation, erosion control, wildlife movement, amphibian and bird habitat

Wetlands / Valley bottoms	Seasonally or permanently moist depressions, floodplains, marshy zones	Flood buffering, groundwater recharge, aquatic biodiversity, dry-season grazing
Upland woodland remnants	Natural or semi-natural tree-dominated habitats in upper slopes and escarpments	Carbon storage, bird habitat, pollination, slope stabilization
Bushland / Shrubland	Mixed shrub and scattered tree vegetation in drier zones	Browse resources, reptile habitat, soil cover, biodiversity refuge
Wooded grassland / Savanna mosaic	Grass-dominated areas with scattered trees and shrubs	Grazing, wildlife habitat, fire regulation, landscape connectivity
Escarpment rocky outcrops / Cliffs	Steep rocky terrain, shallow soils, cliffs, exposed slopes	Specialized flora, raptor nesting, reptile refuge, slope stability
Agroforestry systems	Farms with retained trees, boundary trees, orchards, mixed tree-crop systems	Shade, pollination, carbon storage, fuelwood, biodiversity support
Cropland / Smallholder farms	Cultivated land under maize, beans, vegetables and mixed cropping	Food production, livelihoods, seasonal habitat for some fauna
Grazing lands / Agro-pastoral rangelands	Open grassland, shrub-grass systems used for livestock	Livestock forage, seed dispersal, rural livelihoods
Secondary regrowth / Fallow vegetation	Previously disturbed areas undergoing natural regeneration	Soil recovery, early succession habitat, pollinator resources
Farm-tree mosaics / Hedgerows	Fragmented tree cover between farms and settlements	Connectivity, nesting habitat, windbreaks, pollinator support
Settlement / Trading centre landscapes	Villages, roadsides, market centres, peri-urban zones	Human habitation, commerce, planted shade trees
Roadside disturbed habitats	Existing road verges, borrow areas, compacted edges	Ruderal vegetation, invasive species colonization zones
Springs / Seepage zones	Small permanent moisture zones from groundwater emergence	Water supply, amphibian habitat, micro-refugia
Culvert drainage microhabitats	Moist artificial drainage zones near roads	Opportunistic wetland species, frogs, insects

5 Potential Adverse Impacts – Biodiversity

5.1 Introduction

This chapter presents the ecological impact assessment for the proposed road upgrading across the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea sections. The assessment identifies and evaluates potential direct and indirect impacts of construction and operation activities on biodiversity, ecosystem processes, and biophysical systems.

The assessment is structured by road section and by taxonomic group (plants, birds, mammals, herpetofauna, invertebrates), as well as by key ecological features (elephant dispersal, human-wildlife conflict, termite habitats, *Ficus sycomorus* distribution). Each impact is classified using the risk methodology defined in Section 5.2. A summary of risk classifications is provided in Section 5.13.

5.2 Risk Classification Methodology

5.2.1 Overview

Impacts in this chapter are classified using a risk matrix that combines Consequence (severity of ecological damage) and Likelihood (probability of occurrence). The resulting risk level (CRITICAL, HIGH, MEDIUM, LOW) determines the intensity of mitigation required in Chapter 6.

5.2.2 Consequence (Severity) Categories

Rating	Descriptor	Ecological Definition	Example
5	Critical	Irreversible loss of a protected species population (IUCN threatened or WCMA protected), permanent loss of critical habitat (wetland, forest, corridor), or violation of national law.	Extirpation of an elephant corridor, destruction of a breeding wetland for endangered amphibian.
4	Major	Long-term (>5 years) but potentially reversible damage to a habitat or species population; loss of keystone species individuals; significant fragmentation of connectivity.	Loss of mature *Ficus sycomorus*, permanent sediment deposition in a stream.
3	Moderate	Medium-term (1–5 years) impact; local reduction in species abundance; temporary habitat degradation from which recovery is possible with active restoration.	Loss of scattered trees, temporary roadkill increase, localized erosion.
2	Minor	Short-term (<1 year) disturbance with full recovery expected without active intervention.	Temporary noise disturbance during construction, dust deposition on roadside vegetation.
1	Negligible	No measurable ecological effect; within natural variability.	Brief presence of construction workers, low-level vibration.

5.2.3 Likelihood (Probability) Categories

Rating	Descriptor	Definition	Example
5	Almost Certain	Expected to occur >90% of the time under normal construction conditions.	Vegetation loss within cleared reserve, soil compaction from machinery.
4	Likely	Likely to occur 50–90% of the time.	Erosion on exposed slopes without mitigation.
3	Possible	May occur 10–50% of the time.	Roadkill at a specific crossing point.
2	Unlikely	Could occur but <10% probability.	Collapse of a termite mound from machinery movement.
1	Rare	May occur only in exceptional circumstances (<1%).	Mass mortality event from accidental chemical spill.

5.2.4 Risk Level Matrix (Consequence × Likelihood)

Likelihood \ Consequence	1 (Negligible)	2 (Minor)	3 (Moderate)	4 (Major)	5 (Critical)
5 (Almost Certain)	MEDIUM	MEDIUM	HIGH	**CRITICAL**	**CRITICAL**
4 (Likely)	LOW	MEDIUM	HIGH	HIGH	**CRITICAL**
3 (Possible)	LOW	MEDIUM	MEDIUM	HIGH	**CRITICAL**
2 (Unlikely)	LOW	LOW	MEDIUM	MEDIUM	HIGH
1 (Rare)	LOW	LOW	LOW	LOW	MEDIUM

5.2.5 Risk Level Definitions and Required Action

Risk Level	Definition	Required Action	Management Priority
CRITICAL	Unacceptable risk. May violate law, cause irreversible damage, or affect protected species or critical habitats.	**Must be avoided.** No construction in area until risk reduced to ≤HIGH through design change or enhanced mitigation. Requires KWS/NEMA approval if unavoidable.	Immediate. Stop work if detected.
HIGH	Major ecological damage likely. Requires stringent, specific mitigation with performance standards and independent verification.	**Must be minimized.** Mitigation measures mandatory with third-party verification. Regular monitoring (weekly/monthly).	High. Senior management attention required.
MEDIUM	Moderate impact, reversible with standard mitigation.	**Manage with routine mitigation.** Standard measures applied. Monthly monitoring.	Routine. Include in regular environmental inspections.
LOW	Minor or negligible impact.	**Monitor only.** No specific mitigation required beyond good practice. Quarterly monitoring.	Low. Track but no special action.

5.3 Potential Impact of Road Upgrading on Biophysical Interactions with Biodiversity

Road upgrading will modify biodiversity primarily by reshaping terrain and hydrological pathways, disturbing soils, and creating a persistent road-edge environment. The most consistent mechanisms through which impacts will occur include cut-and-fill earthworks that will alter slope stability and expand edge habitats; drainage works that will reroute runoff and increase hydrologic connectivity to streams; soil compaction and erosion that will change infiltration and sediment delivery; and land-use intensification that will follow improved access. These processes are well documented in road ecology as key drivers of indirect and long-term biodiversity change beyond the immediate construction footprint (Forman et al., 2003; Coffin, 2007; van der Ree et al., 2015).

5.3.1 Biretwo – Arror - Chesongoch Section: Impact on Biophysical Interactions with Biodiversity

The Biretwo–Chesongoch section is characterised by escarpment slopes, rocky terrain, and dry to semi-arid bushland–savanna mosaics. Road upgrading will most strongly modify slope and drainage, with cascading effects on habitat structure. Earthworks required for alignment improvement will involve cut slopes, fills, and local benching, which will increase exposed soil and rock surfaces while altering natural runoff pathways.

Impact	Description	Consequence	Likelihood	Risk Level
Edge effect intensification	Increased light penetration, surface temperatures, and wind exposure along the road corridor, favouring disturbance-tolerant species and reducing suitability for cover-dependent fauna.	4 (Major)	5 (Almost Certain)	**CRITICAL**
Drainage system modification	New side drains and culverts intercept diffuse hillslope flow and discharge at discrete points, leading to gully formation and downslope erosion.	4 (Major)	4 (Likely)	**HIGH**
Soil degradation	Grading and compaction mix soil horizons, increase bulk density, reduce infiltration, and selectively remove fine particles through erosion.	3 (Moderate)	5 (Almost Certain)	**HIGH**
Microclimatic alteration	Vegetation clearance and compacted surfaces increase surface heating and reduce relative humidity near the ground.	2 (Minor)	4 (Likely)	**MEDIUM**
Land-use intensification	Improved road conditions increase human access, accelerating settlement growth, cultivation expansion, and resource extraction.	3 (Moderate)	3 (Possible)	**MEDIUM**

5.3.1.1 Chainage-Specific Risk Zones

Chainage	Key Vulnerability	Consequence	Likelihood	Risk Level
9+000–22+000	Escarpment slopes, shallow soils, bushland vegetation	4 (Major)	5 (Almost Certain)	**CRITICAL**
23+000–36+500	Seasonal drainage lines, riparian vegetation, moisture refugia	3 (Moderate)	4 (Likely)	**HIGH**
37+000–55+000	Open savanna, scattered woody species, invasive species risk	2 (Minor)	4 (Likely)	**MEDIUM**
40+000–63+000	Steep slopes, erosion risk, rock-dependent species	4 (Major)	5 (Almost Certain)	**CRITICAL**
0+000–8+500	Settlement areas, modified vegetation, dust risk	2 (Minor)	3 (Possible)	**LOW**

5.3.2 Nyaru – Kimwarer – Kapkayo Section: Impacts on Biophysical Interactions with Biodiversity

The Nyaru–Kimwarer–Kapkayo section will experience particularly strong biodiversity impacts because it supports woodland, riverine strips, and forest-edge habitats. Road widening and slope modification will remove trees, shrubs, and understorey vegetation, reducing canopy continuity and altering structural complexity.

Impact	Description	Consequence	Likelihood	Risk Level
Canopy loss and edge effects	Removal of trees and understorey vegetation reduces interior habitat quality and increases edge effects along the corridor.	3 (Moderate)	4 (Likely)	**HIGH**
Riparian system alteration	Culvert installation and channel realignment disrupt longitudinal and lateral connectivity, affecting aquatic organisms and riverine food webs.	3 (Moderate)	3 (Possible)	**MEDIUM**
Soil disturbance	Compaction and stripping of organic-rich soils under woodland habitat slow natural regeneration and favour invasive species.	3 (Moderate)	4 (Likely)	**HIGH**
Microclimatic change	Canopy removal increases solar radiation and airflow, lowering relative humidity and increasing temperature extremes near the ground.	2 (Minor)	3 (Possible)	**MEDIUM**
Land-use intensification	Improved access intersects fertile valley soils, leading to expansion of cultivation, fuelwood harvesting, and roadside settlements.	3 (Moderate)	3 (Possible)	**MEDIUM**

5.3.2.1 Chainage-Specific Risk Zones

Chainage	Key Vulnerability	Consequence	Likelihood	Risk Level
3+500–14+000	Escarpment bushland, woodland edges, wildlife corridors	3 (Moderate)	4 (Likely)	**HIGH**
14+000–22+500	Drainage channels, riparian vegetation, moisture refugia	3 (Moderate)	3 (Possible)	**MEDIUM**
22+500–30+800	Open savanna, farmland, scattered trees, roadkill risk	2 (Minor)	3 (Possible)	**LOW**

5.3.3 Kimwarer – Emsea Section: Impacts on Biophysical Interactions with Biodiversity

The Kimwarer–Emsea section traverses valley bottoms, floodplains, and riparian corridors. Drainage modification will be the dominant driver of biodiversity change. Upgrading works will increase the efficiency of stormwater conveyance, shortening water residence time on floodplains and concentrating discharge at culvert outlets.

Impact	Description	Consequence	Likelihood	Risk Level
Hydrological alteration	Increased stormwater conveyance shortens water residence time on floodplains, alters inundation patterns, and reduces habitat quality for amphibians and aquatic invertebrates.	4 (Major)	4 (Likely)	**HIGH**

Flow barrier effects	Raised embankments redirect floodwaters, changing the location and duration of temporary pools critical for amphibian breeding.	3 (Moderate)	3 (Possible)	**MEDIUM**
Sedimentation	Compacted surfaces and fine sediments transported into wetlands smother benthic habitats and reduce water quality.	3 (Moderate)	4 (Likely)	**HIGH**
Microclimatic and hydrological interaction	Vegetation clearance and altered hydrology increase evaporation in some areas while creating stagnant water in others.	2 (Minor)	2 (Unlikely)	**LOW**
Land-use intensification	Improved transport intensifies agriculture and settlement expansion, increasing nutrient runoff and pesticide inputs to riparian zones.	3 (Moderate)	3 (Possible)	**MEDIUM**

5.3.3.1 Chainage-Specific Risk Zones

Chainage	Key Vulnerability	Consequence	Likelihood	Risk Level
4+000–9+500	Valley-bottom systems, multiple drainage crossings, riparian vegetation	4 (Major)	4 (Likely)	**HIGH**
9+500–15+000	Open grassland, bushland, drainage lines, sediment risk	2 (Minor)	3 (Possible)	**LOW**
11+200–18+600	Wetland margins, floodplains, amphibian breeding sites	4 (Major)	4 (Likely)	**HIGH**
12+400–16+800	Rivers, floodplains, aquatic and semi-aquatic habitats	4 (Major)	4 (Likely)	**HIGH**
15+000–19+000	Converging drainage channels, denser vegetation, *Ficus* trees	3 (Moderate)	3 (Possible)	**MEDIUM**

5.4 Potential Impacts on Plant Distribution

5.4.1 Biretwo – Arror – Chesongoch Section

Chainage	Vegetation Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–8+500	Settlement, agriculture, secondary vegetation	Road widening results in further loss of secondary vegetation and roadside tree cover, increasing soil exposure.	2 (Minor)	4 (Likely)	**MEDIUM**
9+000–22+000	Escarpment bushland, rocky terrain, shallow soils	Cut-and-fill works and rock excavation cause direct loss of shrubs and grasses, fragmentation of bushland patches, and removal of stabilizing root systems.	4 (Major)	5 (Almost Certain)	**CRITICAL**
23+000–36+500	Seasonal drainage lines, riparian shrubs, grasses	Road upgrading and drainage realignment result in removal of riparian vegetation, alteration of moisture regimes, and disruption of natural regeneration.	3 (Moderate)	4 (Likely)	**HIGH**

37+000–55+000	Open savanna, bushland, scattered woody species	Clearing for road widening reduces vegetation cover, promotes edge effects, and creates disturbed corridors favouring invasive species.	2 (Minor)	4 (Likely)	**MEDIUM**
56+000–70+879	Grassland, shrubs, riparian vegetation along drainage channels	Construction leads to loss of riparian plants, soil compaction, and reduced natural regeneration capacity.	2 (Minor)	3 (Possible)	**LOW**

5.4.2 Nyaru – Kimwarer – Kapkayo Section

Chainage	Vegetation Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–3+500	Settlement, grazing, small-scale farming	Road widening results in further removal of secondary shrubs, grasses, and isolated trees, reducing erosion protection.	2 (Minor)	4 (Likely)	**MEDIUM**
3+500–14+000	Escarpment bushland, rocky outcrops, shallow soils	Cut-and-fill operations cause direct loss of woody vegetation and ground cover, increasing vulnerability to erosion and invasive species.	3 (Moderate)	4 (Likely)	**HIGH**
14+000–22+500	Seasonal drainage channels, foot-slope zones, grasses, shrubs	Road upgrading and drainage realignment result in partial removal of riparian vegetation and alteration of natural water flow patterns.	3 (Moderate)	3 (Possible)	**MEDIUM**
22+500–30+800	Open savanna, cultivated land, grasses, shrubs, scattered trees	Clearing for road widening fragments remaining vegetation patches, reduces tree cover, and creates disturbed corridors susceptible to invasion.	2 (Minor)	3 (Possible)	**LOW**

5.4.3 Kimwarer – Emsea Section

Chainage	Vegetation Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–4+000	Settlement, cultivation, grazing, grasses, shrubs	Road upgrading results in removal of roadside grasses, shrubs, and occasional trees, increasing soil compaction.	2 (Minor)	4 (Likely)	**MEDIUM**
4+000–9+500	Low-lying areas, multiple drainage crossings, riparian vegetation	Drainage works and culvert installation cause direct loss of riparian plants and alteration of moisture gradients, affecting downstream vegetation regeneration.	3 (Moderate)	4 (Likely)	**HIGH**

9+500–15+000	Open grassland, bushland, drainage lines	Clearing and earthworks reduce ground cover, expose soils to erosion, and create linear disturbed corridors favourable to invasive species.	2 (Minor)	3 (Possible)	**LOW**
15+000–19+000	Valley bottoms, drainage convergence zones, denser shrubs and grasses	Construction leads to loss of riparian vegetation, soil compaction, and reduced moisture retention.	3 (Moderate)	3 (Possible)	**MEDIUM**

5.5 Potential Impacts on Herpetofauna

5.5.1 Biretwo – Arror – Chesongoch Section

Chainage / Location	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
5+000–22+000; 40+000–63+000	Rocky escarpments, road cuttings, termite mounds, open bushland	Cut-and-fill operations and rock excavation increase risk of direct mortality to reptiles occupying crevices and burrows; removal of surface rocks reduces availability of thermal refugia and shelter.	4 (Major)	4 (Likely)	**HIGH**
12+000–18+800; 28+400–36+200; 52+000–66+500	Seasonal streams, drainage crossings, temporary rain-fed pools	Modification of drainage channels and culverts affects ephemeral breeding sites used by amphibians; increased traffic speeds elevate roadkill risk for basking reptiles.	3 (Moderate)	4 (Likely)	**HIGH**
All sections	Road surface	Increased traffic speeds following upgrading elevate roadkill risk for basking reptiles, particularly tortoises and slow-moving snakes.	3 (Moderate)	3 (Possible)	**MEDIUM**

5.5.2 Nyaru – Kimwarer – Kapkayo Section

Chainage / Location	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
7+200–14+600; 21+400–26+800	Drainage channels, streams, riparian vegetation	Road upgrading modifies hydrological connectivity, alters breeding sites for frogs, and increases sedimentation into streams.	3 (Moderate)	3 (Possible)	**MEDIUM**
3+500–14+000	Woodland, forest edges, shaded microhabitats	Clearing of roadside vegetation reduces shaded, humid microhabitats required by chameleons and forest-edge snakes.	3 (Moderate)	3 (Possible)	**MEDIUM**

All sections	Road surface and adjacent habitat	Increased night-time traffic heightens mortality risk for amphibians migrating to breeding sites during rainy periods.	2 (Minor)	3 (Possible)	**LOW**

5.5.3 Kimwarer – Emsea Section

Chainage / Location	**Habitat Type**	**Impact Description**	**Consequence**	**Likelihood**	**Risk Level**
11+200–18+600	Rivers, floodplains, wetlands, aquatic and semi-aquatic habitats	Road upgrading in close proximity to rivers, floodplains, and wetland margins increases risks of habitat loss, altered flood regimes, pollution, and direct mortality of amphibians and semi-aquatic reptiles.	4 (Major)	4 (Likely)	**HIGH**
12+400–16+800	Wetland margins, permanent water bodies	Species such as *Xenopus*, *Pelusios*, *Natriciteres*, and *Varanus niloticus* are particularly vulnerable to changes in water quality and connectivity.	4 (Major)	3 (Possible)	**H**

5.6 Potential Impacts on Birds

5.6.1 Biretwo – Arror – Chesongoch Section

Chainage	**Habitat Type**	**Impact Description**	**Consequence**	**Likelihood**	**Risk Level**
0+000–12+500	Cultivated land, bushland, settlements	Road widening and increased traffic reduce roadside nesting and perching opportunities; temporary displacement during construction.	2 (Minor)	4 (Likely)	**MEDIUM**
12+500–38+000	Escarpment slopes, rocky terrain, woodland insectivores, raptors	Slope cutting and vegetation removal result in loss of nesting sites, reduced prey availability for insectivores, and disturbance to raptor foraging territories.	3 (Moderate)	4 (Likely)	**HIGH**
38+000–55+000	Drainage channels, seasonal streams, riparian vegetation	Culvert installation and drainage realignment reduce riparian cover and temporarily degrade feeding and breeding habitats for kingfishers, wagtails, and insectivorous birds.	2 (Minor)	3 (Possible)	**LOW**
55+000–70+879	Open savanna, bushland	Increased traffic and habitat fragmentation increase collision risk and reduce habitat continuity for open-country birds and aerial insectivores.	2 (Minor)	3 (Possible)	**LOW**

5.6.2 Nyaru – Kimwarer – Kapkayo Section

Chainage	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–3+500	Farms, settlements, disturbance-tolerant species	Construction noise, increased traffic, and vegetation removal reduce nesting opportunities and temporarily displace birds.	2 (Minor)	4 (Likely)	**MEDIUM**
3+500–14+000	Escarpment slopes, bushland, woodland insectivores, raptors	Vegetation clearance and slope cutting result in loss of foraging and nesting sites, particularly for cavity nesters and shrub-dependent species.	3 (Moderate)	4 (Likely)	**HIGH**
14+000–22+500	Seasonal drainage channels, riparian vegetation	Culvert installation and drainage realignment reduce riparian cover and temporarily degrade feeding and breeding habitats for kingfishers, wagtails, and fruit-feeding birds.	2 (Minor)	3 (Possible)	**LOW**
22+500–30+800	Open savanna, cultivated landscapes	Fragmentation of tree cover reduces perching and nesting structures and increases exposure to predation.	2 (Minor)	3 (Possible)	**LOW**

5.6.3 Kimwarer – Emsea Section

Chainage	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–4+000	Settlement, farmland, generalist species	Construction disturbance causes short-term displacement but limited long-term impact.	2 (Minor)	3 (Possible)	**LOW**
4+000–9+500	Streams, riparian vegetation, water-associated birds	Drainage works remove riparian cover and reduce prey availability, directly affecting kingfishers, herons, ibises, wagtails, and insectivorous birds.	3 (Moderate)	4 (Likely)	**HIGH**
9+500–15+000	Open grassland, bushland, seed-eaters, aerial insectivores	Loss of ground cover and shrubs reduces nesting opportunities and increases exposure to predators.	2 (Minor)	3 (Possible)	**LOW**
15+000–19+000	Converging drainage channels, denser vegetation, mixed assemblages	Disturbance fragments habitat connectivity and reduces refuge availability for mixed assemblages of riparian and woodland-edge birds.	2 (Minor)	3 (Possible)	**LOW**

5.7 Potential Impacts on Invertebrates

5.7.1 Biretwo – Arror – Chesongoch Section

Chainage	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–12+500	Farms, roadside vegetation, disturbance-tolerant species	Construction causes short-term declines in abundance; recovery likely with revegetation.	2 (Minor)	4 (Likely)	**MEDIUM**
12+500–38+000	Bushland, escarpment, native shrubs, flowering plants	Vegetation clearance and slope stabilization remove host plants and nesting substrates for butterflies, bees, and predatory insects, resulting in localized population declines.	3 (Moderate)	4 (Likely)	**HIGH**
38+000–55+000	Seasonal streams, drainage lines, aquatic and semi-aquatic invertebrates	Culvert installation and sedimentation disrupt microhabitats and reduce water quality, affecting larval stages and molluscs.	2 (Minor)	3 (Possible)	**LOW**
55+000–70+879	Open habitats, generalist and opportunistic species	Open habitats favour generalist and opportunistic invertebrates, including pest species, where vegetation cover is reduced.	1 (Negligible)	3 (Possible)	**LOW**

5.7.2 Nyaru – Kimwarer – Kapkayo Section

Chainage	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–3+500	Farms, weedy margins, disturbance-tolerant species	Construction temporarily reduces abundance; recovery likely with vegetation reinstatement.	2 (Minor)	4 (Likely)	**MEDIUM**
3+500–14+000	Bushland, woodland, native vegetation, pollinators	Clearing and slope stabilization remove host plants and nesting substrates for butterflies, bees, and predatory insects, leading to localized population declines.	3 (Moderate)	4 (Likely)	**HIGH**
14+000–22+500	Drainage crossings, aquatic and semi-aquatic invertebrates	Culvert installation disrupts microhabitats and water quality, reducing invertebrate diversity and abundance.	2 (Minor)	3 (Possible)	**LOW**
22+500–30+800	Open landscapes, generalist pollinators, pest species	Increased disturbance favours invasive and opportunistic taxa.	1 (Negligible)	3 (Possible)	**LOW**

5.7.3 Kimwarer – Emsea Section

Chainage	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–4+000	Disturbance-tolerant insects	Construction disturbance causes short-term displacement of disturbance-tolerant insects; full recovery expected with vegetation reinstatement	2 (Minor)	3 (Possible)	**MEDIUM**
4+000–9+500	Wetlands, streams, aquatic insects	Drainage modification and sedimentation highly affect aquatic invertebrates during construction.	3 (Moderate)	4 (Likely)	**HIGH**
9+500–15+000	Open grassland, insects	Vegetation clearance and soil compaction cause decline in open grassland insects.	2 (Minor)	3 (Possible)	**LOW**
15+000–19+000	Riparian vegetation, invertebrate communities	Habitat fragmentation and altered moisture regimes affect riparian invertebrate communities.	2 (Minor)	3 (Possible)	**LOW**

5.8 Potential Impacts on Mammals

5.8.1 Biretwo – Arror – Chesongoch Section

Chainage	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–12+500	Human-influenced, small mammals, generalist species	Road widening increases roadkill risk, particularly for rodents and small carnivores.	2 (Minor)	4 (Likely)	**MEDIUM**
12+500–38+000	Escarpment slopes, bushland, antelopes, primates, carnivores, hyraxes	Vegetation clearance and blasting fragment habitats, disrupt movement routes, and reduce cover.	3 (Moderate)	4 (Likely)	**HIGH**
38+000–55+000	Drainage lines, movement corridors	Modification of drainage lines reduces cover and increases exposure to predators and human disturbance.	2 (Minor)	3 (Possible)	**LOW**
55+000–70+879	Open savanna, medium-sized mammals	Open savanna conditions increase likelihood of wildlife-vehicle collisions.	2 (Minor)	3 (Possible)	**LOW**

5.8.2 Nyaru – Kimwarer – Kapkayo Section

Chainage	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–3+500	Human-influenced, small mammals	Increased roadkill risk for small mammals.	2 (Minor)	4 (Likely)	**MEDIUM**
3+500–14+000	Escarpment, bushland, small antelopes, primates, carnivores, rodents	Vegetation clearance and blasting fragment habitat and disrupt movement routes.	3 (Moderate)	4 (Likely)	**HIGH**

14+000–22+500	Riparian zones, movement corridors	Drainage works reduce cover and increase exposure.	2 (Minor)	3 (Possible)	**LOW**
22+500–30+800	Open savanna, farmland, generalist mammals	Increased collision risk with vehicles.	2 (Minor)	3 (Possible)	**LOW**

5.8.3 Kimwarer – Emsea Section

Chainage	Habitat Type	Impact Description	Consequence	Likelihood	Risk Level
0+000–4+000	Disturbance-tolerant species	Limited impacts.	1 (Negligible)	2 (Unlikely)	**LOW**
4+000–9+500	Riparian corridors, movement routes	Culvert and bridge works disrupt connectivity for mammal movement.	3 (Moderate)	3 (Possible)	**MEDIUM**
9+500–15+000	Open habitats, small and medium mammals	Open habitats increase roadkill risk.	2 (Minor)	3 (Possible)	**LOW**
15+000–19+000	Riparian corridors, converging drainage lines, wetland margins, and settlement-agricultural mosaic	Converging drainage lines support higher mammal activity and vulnerability.	2 (Minor)	3 (Possible)	**LOW**

5.9 Potential Impacts on Elephant Dispersal Areas (Biretwo – Chesongoch Section)

Elephant dispersal along the Biretwo–Chesongoch corridor is strongly seasonal, with dispersal from Rimoi National Reserve occurring mainly during the long rains (May–July). During this period, elephants avoid waterlogged downstream valleys and preferentially use dry, well-drained mid-slopes and interfluves.
Road upgrading can indirectly affect elephant dispersal by altering movement behaviour rather than through direct habitat loss alone. Increased traffic speed and volume, construction noise, night-time disturbance, and the physical widening of the road can create an avoidance barrier that elephants are reluctant to cross.

Chainage	Location	Impact Description	Consequence	Likelihood	Risk Level
13+000–17+000	Songeto–Rimo	Elephants cross road from Rimoi National Reserve onto mid-slope agricultural land. Road upgrading may create avoidance barrier, redirecting elephants into farmland.	5 (Critical)	4 (Likely)	**CRITICAL**
21+000–24+000	Anin–Komoigon	Key dispersal route crossing well-drained slopes. Road upgrading may funnel elephants into fewer remaining pathways, increasing conflict.	5 (Critical)	4 (Likely)	**CRITICAL**
37+000–40+000	Chegilet–Koitilial	Transition zone where elephants avoid saturated drainage corridors and use drier ridges. Road drainage modifications may alter movement patterns.	5 (Critical)	3 (Possible)	**CRITICAL**
49+000–51+000	Aror	Convergence of elephant dispersal paths with cultivated land on dry terrain. Road	5 (Critical)	3 (Possible)	**CRITICAL**

		upgrading may redirect elephants into farms.			

5.10 Potential Impacts on Human–Wildlife Conflict Areas (Biretwo – Chesongoch Section)

Indirect impacts on human–wildlife conflict arise when road upgrading increases accessibility, facilitates agricultural expansion, and alters wildlife movement patterns. Roads can unintentionally intensify conflict by creating linear barriers that redirect wildlife into croplands or by encouraging settlement and cultivation closer to dispersal routes.

Chainage	Location	Impact Description	Consequence	Likelihood	Risk Level
13+000–17+000	Songeto–Rimo	Elephants crossing onto agricultural land during rainy season. Road upgrading may increase conflict by altering movement behaviour.	4 (Major)	4 (Likely)	**HIGH**
21+000–24+000	Anin–Komoigon	Most pronounced HWC hotspot. Maize cultivation on well-drained slopes attracts elephants. Road upgrading may intensify conflict.	4 (Major)	4 (Likely)	**HIGH**
37+000–40+000	Chegilet–Koitilial	Elephants use drier ridges adjacent to road. Road drainage modifications may redirect elephants into cultivated plots.	4 (Major)	3 (Possible)	**HIGH**

6 Mitigation Measures Management Controls

6.1 Introduction to Mitigation Measures

This chapter presents the mandatory mitigation measures for all anticipated environmental and biodiversity impacts identified in Chapter 5. This chapter is legally binding. All Contractors, subcontractors, supervising engineers, and environmental personnel shall comply with every measure specified herein. Non-compliance constitutes a breach of contract and may result in penalties, suspension of works, or legal action under the Environmental Management and Coordination Act (EMCA) 1999.

Each mitigation measure is presented with:

- **Mandatory Action:** Precisely what shall be done (using "shall" not "should")
- **Performance Standard:** The measurable target that defines success
- **Responsible Party (Implementation):** The specific entity accountable for implementation
- **Timeline:** When the action shall be completed
- **Cost Code:** Reference to the budget line item (see Chapter 8)

The mitigation hierarchy (Avoid → Minimize → Restore → Offset) governs all actions. Avoidance takes precedence over minimization, and restoration takes precedence over offsetting.

6.2 Risk Level Reference

The full risk classification methodology, including consequence categories (1–5), likelihood categories (1–5), the risk matrix, and detailed risk level definitions, is presented in Chapter 5, Section 5.2.

The table below summarizes the four risk levels and their implications for mitigation prioritization in this chapter. For the application of these risk levels to specific impact categories and chainage sections, see Section 6.10 (Risk Summary Table for All Mitigation Measures) .

Risk Level	Definition	Mitigation Implication	Monitoring Frequency
CRITICAL	Unacceptable risk. May violate law or cause irreversible damage to protected species or critical habitats.	Must be avoided. No construction in area until risk reduced. Requires KWS/NEMA approval if unavoidable.	Weekly or daily (peak season)
HIGH	Major ecological damage likely. Requires stringent, specific mitigation with performance standards and independent verification.	Must be minimized. Mitigation measures mandatory with third-party verification.	Weekly or monthly
MEDIUM	Moderate impact, reversible with standard mitigation.	Manage with routine mitigation. Standard measures applied.	Monthly
LOW	Minor or negligible impact.	Monitor only. No specific mitigation required beyond good practice.	Quarterly

6.3 Definition of Mitigation Measure Codes

Each mitigation measure in this BMP is assigned a unique alphanumeric code for traceability, linking to monitoring indicators and budget lines.

Code Structure: M-XX-NN

Component	Position	Meaning	Possible Values
M	Prefix	Mandatory Mitigation	Always "M"
XX	Middle (2 letters)	Road Section	BC = Biretwo–Chesongoch NK = Nyaru–Kimwarer–Kapkayo KE = Kimwarer–Emsea CC = Cross-Cutting
NN	Suffix (2 digits)	Sequential measure number within section	01 to 99

Example Codes:

Code	Meaning
M-BC-01	Mandatory Mitigation, Biretwo–Chesongoch section, measure #01
M-NK-04	Mandatory Mitigation, Nyaru–Kapkayo section, measure #04
M-KE-06	Mandatory Mitigation, Kimwarer–Emsea section, measure #06
M-CC-03	Mandatory Mitigation, Cross-Cutting, measure #03

6.4 Definition of Impact Categories

The BMP organizes impacts into the following categories used throughout this chapter:

Category Code	Category Name	Description
ESC	Escarpment and Slope Systems	Steep terrain (>30% slope), erosion risk, shallow soils, rock-dependent species
RIP	Riparian and Drainage Crossings	Streams, rivers, drainage channels, wetlands, amphibian breeding habitat
WET	Wetland and Valley-Bottom Systems	Permanent or seasonal wetlands, floodplains, high moisture availability
WLD	Wildlife Movement Corridors	Elephant dispersal routes, primate crossing points, landscape connectivity
HAB	Woodland and Bushland Habitats	Native woody vegetation, canopy cover, forest-edge species
AGR	Agricultural and Open Landscapes	Cultivated areas, scattered trees, roadkill risk, human-wildlife interface
KEY	Keystone Species	*Ficus sycomorus* trees, termite mounds, other ecosystem engineers
CC	Cross-Cutting	Measures applicable to all sections (training, lighting, HWC, etc.)

6.5 Biretwo – Arror – Chesongoch Section

This section traverses an escarpment-to-upland landscape with strong variability in slope, drainage, and land use. The most challenging terrain occurs within the escarpment zones (9+000–22+000 and 40+000–63+000), where steep gradients dominate. Slopes exceeding 60–63.9% occur as localized high-risk pockets, notably around 44+700–45+700 and 48+000–49+200, associated with escarpment breaks, rocky outcrops, and incised terrain. These areas are characterized by shallow soils, rapid runoff, and high susceptibility to erosion and slope instability, making them critical for both engineering and ecological management. Seasonal drainage lines and riparian zones (23+000–36+500 and 52+000–66+500) form sensitive ecological corridors, supporting localized biodiversity but highly vulnerable to hydrological disruption. Open savanna (37+000–55+000) provides important habitat connectivity, while settled areas (0+000–8+500) present risks related to fragmentation, invasive species, and wildlife–vehicle interactions. The mitigation measures are organized by these four landscape types, with the most intensive measures applied to the CRITICAL-risk escarpment zones.

6.5.1 Escarpment and Slope Systems (Chainage 9+000–22+000; 40+000–63+000)

These sections are characterized by very steep slopes (often exceeding 63.9% rise), shallow rocky soils, dense drainage networks, and slow-regenerating bushland vegetation. These areas are highly susceptible to erosion, slope instability, and loss of rock-dwelling reptile microhabitats. The following measures focus on strict clearing control, retention of mature trees, rapid bioengineering stabilization, creation of rock refugia, and phased construction to allow fauna displacement.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-BC-01	Vegetation loss, habitat fragmentation	Demarcate road reserve with flagged pegs; no clearing outside reserve; phased clearing in ≤500 m segments	Zero unauthorized clearing	Contractor's Site Manager	Pre-construction + ongoing	BC-CLEAR-01
M-BC-02	Loss of mature trees, habitat structure	Retain all trees DBH ≥30 cm within 10 m of reserve; physical protection fencing; KES 50,000 penalty per unauthorized removal	100% retention of non-authorized trees	Contractor's Environmental Officer	Pre-construction + ongoing	BC-TREE-02
M-BC-03	Slope instability, erosion, loss of vegetation cover	Apply bioengineering stabilization within 7 days of grading: topsoil (15 cm),	≥80% vegetation cover at 6 months; ≥95% of slope area without	Contractor's Site Manager	Within 7 days of final grading	BC-SLOPE-03

		native hydroseeding, coir blankets on >30% slopes, brush layering	erosion rills >10 cm after first rains			
M-BC-04	Loss of rock-dwelling reptile microhabitats	Place excavated rock piles (2–3 m³) at ≤100 m intervals along cut slopes; locate ≥5 m from road edge	Minimum 15 rock piles/km; reptile occupancy in ≥50% of piles within 12 months	Contractor's Site Manager	During slope finishing	BC-ROCK-04
M-BC-05	Continuous disturbance preventing fauna displacement	Divide escarpment into 500 m work zones; max 2 adjacent zones active; maintain 200 m undisturbed buffer between zones	Maximum continuous disturbed length ≤1,000 m; zero construction-related mortality of protected species	Contractor's Site Manager	Throughout construction	BC-PHASE-05

6.5.2 Riparian and Drainage Crossings (Chainage 23+000–36+500; 52+000–66+500)

These sections contain the major drainage channels including long-course channels with large upstream catchments that convey substantial runoff during storm events. These areas are critical for amphibian breeding, support riparian vegetation and bird communities, and are highly sensitive to sedimentation. The following measures focus on retaining riparian buffers, installing fauna-friendly culverts, controlling sediment, restricting in-stream works during breeding seasons, and restoring disturbed riparian zones immediately after construction.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-BC-06	Loss of riparian habitat, sedimentation	Retain 30 m riparian buffer on each side of all streams; demarcate with fencing; no camps, storage, or vehicles in buffer	100% retention of buffer outside direct footprint; no sediment plumes entering streams	Contractor's Environmental Officer	Pre-construction (demarcation); ongoing (compliance)	BC-RIP-06
M-BC-07	Disruption of amphibian/reptile movement, hydrological alteration	Install fauna-friendly culverts: min 1.2 m box or 1.5 m pipe; recessed invert with natural substrate; dry ledge (30	Amphibian/reptile passage confirmed in ≥70% of culverts within 12 months	KeNHA Design Engineer (spec); Contractor (install)	Design phase; construction	BC-CULV-07

		cm); bridge preferred where stream width >5 m				
M-BC-08	Sedimentation of water bodies, water quality decline	Install double silt fences, sediment basin (10 m³), and check dams before in-stream work; inspect daily during rain; maintain until ≥90% vegetation cover	Downstream turbidity ≤25 NTU above baseline; zero visible sediment plumes beyond 50 m	Contractor's Site Manager	Pre-construction (install); ongoing (inspection)	BC-SED-08
M-BC-09	Disruption of amphibian breeding	No in-stream works during amphibian breeding season (1 Mar–31 May; 1 Oct–30 Nov)	Zero in-stream works during restricted periods; no observed mortality of amphibian eggs or larvae	Contractor's Site Manager	Construction scheduling	BC-SEASON-09
M-BC-10	Loss of riparian vegetation, habitat degradation	Within 14 days of completion: remove temporary structures; reshape banks; respread topsoil (15 cm); plant native riparian species; mulch; install tree guards	≥90% survival of planted saplings at 12 months; ≥80% vegetation cover on restored banks at 6 months	Contractor's Environmental Officer	Within 14 days of works completion at each crossing	BC-RESTORE-10

6.5.3 Open Savanna and Disturbed Landscapes (Chainage 37+000–55+000)

This section consists of open savanna and bushland with scattered woody species. While less sensitive than the escarpment and riparian zones, it is vulnerable to invasive species colonization (particularly Prosopis juliflora and Opuntia elatior, documented in (section 4.34.1) and wildlife-vehicle collisions. The following measures focus on preventing invasive species spread, rehabilitating disturbed areas with native seed mixes, and implementing traffic calming to reduce roadkill.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code

M-BC-11	Invasive species colonization	Wash equipment at designated bay before entry; manually remove invasive plants prior to clearing; bag and dispose invasives; monitor for regrowth for 2 years	Zero new invasive establishment; ≥95% reduction in invasive cover at 12 months	Contractor's Environmental Officer	Pre-construction (washing); construction (removal); post-construction (monitoring)	BC-INVASIVE-11
M-BC-12	Habitat degradation, loss of ground cover	Rehabilitate disturbed areas within 14 days: respread topsoil (10 cm); hydroseed native grass-forb mix (80% grass, 20% forb); temporary fencing if grazed	≥70% vegetation cover at 6 months; ≥50% native species at 12 months	Contractor's Environmental Officer	Within 14 days of final disturbance	BC-REHAB-12
M-BC-13	Wildlife-vehicle collisions	Install wildlife warning signage at 500 m intervals; rumble strips at 1,000 m intervals; speed limits (60 km/h day, 40 km/h night); conduct weekly roadkill surveys for 12 months	Roadkill index ≤0.5 animals/km/month over 12 months	KeNHA Operations (signage); Contractor (surveys)	Pre-opening (installation); operation (surveys)	BC-ROADKILL-13

6.5.4 Settlement and Modified Landscapes (Chainage 0+000–8+500)

This section passes through Biretwo trading centre and adjacent settled agricultural areas. The landscape is already modified, and ecological sensitivity is relatively low. Mitigation focuses on managing construction nuisances (dust) and minimizing the construction footprint to prevent unnecessary habitat degradation.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-BC-14	Dust affecting communities	Apply water spraying 3 times daily within 200 m of dwellings;	Visible dust plumes not beyond 50 m; zero unresolved dust complaints	Contractor's Site Manager	Throughout construction	BC-DUST-14

	and roadside vegetation	use non-toxic dust suppressants if needed				
M-BC-15	Habitat degradation from construction footprint	Designate and demarcate all camps and storage areas before establishment; locate ≥100 m from watercourses, ≥50 m from mature trees; on already disturbed land where possible	Zero encroachment outside designated areas; ≥70% vegetation cover on rehabilitated sites within 6 months	Contractor's Site Manager	Pre-construction (designation); ongoing (compliance)	BC-FOOTPRINT-15

6.6 Nyaru – Kimwarer – Kapkayo Section

This section is the most challenging of the three road sections due to the steep escarpment terrain at the western end near Nyaru. The slopes from Nyaru to Kimwarer (approximately chainage 0+000 to 6+000) are predominantly steep to very steep, commonly exceeding 30% rise and locally reaching the highest slope classes. This rugged escarpment terrain, combined with the presence of woodland and forest-edge habitats (section 5.3.2), creates the highest risk of slope instability, habitat fragmentation, and wildlife movement disruption across all sections. The section traverses a transition from this challenging escarpment bushland (3+500–14+000) through mid-slope drainage systems and moisture refugia (14+000–22+500) to open savanna and agricultural landscapes (22+500–30+800). Mitigation prioritizes slope stabilization, wildlife corridor protection, blasting controls, amphibian-friendly drainage, and roadkill management.

6.6.1 Escarpment and Mid-Slope Habitats (Chainage 3+500–14+000)

This is the most geomorphologically challenging part of the project. The alignment from Nyaru through Kimwarer traverses steep to very steep escarpment slopes with frequent sharp bends and abrupt elevation changes. These sections contain woodland, bushland, and forest-edge habitats that support primates, antelopes, and diverse bird communities. The measures focus on retaining mature trees, maintaining wildlife corridors, controlling blasting impacts, and stabilizing slopes to prevent erosion and mass wasting.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-NK-01	Habitat fragmentation, vegetation loss, loss of canopy cover	Conduct tree survey (DBH ≥20 cm); retain all mapped trees unless approved for removal; plant 10 native saplings per tree removed; maintain 50 m wide unobstructed wildlife corridors	≥95% retention of trees; ≥80% survival of compensatory saplings at 24 months	Contractor's Environmental Officer	Pre-construction (survey); construction (retention); post-construction (planting)	NK-TREE-01

M-NK-02	Disruption of wildlife movement	Install box culverts (min 2 m × 2 m) or open-span bridges at wildlife corridor crossing points; align with natural movement paths; vegetate approach ramps	Crossing structure usage by medium mammals in ≥70% of structures within 12 months	KeNHA Design Engineer; Contractor (install)	Design phase; construction (months 6–12)	NK-CROSS-02
M-NK-03	Noise and vibration disturbance to wildlife	For blasting: notify 72 hours in advance; conduct between 1000–1400 hours; use controlled techniques; establish 200 m wildlife cordon; haze large mammals before detonation	PPV ≤50 mm/s at 50 m; zero wildlife mortality; no primate troop displacement >7 days	Contractor's Blasting Engineer	As required during construction	NK-BLAST-03

6.6.2 Drainage Systems and Moisture Refugia (Chainage 14+000–22+500)

This section contains seasonal drainage channels, seepage zones, and wet meadows that serve as moisture refugia. These areas support amphibian breeding and provide critical microhabitats during dry periods. Mitigation focuses on designing amphibian-friendly drainage structures and protecting moisture refugia from construction disturbance.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-NK-04	Amphibian habitat degradation, hydrological disruption	Install culverts with recessed invert, natural substrate, dry ledge (30 cm), gentle approach gradients (≤10%); install amphibian escape ramps on side drains >15 cm deep	Amphibian diversity index (Shannon H') decline ≤20% from baseline at 12 months	KeNHA Design Engineer; Contractor (install)	Design phase; construction	NK-AMPH-04
M-NK-05	Loss of moisture refugia	Identify and demarcate moisture refugia (seepage zones, wet meadows) within 100 m; no construction activity in refugia; design drainage to maintain subsurface flow	Zero encroachment into refugia; no reduction in wet-season saturated area extent	Contractor's Environmental Officer	Pre-construction (demarcation); ongoing (compliance)	NK-REFUGIA-05

6.6.3 Open Savanna and Agricultural Landscapes (Chainage 22+500–30+800) – Risk Level: LOW

This section approaches Kapkayo trading centre and consists of open savanna, cultivated land, and scattered trees. The terrain becomes increasingly subdued with gentle slopes (0–15% rise). Mitigation focuses on retaining scattered trees for habitat connectivity and reducing wildlife-vehicle collisions through traffic calming measures.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-NK-06	Loss of scattered trees, habitat simplification	Retain all scattered trees (DBH ≥15 cm) within 20 m of reserve; if removal unavoidable, plant 5 native saplings per tree within 100 m	≥90% retention of mapped trees; ≥80% survival of compensatory saplings at 24 months	Contractor's Environmental Officer	Pre-construction (mapping); construction (retention); post-construction (planting)	NK-TREE-06
M-NK-07	Wildlife-vehicle collisions	Install wildlife warning signage at 300 m intervals; rumble strips at 500 m intervals; dynamic speed display signs at two highest-risk zones; night-time speed limit 50 km/h	Roadkill index ≤0.8 animals/km/month; zero large mammal roadkill in first 12 months	KeNHA Operations; Contractor (install)	Pre-opening (installation); operation (monitoring)	NK-SPEED-07

6.7 Kimwarer – Emsea Section

This section traverses the most hydrologically sensitive areas of the project, including valley-bottom wetlands (4+000–9+500 and 12+400–16+800), floodplains, and riparian biodiversity hotspots (15+000–19+000) approaching Emsea trading centre. The drainage density is high with frequent road-channel intersections and large contributing catchments. These areas support water-dependent mammals (hippos, otters, primates), amphibians, and aquatic invertebrates. Mitigation prioritizes open-span bridges over culverts, floodplain connectivity, strict sediment control, protection of amphibian breeding sites, and enhanced riparian buffers.

6.7.1 Valley-Bottom and Wetland Systems (Chainage 4+000–9+500; 12+400–16+800)

These sections contain perennial streams, wetlands, and floodplains that are critical for aquatic biodiversity. These areas are highly sensitive to hydrological alteration and sedimentation. The measures focus on preserving hydrological connectivity, preventing sedimentation, and protecting amphibian breeding sites.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-KE-01	Hydrological disruption, wetland degradation, loss of aquatic habitat	Construct open-span bridges (not culverts) at all perennial stream and wetland crossings; span = channel width + 10 m; abutments set back ≥10 m from high-water mark; no in-stream piers	Zero wetland loss attributable to road; ≤15% decline in macroinvertebrate diversity at 12 months	KeNHA Design Engineer; Contractor (construct)	Design phase; construction (months 8–16)	KE-BRIDGE-01
M-KE-02	Alteration of floodplain hydrology	Install flood-relief culverts at ≤200 m intervals in floodplain sections; size for 10-year flood; minimize embankment height (max 1.5 m above natural ground)	Flood duration/extent change ≤10% from baseline	KeNHA Design Engineer (hydrology); Contractor (construct)	Design phase; construction	KE-FLOOD-02
M-KE-03	Sedimentation of wetlands and water bodies	Install double silt fences and sediment basin at every outfall within 200 m of wetland; use flocculants (non-toxic) if approved; daily turbidity monitoring; stop earthworks if turbidity >50 NTU for 2 consecutive days	Turbidity within wetlands ≤30 NTU above baseline; zero visible sediment on wetland vegetation	Contractor's Environmental Officer	Throughout construction	KE-SED-03
M-KE-04	Loss of amphibian breeding sites	Map amphibian breeding sites pre-wet season; no in-stream works within 100 m of breeding sites during breeding season (Mar–May, Oct–Nov); construct temporary breeding ponds if avoidance impossible	No reduction in amphibian species richness at affected sites at 12 months; ≥50% metamorphosis success in artificial ponds	Contractor's Environmental Officer	Pre-construction (survey); construction (avoidance/compensation)	KE-BREED-04

6.7.2 Riparian Biodiversity Hotspots (Chainage 15+000–19+000)

This section includes converging drainage channels, denser riparian vegetation, and Ficus sycomorus trees. It supports the highest biodiversity of the Kimwarer–Emsea section, including water-dependent mammals and riparian bird assemblages. Mitigation focuses on an enhanced 50 m riparian buffer and strict protection of Ficus sycomorus trees.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-KE-05	Loss of riparian habitat, fragmentation of linear wildlife corridors	Retain 50 m riparian buffer on each side of drainage channels; no clearing, machinery, or drainage outfalls in buffer without energy dissipation; fence with wildlife-friendly fencing	100% buffer retained; ≤10% decline in riparian bird species richness at 12 months	Contractor's Environmental Officer	Pre-construction (fencing); ongoing (compliance)	KE-BUFFER-05
M-KE-06	Decline of *Ficus sycomorus* populations	Protect all *Ficus sycomorus* trees with 15 m root protection zone (or 5 m beyond drip line); no excavation, compaction, drainage change, or storage in zone; plant 5 saplings per existing tree within 500 m; water weekly for 6 months	100% survival of existing trees; ≥80% survival of planted saplings at 24 months	Contractor's Environmental Officer	Pre-construction (demarcation); construction (protection); post-construction (planting)	KE-FIGUS-06

6.8 Cross-Cutting Mitigation Measures (All Sections)

These measures apply across all three road sections and address issues that are not location-specific: elephant dispersal and human-wildlife conflict (focused on the four high-risk zones in Biretwo–Chesongoch), termite mound protection (focused on high-risk zones in Biretwo–Chesongoch), worker training, and lighting control.

Code	Impact	Mandatory Action (Summary)	Performance Standard	Responsible Party (Implementation)	Timeline	Cost Code
M-CC-01	Disruption of elephant dispersal, increased human-	Establish community-based early warning system for elephants in four high-risk zones; trained scouts, SMS alerts, protocol for temporary road closure (KWS-led)	Alert transmission ≤10 minutes; zero human injury from elephants during construction and first 2 years of operation	Contractor (establishment, first 2 years); KeNHA (ongoing)	Pre-opening (establishment); operation (maintenance)	CC-HWC-01

	wildlife conflict					
M-CC-02	Increased crop raiding (human-wildlife conflict)	Work with County Government to establish voluntary land-use agreements discouraging palatable crops within 200 m of elephant crossing zones; provide starter packs for alternative crops	≥50% reduction in crop damage incidents in target zones within 2 years	Contractor (funding); County Government (facilitation)	Pre-construction (workshops); operation (implementation)	CC-LAND-02
M-CC-03	Loss of termite habitats (ecosystem engineers)	Conduct pre-construction survey to map termite mounds within 50 m of reserve in high-risk zones; demarcate 5 m protection zones; no construction activity in zones; relocate if unavoidable	≥95% of mapped mounds intact and active at 12 months; ≥70% of relocated mounds show termite activity	Contractor's Environmental Officer	Pre-construction (survey); construction (protection)	CC-TERMITE-03
M-CC-04	Lack of worker awareness leading to wildlife disturbance	Mandatory 4-hour biodiversity training for all workers before site access; refresher every 6 months; training records maintained on site	100% worker training completion; zero wildlife harassment, hunting, or collection incidents	Contractor's Environmental Officer	Pre-construction (initial); ongoing (refresher)	CC-TRAIN-04
M-CC-05	Night-time disturbance to wildlife (lighting)	No permanent road lighting within 1 km of wildlife crossing zones without KWS/IEC approval; where approved, use low-intensity (max 70 lux), downward-directed, motion-sensor LED lights	Light spill at 50 m from road edge ≤1 lux; no observed avoidance behavior of crossing structures attributable to lighting	KeNHA Design Engineer (permanent); Contractor (construction)	Design phase; construction; operation	CC-LIGHT-05

6.9 Non-Compliance and Penalties

The following penalties shall apply for non-compliance with any mandatory mitigation measure:

Violation	First Offense	Second Offense	Third Offense
Unauthorized clearing outside reserve	KES 100,000 + immediate restoration	KES 250,000 + stop-work order for section	Contract termination + NEMA prosecution

Unauthorized tree removal (per tree)	KES 50,000 + 20x compensatory planting	KES 100,000 + 50x planting	KES 250,000 + contract termination
Sediment discharge into water body	KES 200,000 + immediate remediation	KES 500,000 + stop-work at crossing	NEMA prosecution + debarment
Wildlife harassment or hunting	KES 500,000 + worker dismissal + report to KWS	Contract termination + criminal prosecution	N/A
Failure to implement worker training	KES 50,000 + suspension until training complete	KES 100,000 + daily penalty	Contract termination
Failure to protect termite mound or *Ficus*	KES 100,000 + restoration plan	KES 250,000 + stop-work in zone	NEMA prosecution

All penalties shall be paid to KeNHA and directed to the project's Environmental Management Fund for biodiversity offset activities.

6.10 Risk Summary Table for All Mitigation Measures

The table below summarizes the risk level for each impact category across all three road sections, with reference to the relevant mitigation measures. This table provides a quick overview for project managers and environmental staff.

Table 6-1: Summary of Risk Levels

Road Section	Impact Category	Chainage	Risk Level	Mitigation Reference
Biretwo–Chesongoch	Escarpment & Slopes	9+000–22+000; 40+000–63+000	CRITICAL	M-BC-01 to M-BC-05
Biretwo–Chesongoch	Elephant Dispersal	13+000–17+000; 21+000–24+000; 37+000–40+000; 49+000–51+000	CRITICAL	M-BC-02, M-CC-01, M-CC-02
Biretwo–Chesongoch	Riparian Systems	23+000–36+500; 52+000–66+500	HIGH	M-BC-06 to M-BC-10
Biretwo–Chesongoch	Human-Wildlife Conflict	Same as elephant corridors	HIGH	M-CC-01, M-CC-02
Biretwo–Chesongoch	Herpetofauna (Rock-dwelling)	9+000–22+000; 40+000–63+000	HIGH	M-BC-04
Biretwo–Chesongoch	Open Savanna	37+000–55+000	MEDIUM	M-BC-11 to M-BC-13
Biretwo–Chesongoch	Settlement Areas	0+000–8+500	LOW	M-BC-14, M-BC-15
Nyaru–Kimwarer–Kapkayo	Escarpment & Bushland	3+500–14+000	HIGH	M-NK-01 to M-NK-03
Nyaru–Kimwarer–Kapkayo	Wildlife Movement	3+500–14+000	HIGH	M-NK-02

Nyaru–Kimwarer–Kapkayo	Riparian Systems	14+000–22+500	MEDIUM	M-NK-04, M-NK-05
Nyaru–Kimwarer–Kapkayo	Open Savanna & Farmland	22+500–30+800	LOW	M-NK-06, M-NK-07
Kimwarer–Emsea	Wetlands & Valley Systems	4+000–9+500; 12+400–16+800	HIGH	M-KE-01 to M-KE-04
Kimwarer–Emsea	Riparian Hotspots	15+000–19+000	HIGH	M-KE-05, M-KE-06
Kimwarer–Emsea	Aquatic Fauna	11+200–18+600	HIGH	M-KE-04
Kimwarer–Emsea	Floodplains	Valley-bottom sections	MEDIUM	M-KE-02
Kimwarer–Emsea	Grassland Systems	9+500–15+000	LOW	(indirect – see M-KE-04)
Cross-cutting	Keystone Species (*Ficus*)	As mapped	HIGH	M-KE-06
Cross-cutting	Keystone Species (Termites)	As mapped	MEDIUM	M-CC-03

7 IMPLEMENTATION, MONITORING AND ADAPTIVE MANAGEMENT FRAMEWORK

7.1 Introduction

This chapter provides the implementation framework for the Biodiversity Management Plan (BMP) for the proposed upgrading of the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea road corridors. The chapter translates the mitigation measures identified in Chapter 6 into practical implementation actions that can be adopted by the Contractor, Supervising Engineer, Kenya National Highways Authority (KeNHA), Kenya Wildlife Service (KWS), and other responsible agencies during construction and operation.

The chapter further establishes the biodiversity monitoring and adaptive management framework required to assess the effectiveness of mitigation measures, track ecological performance, identify emerging environmental risks, and guide corrective actions throughout the project lifecycle.

7.2 Biodiversity Management Plan (BMP) Implementation Matrix

7.2.1 Purpose of the BMP Matrix

The BMP implementation matrix provides a practical summary of biodiversity management measures, implementation responsibilities, monitoring indicators, compliance requirements, and reporting obligations. The matrix is intended to serve as the primary operational biodiversity management tool for the Contractor and Supervising Engineer during project implementation.

7.2.2 Summary BMP Implementation Matrix

Biodiversity Issue	Key Impact/Risk	Mitigation / Management Measure	Project Phase	Responsible Party	Monitoring Indicator	Reporting Frequency
Vegetation Clearance	Habitat loss and fragmentation	Minimise clearing footprint; retain mature indigenous trees; demarcate no-go zones	Construction	Contractor / Supervising Engineer / KeNHA	Area cleared vs approved limits	Monthly
Riparian Disturbance	Sedimentation and water quality degradation	Maintain riparian buffers; install sediment traps; avoid spoil disposal near rivers	Construction	Contractor	Sediment levels; riparian vegetation condition	Monthly
Escarpment Instability	Landslides and erosion	Slope stabilization; benching;	Construction & Operation	Contractor / Supervising Engineer	Slope failure incidents;	Monthly

		retaining structures; controlled runoff drainage			erosion severity	
Wildlife Movement Obstruction	Habitat fragmentation and roadkill	Install culverts, underpasses, fauna-friendly crossings, warning signage	Construction & Operation	Contractor / KeNHA / KWS	Wildlife crossing use; roadkill frequency	Quarterly
Dust and Noise	Disturbance to fauna and communities	Water spraying; speed control; equipment maintenance	Construction	Contractor	Dust levels; complaints received	Weekly
Invasive Species Spread	Habitat degradation	Machinery cleaning; controlled fill sourcing; rapid revegetation	Construction & Operation	Contractor / KeNHA	Presence of invasive species	Quarterly
Wetland Disturbance	Loss of wetland ecological function	Avoid unnecessary drainage alteration; maintain hydrological connectivity	Construction & Operation	Contractor / Supervising Engineer	Wetland condition	Quarterly
Borrow Pit Degradation	Soil erosion and habitat destruction	Progressive rehabilitation; topsoil replacement; revegetation	Construction	Contractor	Rehabilitated borrow areas	Monthly
Pollution and Waste	Soil and water contamination	Hazardous material controls; waste segregation; spill response measures	Construction	Contractor	Spill incidents; waste records	Monthly
Human–Wildlife Conflict	Increased conflict risk	Community awareness; wildlife signage; controlled	Construction & Operation	Contractor / KWS / KeNHA	Conflict incidents reported	Quarterly

		worker conduct				
Revegetation Failure	Poor ecological recovery	Use native species; maintenance watering; replacement planting	Construction & Operation	Contractor / KeNHA	Vegetation survival rate	Quarterly
Contractor Non-Compliance	Environmental degradation	Enforce penalties and compliance audits	Construction	Supervising Engineer / KeNHA	Number of non-compliance notices	Monthly

7.3 Institutional Roles and Responsibilities

7.3.1 Kenya National Highways Authority (KeNHA)

KeNHA shall serve as the lead implementing agency responsible for overall BMP compliance, integration of biodiversity requirements into contractual obligations, supervision of environmental performance, coordination with regulatory agencies, and allocation of resources for biodiversity management.

7.3.2 Contractor

The Contractor shall be responsible for day-to-day implementation of all biodiversity mitigation measures during construction. This includes vegetation protection, erosion control, waste management, pollution prevention, restoration of disturbed areas, wildlife protection, invasive species management, and environmental reporting.

7.3.3 Supervising Engineer

The Supervising Engineer shall oversee contractor compliance with the BMP and verify implementation of mitigation measures, environmental specifications, monitoring activities, corrective actions, and reporting obligations.

7.3.4 Kenya Wildlife Service (KWS)

KWS shall provide technical guidance on wildlife protection, ecological connectivity, wildlife crossings, roadkill management, and human–wildlife conflict mitigation where relevant.

7.4 Biodiversity Monitoring Framework

7.4.1 Purpose of Monitoring

The biodiversity monitoring framework is intended to:

- evaluate effectiveness of mitigation measures;
- detect emerging environmental impacts;
- assess ecosystem recovery;
- track biodiversity trends; and
- support adaptive management throughout project implementation.

7.4.2 Key Monitoring Indicators

The following indicators shall be monitored throughout construction and operation:

- vegetation recovery and survival rates;
- erosion severity and sedimentation levels;
- riparian habitat condition;
- wildlife sightings and wildlife crossings;
- roadkill frequency;
- invasive species occurrence;
- drainage functionality;
- water quality at crossings;
- rehabilitation success of disturbed areas; and
- compliance with environmental controls.

7.5 Adaptive Management Framework

Adaptive management shall be applied where monitoring indicates that mitigation measures are ineffective or where unexpected biodiversity impacts emerge. Corrective actions may include:

- redesign of drainage systems;
- reinforcement of erosion controls;
- additional revegetation;
- installation of additional wildlife crossings;
- modification of construction practices; and
- enhanced environmental supervision.

Annual BMP performance reviews shall be undertaken jointly by KeNHA, the Supervising Engineer, KWS, and relevant environmental authorities.

7.6 Reporting Requirements

The Contractor shall prepare:

- weekly site environmental inspection records;
- monthly biodiversity compliance reports;
- incident and non-compliance reports;
- rehabilitation progress reports; and
- final biodiversity restoration reports.

The Supervising Engineer shall submit consolidated quarterly environmental performance reports to KeNHA and relevant regulators.

7.6.1 Biretwo – Arror – Chesongoch Section

This section traverses escarpment slopes, rocky terrain, dry bushland, and seasonal drainage lines. Monitoring focuses on slope stability, riparian health, elephant movement, human-wildlife conflict, keystone species (*Ficus sycomorus*), and soil function (termites).

Impact Category	Specific Impact	Chainage / Location	Monitoring Indicator	Method of Measurement	Frequency	Responsibility (Monitoring)	Cost Code
Escarpment & Slopes	Vegetation loss and slope instability	9+000–22+000; 40+000–63+000	Percentage vegetation cover recovery; erosion incidence (number of rills >10 cm depth per 100 m)	Field vegetation surveys (1 m × 1 m quadrats, 10 per km); erosion mapping (GPS track of visible erosion features)	Quarterly	IEC	MON-BC-VEG-01
Riparian Systems	Hydrological alteration and sedimentation	23+000–36+500; 52+000–66+500	Turbidity (NTU above baseline); riparian vegetation cover (%)	Water quality sampling (turbidity meter, grab samples); vegetation surveys (belt transects along 100 m reaches)	Monthly (construction), Quarterly (operation)	IEC / WRA	MON-BC-WAT-02
Wildlife Movement (Elephants)	Disruption of dispersal routes	13+000–17+000; 21+000–24+000; 37+000–40+000; 49+000–51+000	Number of elephant crossings per month; crossing structure usage (%)	Camera traps (minimum 2 per crossing zone, 24-hour operation); spoor counts (morning surveys along 500 m approaches)	Monthly	KWS / IEC	MON-BC-ELE-03
Human–Wildlife Conflict	Increased crop raiding	Same as above	Number of conflict incidents reported per month (by type: crop damage, property damage, human injury)	Community reporting logs (maintained by CLO); incident records from KWS and County Government	Monthly (May–July peak season enhanced frequency to weekly)	County Government / KWS	MON-BC-HWC-04
Keystone Species (*Ficus sycomorus*)	Tree decline due to hydrological changes	Same as above + all drainage zones with *Ficus* presence	Tree health index (0–100% canopy dieback); survival rate (%)	Field assessment (visual estimate of canopy dieback, root exposure, leaf condition);	Biannual (pre-wet and post-dry seasons)	IEC / KFS	MON-BC-FIG-05

				permanent monitoring plots around each tree			
Soil & Termites	Habitat degradation and soil function loss	Same as above	Number of active termite mounds per km; soil infiltration rate (minutes per cm)	Transect surveys (50 m width, count all mounds with fresh workings); double-ring infiltrometer tests (3 replicates per km)	Biannual	IEC	MON-BC-SOIL-06

7.6.2 Nyaru – Kimwarer – Kapkayo Section

This section traverses escarpment bushland, woodland edges, mid-slope systems, and riparian corridors. Monitoring focuses on habitat connectivity, riparian integrity, roadkill, wildlife movement, pollinators, and aquatic systems.

Impact Category	Specific Impact	Chainage / Location	Monitoring Indicator	Method of Measurement	Frequency	Responsibility (Monitoring)	Cost Code
Escarpment & Bushland	Habitat fragmentation	3+500–14+000	Vegetation continuity index (scale 0–1); canopy cover (%)	Transect surveys (point-intercept method every 20 m); remote sensing (NDVI from Sentinel-2 imagery)	Quarterly	IEC	MON-NK-VEG-07
Riparian Systems	Vegetation loss and hydrological disruption	14+000–22+500	Riparian buffer width (m); water flow continuity (presence/absence of dry sections)	Field surveys (GPS measurement from stream bank to edge of disturbance); hydrological observation (visual assessment at 500 m intervals)	Quarterly	IEC / Contractor's Environmental Officer	MON-NK-WAT-08

Open Savanna & Farmland	Increased roadkill	22+500–30+800	Roadkill frequency (animals/km/month) by taxonomic group (mammal, bird, reptile, amphibian)	Road surveys (vehicle transect at 20 km/h, two observers, dawn and dusk)	Monthly	IEC / KWS	MON-NK-RKILL-09
Mammals & Wildlife	Disruption of movement routes	3+500–14+000	Wildlife crossing frequency (non-elephant, by species group)	Camera traps (minimum 1 per km in corridor zones); spoor tracking (morning surveys)	Monthly	KWS / IEC	MON-NK-WILD-10
Invertebrates & Pollinators	Decline in pollinators	3+500–14+000	Pollinator abundance (number per 100 sweeps); diversity index (Shannon H')	Sweep netting (50 sweeps per transect, 3 transects per km); pan traps (yellow, blue, white bowls)	Seasonal (wet season and dry season)	IEC	MON-NK-POLL-11
Aquatic Systems	Habitat degradation	14+000–22+500	Macroinvertebrate diversity index (Shannon H'); water quality (pH, dissolved oxygen, conductivity)	Kick net sampling (3-minute sample per site); lab analysis of water samples	Quarterly	IEC / WRA	MON-NK-AQUA-12

7.6.3 Kimwarer – Emsea Section

This section traverses valley-bottom systems, wetlands, floodplains, and riparian hotspots. Monitoring focuses on wetland hydrology, floodplain connectivity, riparian habitat integrity, aquatic fauna, invertebrate communities, and grassland vegetation.

Impact Category	Specific Impact	Chainage / Location	Monitoring Indicator	Method of Measurement	Frequency	Responsibility (Monitoring)	Cost Code
Wetlands & Valley Systems	Hydrological disruption	4+000–9+500; 12+400–16+800	Water level variation (cm above/below baseline); wetland extent (ha)	Hydrological monitoring (staff gauges installed at 5 locations, read weekly); GIS mapping (delineation from Sentinel-2 or drone imagery)	Monthly (wet season), Quarterly (dry season)	IEC / WRA	MON-KE-WET-13
Floodplains	Alteration of flooding regime	All valley-bottom sections	Flood frequency (number of events per season); flood duration (days)	Field observation (visual confirmation at 5 fixed points); hydrological data (rainfall records and water level loggers)	Seasonal (wet season only)	IEC / WRA	MON-KE-FLOOD-14
Riparian Habitats	Habitat loss and fragmentation	15+000–19+000	Riparian vegetation cover (%); plant species richness (number of species per 100 m)	Field vegetation surveys (1 m × 1 m quadrats every 50 m, plus full species list per reach)	Quarterly	IEC / KFS	MON-KE-RIP-15
Aquatic Fauna	Habitat loss	11+200–18+600	Amphibian abundance (number per 100 m transect); aquatic species presence (fish, crabs, aquatic reptiles)	Visual encounter surveys (night transects with headlamps, 500 m per site); dip net sampling (20 sweeps per site)	Seasonal (wet season, peak breeding months March–May and October–November)	IEC / KWS	MON-KE-AMPH-16
Invertebrates	Sedimentation impacts	4+000–9+500	Sediment load (mg/L); aquatic invertebrate diversity (Shannon H')	Water sampling (suspended sediment, grab samples during and after rainfall); kick net sampling (3-minute sample per site)	Quarterly (with enhanced sampling after major rainfall events >50 mm in 24 hours)	IEC / WRA	MON-KE-INV-17

Grassland Systems	Vegetation decline	9+500–15+000	Vegetation cover (%); species diversity (Shannon H')	Field surveys (1 m × 1 m quadrats, 10 per km); species identification and cover estimation	Quarterly	IEC	MON-KE-GRASS-18

7.7 Monitoring Thresholds and Trigger Values

The table below defines quantitative, color-coded thresholds for each key indicator:

Status	Color	Definition	Action Required
Acceptable	Green	Performance meets or exceeds the Chapter 6 performance standard	Continue routine monitoring. No action required.
Caution	Amber	Performance is approaching the critical threshold but has not yet exceeded it	Issue Caution Notice. Increase monitoring frequency to weekly. Re-evaluate in 14 days.
Critical	Red	Performance has fallen below the minimum acceptable level	Issue Non-Compliance Notice. Initiate mandatory corrective action within 7 days.

Critical rule: If a Red threshold is exceeded, the corrective action shall be initiated within **7 days**. The Contractor shall submit a written Root Cause Analysis and Corrective Action Plan within **14 days**.

7.7.1 Thresholds Table

Indicator	Chainage	Acceptable (Green)	Caution (Amber)	Critical (Red)	Mandatory Corrective Action	Related Chapter 6 Measure	Cost Code
Turbidity in stream at drainage crossing	23+000–36+500; 52+000–66+500	< 25 NTU above baseline	25–50 NTU above baseline for > 7 days	> 50 NTU above baseline for > 3 days	Contractor shall stop works at that crossing, install additional silt fences and sediment basins, and submit remediation plan within 48 hours.	M-BC-08	MON-BC-WAT-02
Elephant crossing frequency (camera trap)	13+000–17+000; 21+000–	≥ 75% of pre-construction baseline	50–75% of baseline for 2 consecutive months	< 50% of baseline for 2 consecutive months	Contractor and KWS shall inspect culverts for blockage, lighting,	M-BC-02, M-NK-02	MON-BC-ELE-03

	24+000; 37+000–40+000; 49+000–51+000				or noise. Within 14 days, install additional guiding structures or temporary speed bumps.		
Roadkill index (all vertebrates)	All sections, aggregated monthly	< 0.5 animals/km/month	0.5–1.5 animals/km/month	> 1.5 animals/km/month for 2 consecutive months	Contractor shall install temporary speed limits (max 40 km/h) and additional warning signage within 7 days. Submit long-term mitigation report within 30 days.	M-BC-13, M-NK-07	MON-NK-RKILL-09
Ficus sycomorus health (canopy dieback)	13+000–17+000; 21+000–24+000; 37+000–40+000; 49+000–51+000 + all drainage zones	< 10% dieback	10–25% dieback	> 25% dieback in any individual tree	Contractor shall install root-zone moisture monitoring. Within 14 days, adjust drainage to restore subsurface flow. If tree dies, plant 10 replacement saplings in same micro-catchment.	M-KE-06	MON-BC-FIG-05
Active termite mound density	13+000–17+000; 21+000–24+000; 37+000–40+000; 49+000–51+000	≥ 90% of baseline	75–90% of baseline	< 75% of baseline	Contractor shall cease soil disturbance in that sub-section. Rehabilitate using salvaged topsoil and avoid compaction. Monitor for 6 months.	M-CC-03	MON-BC-SOIL-06
Human-wildlife conflict incidents	13+000–17+000; 21+000–24+000; 37+000–	< 50% of pre-construction baseline (target achieved)	50–75% of baseline	> 75% of baseline for 2 consecutive months	Contractor and County Government shall convene emergency community meeting, review land-use	M-CC-02	MON-BC-HWC-04

	40+000; 49+000–51+000				agreements, and implement additional deterrent measures (e.g., chili fences, watchtowers) within 14 days.		
Vegetation cover on treated slopes	9+000–22+000; 40+000–63+000	≥ 80% cover at 6 months post-treatment	60–80% cover at 6 months	< 60% cover at 6 months post-treatment	Contractor shall reseed with native mix, apply erosion blanket, and extend monitoring for additional 6 months.	M-BC-03	MON-BC-VEG-01
Amphibian abundance at breeding sites	11+200–18+600	≥ 80% of pre-construction baseline	50–80% of baseline	< 50% of baseline at any monitored breeding site	Contractor shall construct temporary off-line breeding ponds (minimum 2 per affected site) and restrict all in-stream works until the next breeding season.	M-KE-04	MON-KE-AMPH-16
Wetland extent	4+000–9+500; 12+400–16+800	≥ 95% of pre-construction baseline	90–95% of baseline	< 90% of baseline	Contractor shall restore hydrological connectivity by removing flow barriers, installing relief culverts, and submitting a wetland restoration plan within 30 days.	M-KE-01, M-KE-02	MON-KE-WET-13

7.8 Adaptive Management Protocol

The Adaptive Management Protocol is the decision-making engine of the monitoring framework. It provides a closed-loop process that transforms raw monitoring data into management action. This protocol ensures that monitoring is not an end in itself but a means to adaptive management.

7.8.1 The Five-Step Protocol

Step	Title	Description	Responsibility	Timeline
Step 1	Routine Monitoring	Collect data per the methods and frequencies specified in Section 7.2. Enter data into the BMP database.	Responsible party per Section 7.2 (IEC, KWS, WRA, County Government)	As specified in Section 7.4 (monthly, quarterly, etc.)
Step 2	Evaluation	Compare data to thresholds defined in Section 7.7. Classify each indicator as Green, Amber, or Red.	IEC	Within 5 working days of data collection
Step 3	Decision and Action	If Green: Continue routine monitoring. If Amber: Issue Caution Notice, increase monitoring frequency to weekly, re-evaluate in 14 days. If Red: Issue Non-Compliance Notice, initiate mandatory corrective action per Section 7.7 within 7 days.	IEC (notices); Contractor (corrective action)	Notice within 24 hours of classification; corrective action initiation within 7 days
Step 4	Verification	Verify the effectiveness of the corrective action through targeted monitoring. If effective: Return to routine monitoring frequency. If ineffective: Escalate to KeNHA Project Manager. Suspend relevant works until compliance achieved. Apply penalties per Chapter 6, Section 6.9.	IEC	Within 7 days of corrective action completion
Step 5	Annual Review	Review all thresholds and adaptive actions. Recommend adjustments based on new data. Submit proposed changes to NEMA for approval as a BMP appendix amendment.	IEC, KeNHA, KWS, WRA, County Government	Every 12 months (anniversary of construction start)

7.8.2 Adaptive Management Decision Matrix

Observed Trend	Classification	Action
Improving (Red → Amber → Green over 3 consecutive monitoring periods)	Positive trend	Step down monitoring frequency (e.g., weekly → monthly → quarterly). Document trend in quarterly report.
Stable within Green range	Acceptable	Maintain routine monitoring frequency. No further action.
Worsening (Green → Amber → Red over 2 consecutive monitoring periods)	Negative trend	Escalate response: increase monitoring frequency, issue notices, implement corrective actions.
No change after corrective action implemented	Ineffective mitigation	Escalate to KeNHA Project Manager. Suspend works. Require design change or additional mitigation measures.

7.8.3 Escalation Pathway

If corrective actions fail to achieve compliance, the following escalation pathway shall be followed:

Level	Trigger	Action	Responsibility
Level 1	Red threshold exceeded	Issue Non-Compliance Notice. Implement mandatory corrective action.	IEC, Contractor
Level 2	Corrective action ineffective after 30 days	Escalate to KeNHA Project Manager. Suspend relevant works. Apply daily penalty (KES 50,000 per day).	IEC, KeNHA Project Manager
Level 3	Continued non-compliance after 60 days	Escalate to KeNHA Environmental & Social Safeguards Unit. Recommend contract termination. Notify NEMA and AfDB.	KeNHA Project Manager
Level 4	Environmental harm occurring	Notify NEMA Compliance Committee. Refer for prosecution under EMCA 1999.	KeNHA, NEMA

7.9 Reporting Requirements

This section establishes three tiers of reporting: routine monitoring reports, event-based reports, and public disclosure requirements.

7.9.1 Routine Monitoring Reports

Report Type	Frequency	Prepared By	Submitted To	Content Requirements
Monthly Monitoring Report	Monthly (by the 10th of the following month)	IEC	KeNHA Environmental & Social Safeguards Unit, Contractor, NEMA (summary only)	Raw data tables for all indicators measured that month; status classification (Green/Amber/Red) for each indicator; copies of any Caution or Non-Compliance Notices issued
Quarterly Monitoring Report	Quarterly (by the 15th of the month following each quarter)	IEC	KeNHA Environmental & Social Safeguards Unit, Contractor, NEMA, KWS, WRA, County Government	Trend analysis comparing current data to previous quarters and pre-construction baseline; evaluation of mitigation effectiveness; any threshold adjustments recommended; summary of corrective actions taken and their outcomes
Annual Monitoring Report	Annually (by 31 January of the following year)	IEC	Same as quarterly + AfDB (upon financing approval)	Comprehensive review of all indicators; statistical analysis of trends; recommendations for threshold revisions; proposed BMP amendments; cost report comparing actual monitoring expenditure to budget

7.9.2 Event-Based Reports

Event	Prepared By	Submitted To	Content Requirements	Timeline
Caution Notice	IEC	Contractor, KeNHA Environmental & Social Safeguards Unit	Indicator exceeded Amber threshold; date and time of exceedance; requirement to increase monitoring frequency	Within 24 hours of Amber classification

Non-Compliance Notice	IEC	Contractor, KeNHA Project Manager, KeNHA Environmental & Social Safeguards Unit	Description of violation; evidence (data, photos); specific corrective action required (from Section 7.3); penalty amount (from Chapter 6, Section 6.7); deadline for compliance	Within 24 hours of Red classification
Corrective Action Plan	Contractor	IEC, KeNHA Project Manager	Root cause analysis; specific actions to be taken; timeline for completion (not exceeding 30 days unless approved by IEC); responsible parties; resources allocated	Within 14 days of Non-Compliance Notice
Verification Report	IEC	KeNHA Project Manager, NEMA (if escalated)	Confirmation of corrective action effectiveness or recommendation for escalation; if ineffective, recommended next steps (penalties, work suspension, contract termination)	Within 7 days of corrective action completion
Incident Report	Contractor (immediate); IEC (investigation)	KeNHA, NEMA, KWS (depending on severity)	Any unplanned event causing or with potential to cause environmental harm (e.g., spill, unauthorized clearing, wildlife mortality); description, cause, consequences, corrective actions taken	Within 24 hours of incident (verbal); within 7 days (written)

7.9.3 Public Disclosure Requirements

The following documents shall be made available to affected communities upon request, through the Community Liaison Officer (CLO):

Document	Format	Location	Notes
Quarterly Monitoring Reports (summary version)	Written summary (2–4 pages) in English and local language (Kalenjin, Swahili)	Posted at trading centers (Biretwo, Chesongoch, Nyaru, Kimwarer, Kapkayo, Emsea); available at site office	Sensitive commercial information (e.g., Contractor's costs) redacted
Grievance log	Anonymized summary (no complainant names)	Available at CLO office	Updated quarterly
Non-Compliance Notices and resolutions	Full text (redacted for confidential information)	Available at site office and KeNHA website	Posted within 7 days of resolution
This BMP (full document)	Digital PDF	KeNHA website; available on request at site office	Disclosed prior to construction start

7.10 Monitoring Cost Codes Summary

This section provides a reference table of all 18 monitoring cost codes introduced in this chapter. These codes follow a consistent naming convention that enables full financial traceability from monitoring activities to budget lines.

7.10.1 Cost Code Naming Convention

Component	Position	Meaning	Example
MON	Prefix	Monitoring (distinguishes from mitigation cost codes in Chapter 6)	MON
XX	Middle (2 letters)	Road section: BC (Biretwo–Chesongoch), NK (Nyaru–Kapkayo), KE (Kimwarer–Emsea)	BC
YYYY	Middle (4 letters)	Indicator type: VEG, WAT, ELE, HWC, FIG, SOIL, WILD, POLL, AQUA, WET, FLOOD, RIP, AMPH, INV, GRASS, RKILL	ELE
NN	Suffix (2 digits)	Sequential number within section	03

7.10.2 Complete Cost Code Reference Table

Cost Code	Description	Indicator Type	Section	Frequency
MON-BC-VEG-01	Vegetation cover and erosion monitoring – Biretwo–Chesongoch	Vegetation recovery	7.6.1	Quarterly
MON-BC-WAT-02	Water quality and riparian monitoring – Biretwo–Chesongoch	Turbidity, riparian cover	7.6.1	Monthly (construction), Quarterly (operation)
MON-BC-ELE-03	Elephant movement monitoring – Biretwo–Chesongoch	Crossing frequency, structure usage	7.6.1	Monthly
MON-BC-HWC-04	Human-wildlife conflict monitoring – Biretwo–Chesongoch	Incident reports	7.6.1	Monthly (May–July peak)
MON-BC-FIG-05	*Ficus sycomorus* health monitoring – Biretwo–Chesongoch	Tree health index, survival	7.6.1	Biannual
MON-BC-SOIL-06	Termite and soil function monitoring – Biretwo–Chesongoch	Mound density, infiltration	7.6.1	Biannual
MON-NK-VEG-07	Vegetation continuity monitoring – Nyaru–Kapkayo	Continuity index, canopy cover	7.6.2	Quarterly
MON-NK-WAT-08	Riparian and hydrological monitoring – Nyaru–Kapkayo	Buffer width, flow continuity	7.6.2	Quarterly
MON-NK-RKILL-09	Roadkill monitoring – Nyaru–Kapkayo	Roadkill frequency	7.6.2	Monthly
MON-NK-WILD-10	Wildlife crossing monitoring – Nyaru–Kapkayo	Crossing frequency (non-elephant)	7.6.2	Monthly
MON-NK-POLL-11	Pollinator monitoring – Nyaru–Kapkayo	Abundance, diversity	7.6.2	Seasonal
MON-NK-AQUA-12	Aquatic system monitoring – Nyaru–Kapkayo	Macroinvertebrate diversity, water quality	7.6.2	Quarterly
MON-KE-WET-13	Wetland hydrological monitoring – Kimwarer–Emsea	Water level, wetland extent	7.6.3	Monthly (wet), Quarterly (dry)
MON-KE-FLOOD-14	Floodplain monitoring – Kimwarer–Emsea	Flood frequency, duration	7.6.3	Seasonal
MON-KE-RIP-15	Riparian habitat monitoring – Kimwarer–Emsea	Vegetation cover, species richness	7.6.3	Quarterly
MON-KE-AMPH-16	Amphibian monitoring – Kimwarer–Emsea	Abundance, species presence	7.6.3	Seasonal

MON-KE-INV-17	Invertebrate and sediment monitoring – Kimwarer–Emsea	Sediment load, invertebrate diversity	7.6.3	Quarterly
MON-KE-GRASS-18	Grassland vegetation monitoring – Kimwarer–Emsea	Cover, species diversity	7.6.3	Quarterly

Soil management should be tailored to local conditions, with particular attention given to clay-rich and erosion-prone soils. Measures to reduce compaction, enhance drainage, and stabilise exposed surfaces should be implemented to maintain soil structure and prevent degradation. Topsoil should be conserved and reused during rehabilitation to support vegetation recovery and soil biological activity.

Construction activities should be carefully managed to minimise ecological disturbance. Phased construction should be adopted to avoid continuous disturbance along long stretches of the road, and sensitive habitats should be avoided when locating camps and material storage areas. Night-time activities should be minimised in ecologically sensitive areas to reduce disturbance to wildlife.

Finally, a robust monitoring and adaptive management framework should be established to track ecological changes over time. Monitoring should include both species-based indicators and ecosystem-level metrics, allowing for early detection of impacts and timely implementation of corrective measures. Continuous coordination among implementing agencies, regulatory authorities, and local communities will be essential to ensure effective implementation and long-term sustainability of the project.

7.11 Contractor Summary BMP Implementation Matrix

This matrix synthesizes day-to-day mitigation obligations, required targets, monitoring methods, and reporting intervals during the active construction phase.

Biodiversity Issue / Risk	Construction Phase Management Measure	Contractor Operational Target / Threshold	Field Method of Measurement	Reporting & Action Timeline
Vegetation Clearance *(Habitat Loss)*	Minimise clearing footprint; retain mature indigenous trees; demarcate no-go zones.	**Green**: Within approved limits. **Red**: Exceeding approved alignment boundary.	Spatial layout verification against design maps; demarcated buffer inspections.	**Monthly Report**. Exceedance requires work halt and boundary correction within 7 days.
Riparian Disturbance *(Water Quality)*	Maintain riparian buffers; install sediment traps; completely avoid spoil disposal near rivers.	**Green**: < 25 NTU turbidity above baseline. **Red**: > 50 NTU above baseline for > 3 days.	Water quality testing using portable turbidity meters at drainage crossings.	**Monthly Report**. Red threshold requires work halt at crossing and silt fence reinforcement within 48 hours.
Escarpment & Slope Instability	Slope stabilization; benching; install retaining structures; controlled runoff drainage.	**Green**: ≥ 80% vegetation cover on treated	Field surveys using 1m × 1m quadrats (10 per	**Monthly (Construction)**; **Quarterly**

		slopes at 6 months. **Red**: < 60% cover at 6 months.	km); erosion rill mapping.	**(Surveys)**. Red requires native reseeding and erosion blankets within 7 days.
Borrow Pit & Soil Degradation	Progressive rehabilitation; topsoil conservation/replacement; rapid revegetation; avoid compaction.	**Green**: Salvaged topsoil reused; no progressive compaction. **Red**: Active termite mound density < 75% of baseline.	Linear transect surveys (50m width) to count active mounds; double-ring infiltrometer tests.	**Monthly Rehabilitation Report**; **Biannual Soil Surveys**. Red requires work halt in sub-section and topsoil rescue.
Dust and Noise Disruption	Continuous water spraying on earth tracks; strict speed controls; routine equipment maintenance.	**Green**: Negligible community dust complaints. **Red**: Unmitigated dust levels or active grievances.	Visual site inspection log sheets; community grievance log tracking.	**Weekly Inspection Records**.
Invasive Species Spread	Mandatory machinery wash-downs; controlled fill material sourcing; rapid revegetation.	**Green**: Zero presence of invasive species on treated zones. **Red**: Colonisation of invasive weeds.	Targeted botanical field inspections of raw material stockpiles and site verges.	**Quarterly Compliance Report**.
Pollution & Waste Management	Hazardous material storage controls; waste segregation; ready spill response kits.	**Green**: Zero uncontained hazardous leaks. **Red**: Any uncontained environmental spill.	Fuel depot inspections; inventory records; rapid incident response logs.	**Monthly Waste Records**. Spills require immediate verbal report within 24 hours, written within 7 days.
Wetland & Valley Disruption	Avoid unnecessary drainage alteration; maintain natural hydrological connectivity.	**Green**: ≥ 95% of pre-construction baseline extent. **Red**: < 90% of baseline wetland extent.	Weekly reading of installed staff gauges; drone or GIS mapping support.	**Monthly (Wet Season)**; **Quarterly (Dry Season)**. Red requires removal of flow barriers within 30 days.

7.12 Conclusion

Implementation of the BMP requires coordinated action among KeNHA, the Contractor, the Supervising Engineer, KWS, and relevant stakeholders. The BMP implementation matrix and monitoring framework provide the operational mechanism for ensuring that biodiversity conservation, ecological connectivity, erosion control, habitat restoration, and environmental compliance are integrated throughout the construction and operational phases of the proposed road upgrading project.

8 Budget

8.1 Overview

This chapter presents the budget for implementation of the Biodiversity Management Plan (BMP). The BMP is a complementary management instrument to the Project Environmental and Social Management Plan (ESMP) and provides detailed biodiversity-specific mitigation, monitoring, and adaptive management measures required to achieve the Project's biodiversity objectives.

The BMP does not replace the ESMP or the Contractor's Environmental and Social Management Plan (C-ESMP). To avoid duplication of effort and double financing, mitigation and monitoring measures that are already included in the civil works contract, ESMP, or C-ESMP are not budgeted again under the BMP unless additional biodiversity-specific actions are required. Detailed implementation responsibilities and schedules for BMP activities are provided in **Chapter 10**.

8.2 Relationship between the BMP and ESMP

The ESMP and BMP are complementary instruments that operate within the Project's overall environmental and social management framework. The ESMP establishes the overarching environmental and social mitigation, monitoring, reporting, and institutional arrangements applicable throughout the Project lifecycle. The BMP builds upon these requirements by providing detailed biodiversity-specific management measures for habitats, flora, fauna, ecological connectivity, invasive species management, wildlife monitoring, and adaptive biodiversity management.

Routine environmental mitigation measures such as erosion and sediment control, drainage management, pollution prevention, occupational health and safety, topsoil management, and routine environmental monitoring are implemented through the ESMP and the Contractor's C-ESMP and are financed through the civil works contract or the Project ESMP budget.

The BMP budget therefore finances only incremental biodiversity-specific measures that are additional to the ESMP requirements, including wildlife collision mitigation, habitat enhancement, invasive species management, biodiversity monitoring, ecological performance evaluation, and adaptive management.

8.3 Relationship between the BMP and the ESMP

Table 8-1 summarizes the relationship between the BMP and the ESMP, identifying the lead implementation instrument, implementing entity, monitoring and reporting arrangements, and budget source for each biodiversity mitigation and monitoring activity. This demonstrates how the two instruments complement one another while avoiding duplication of effort, monitoring, and financing.

Table 8-1:Relationship between the BMP and the ESMP

BMP Activity	Corresponding ESMP Activity	Lead Instrument	Implementing Entity	Monitoring & Reporting Route	Budget Source
Wildlife warning signage, speed	Wildlife collision mitigation	BMP	Contractor (construction); KeNHA (operation) in	Contractor → Supervising	BMP

management and roadkill mitigation			collaboration with KWS	Engineer → IEC → KeNHA	
Wildlife movement and roadkill monitoring	Biodiversity monitoring	BMP	KeNHA and KWS	KeNHA Environment Unit → IEC → AfDB	BMP
Elephant crossing monitoring	Biodiversity monitoring	BMP	KeNHA and KWS	KeNHA → IEC	BMP
Habitat restoration success monitoring	Vegetation rehabilitation	BMP	Contractor / KeNHA	IEC	BMP
Invasive species monitoring and control	Vegetation management	BMP	Contractor / KeNHA	IEC	BMP
Human–wildlife conflict mitigation	Community safety measures	BMP	KeNHA, KWS and County Government	KeNHA → IEC	BMP
Erosion and sediment control	Construction ESMP	ESMP	Contractor	Supervising Engineer	Civil Works Contract
Slope stabilization	Construction ESMP	ESMP	Contractor	Supervising Engineer	Civil Works Contract
Topsoil salvage and respreading	Construction ESMP	ESMP	Contractor	Supervising Engineer	Civil Works Contract
Routine revegetation of disturbed areas	Construction ESMP	ESMP	Contractor	Supervising Engineer	Civil Works Contract
Routine water quality monitoring	ESMP Monitoring Plan	ESMP	Contractor / KeNHA	Supervising Engineer → KeNHA	ESMP
Routine vegetation monitoring	ESMP Monitoring Plan	ESMP	Contractor / KeNHA	Supervising Engineer → KeNHA	ESMP
Worker environmental awareness training	ESMP	ESMP	Contractor	Supervising Engineer	ESMP

Note: *Table 8-1 demonstrates the complementary roles of the BMP and the ESMP. Routine environmental mitigation and monitoring are implemented through the ESMP and the civil works contract, while the BMP addresses incremental biodiversity-specific measures.*

8.4 Budget Assumptions

Assumption	Value
Base year for cost estimation	2026
Annual inflation adjustment	5% per annum (applied to multi-year items)
Contingency	15% of total (excluding base construction)
Currency	Kenyan Shillings (KES)
Exchange rate reference (for AfDB reporting)	1 USD = 130 KES (as of April 2026)

8.5 Mitigation Measures Budget

Table 8-2 presents the estimated costs of implementing incremental biodiversity-specific mitigation measures under the BMP. Environmental mitigation measures already included in the ESMP or civil works contract are identified in Table 8-1 and are not budgeted again under the BMP.

Table 8-2: Budget

Category	Specific Measure	Related BMP Measure	Relationship with ESMP/Civil Works	Cost Code	Estimated Cost (KES)	Budget Source	Timing
Wildlife collision mitigation	Wildlife warning signage at 500 m intervals, rumble strips at 1,000 m intervals, and biodiversity-specific traffic calming at identified wildlife crossing zones	M-BC-13, M-NK-07	Additional biodiversity mitigation supplementing the ESMP	BC-ROADKILL-13	2,400,000	BMP	Construction and early operation
Habitat connectivity	Biodiversity review of open-span bridge and wildlife crossing designs to ensure ecological functionality	M-KE-01	Civil works finance construction; BMP finances biodiversity-specific design review and ecological verification	KE-BRIDGE-01	1,500,000	BMP	Detailed design and construction
Habitat enhancement	Restoration of ecologically sensitive habitats using native species and habitat-specific planting	M-BC-12, M-KE-06	Routine site rehabilitation is covered under the ESMP; BMP covers biodiversity enhancement only	BC-HAB-12	4,000,000	BMP	Construction and post-construction
Rock refugia creation	Placement of excavated rock piles to create reptile microhabitats	M-BC-04	Biodiversity-specific measure not included in the ESMP	BC-ROCK-04	1,200,000	BMP	Construction

Invasive species management	Control and monitoring of invasive alien species (*Prosopis*, *Opuntia*) in disturbed habitats	M-BC-11	Additional biodiversity management beyond routine vegetation maintenance	BC-INVASIVE-11	1,500,000	BMP	Post-construction (Years 1–2)
Keystone species conservation	Protection and enhancement of ecologically important tree species (e.g., *Ficus* spp.)	M-KE-06	Routine compensatory planting is financed under the ESMP; BMP covers conservation of keystone species	KE-FIGUS-06	1,000,000	BMP	Construction and post-construction
Termite mound conservation	Protection and, where necessary, relocation of ecologically important termite mounds	M-CC-03	Biodiversity-specific mitigation measure	CC-TERMITE-03	800,000	BMP	Pre-construction and construction
Human–wildlife conflict mitigation	Early warning systems, community awareness, land-use advisory support, and biodiversity-based conflict mitigation	M-CC-01, M-CC-02	Biodiversity-specific measure	CC-HWC-01	2,500,000	BMP	Pre-construction through operation
Biodiversity awareness and training	Specialist biodiversity training for Contractor personnel, including wildlife encounter procedures, protected species identification, and implementation of the BMP	M-CC-04	General environmental induction is covered under the ESMP; BMP covers specialised biodiversity training	CC-TRAIN-04	300,000	BMP	Pre-construction and refresher training

Wildlife-sensitive lighting	Wildlife-friendly lighting design (shielding, motion sensors, directional lighting) at identified sensitive locations	M-CC-05	Incremental biodiversity requirement beyond standard road lighting	CC-LIGHT-05	600,000	BMP	Construction
Subtotal – Mitigation					**15,800,000.00**		

Note: *Routine environmental mitigation measures, including erosion and sediment control, slope stabilization, topsoil management, routine revegetation, general tree replacement, pollution prevention, and standard environmental awareness training, are implemented through the Project ESMP and the Contractor's Environmental and Social Management Plan (C-ESMP) and financed through the civil works contract. The costs presented in Table 8-2 represent only the incremental biodiversity-specific measures required under this BMP and are therefore not duplicated within the ESMP budget.*

8.6 Biodiversity Monitoring Budget

Table 8-3 presents the estimated budget for biodiversity monitoring under the BMP. Routine environmental compliance monitoring required under the ESMP—including monitoring of erosion and sediment control measures, routine water quality, drainage, air quality, noise, waste management, and occupational health and safety—is financed through the ESMP and is therefore not duplicated under this BMP.

The monitoring activities presented below focus on evaluating the effectiveness of biodiversity mitigation measures, tracking ecological recovery, assessing wildlife responses to the Project, and informing adaptive management.

Table 8-3: iodiversity Monitoring Budget

Category	Monitoring Activity	Related Chapter 7 Indicator	Relationship with ESMP	Estimated Cost (KES)	Budget Source	Monitoring Frequency
Habitat restoration	Native vegetation recovery, habitat structure, species richness, restoration success	MON-BC-VEG-01, MON-NK-VEG-07	Ecological restoration monitoring supplementing routine ESMP revegetation monitoring	900,000	BMP	Quarterly
Aquatic biodiversity	Aquatic macroinvertebrate diversity, amphibian habitat condition,	MON-NK-AQUA-12, MON-KE-AMPH-16	Ecological monitoring only; routine water	1,200,000	BMP	Quarterly

	wetland ecological integrity		quality monitoring under ESMP			
Wildlife movement	Elephant crossing frequency, wildlife crossing success, roadkill surveys	MON-BC-ELE-03, MON-NK-WILD-10, MON-NK-RKILL-09	BMP-specific	2,400,000	BMP	Weekly roadkill surveys (Year 1), quarterly thereafter
Human–wildlife conflict	Conflict incidents, response effectiveness, community feedback	MON-BC-HWC-04	BMP-specific	600,000	BMP	Monthly
Keystone species	Health and survival of *Ficus* spp. and other priority species	MON-BC-FIG-05	BMP-specific	400,000	BMP	Biannual
Pollinators	Pollinator abundance and diversity	MON-NK-POLL-11	BMP-specific	600,000	BMP	Seasonal
Invasive species	Distribution and abundance of invasive alien species	MON-BC-INV-08	BMP-specific	600,000	BMP	Biannual
Wetland ecology	Wetland habitat condition and vegetation	MON-KE-WET-13	Ecological monitoring only; hydrological monitoring under ESMP	600,000	BMP	Quarterly
Biodiversity reporting	Biodiversity database management, analysis, IEC reporting, annual BMP review					
Subtotal – Monitoring				**8,300,000**		

Note: *Routine environmental monitoring, including water quality compliance, erosion and sediment control, slope stability, drainage performance, air quality, noise, waste management, occupational health and safety, and general environmental compliance monitoring, is undertaken through the ESMP and financed under the Project's environmental management budget. The monitoring activities presented in Table 8-3 are limited to biodiversity-specific monitoring required to evaluate ecological outcomes, verify the effectiveness of biodiversity mitigation measures, and support adaptive management under the BMP.*

8.7 Total Budget Summary

Table 8-4 presents the total estimated budget for implementation of the BMP. The budget includes only incremental biodiversity-specific mitigation, monitoring, reporting, and adaptive management measures that are additional to those provided under the Project ESMP and the civil works contract.

Table 8-4: Total Estimated Budget for BMP Implementation

Category	Estimated Cost (KES)	Percentage of Total
Biodiversity Mitigation Measures	15,800,000	57.0%

Biodiversity Monitoring Activities	8,300,000	30.0%
Subtotal (excluding contingency)	**24,100,000**	**87.0%**
Contingency (15%)	3,615,000	13.0%
TOTAL BMP BUDGET	**27,715,000**	**100%**

8.8 Budget Notes

Note	Explanation
1	The BMP budget covers only incremental biodiversity-specific mitigation, monitoring, adaptive management, and reporting activities.
2	Environmental mitigation and monitoring measures included in the civil works contract, Contractor's C-ESMP, or Project ESMP are not budgeted again under the BMP.
3	Table 8-1 provides the cross-reference between the BMP and ESMP and identifies the lead implementation instrument, implementing entity, monitoring and reporting route, and budget source for each activity.
4	Monitoring costs cover the construction period and the post-construction operation monitoring period identified in Chapter 10.
5	Annual budget adjustments shall account for inflation and any approved changes arising from adaptive management reviews.

9 Grievance Mechanism

9.1 Overview

This section establishes a formal grievance mechanism to receive, investigate, and resolve complaints related to biodiversity impacts, non-compliance with this BMP, or human-wildlife conflict arising from the project.

The mechanism is available to any affected person or community at no cost. Retaliation against any person using the grievance mechanism is strictly prohibited and shall result in penalties per Chapter 6, Section 6.9.

9.2 Scope of the Grievance Mechanism

The grievance mechanism accepts complaints related to:

Category	Examples
Biodiversity impacts	Unauthorized vegetation clearing, disturbance to wildlife, damage to *Ficus sycomorus* trees, destruction of termite mounds
Non-compliance with BMP	Failure to install silt fences, failure to retain riparian buffers, failure to implement crossing structures
Human-wildlife conflict	Crop raiding, property damage, threat to human safety from wildlife (especially elephants)
Monitoring failures	Failure to conduct required monitoring, failure to report results, failure to respond to threshold exceedances
Dust, noise, or vibration	Impacts on community from construction activities (to the extent they affect biodiversity or human-wildlife interaction)
Grievance process failures	Failure to acknowledge, investigate, or resolve a previously filed grievance

9.3 Grievance Submission Channels

Complainants may submit grievances through any of the following channels:

Channel	Method	Accessibility
Written	Drop box at project site office (Biretwo, Kimwarer, or Chesongoch field office)	Available 24/7; forms provided in English, Swahili, and Kalenjin
Verbal	Community Liaison Officer (CLO) – mobile number to be displayed at all trading centers, site offices, and community notice boards	Available during working hours (8:00 AM – 5:00 PM); voicemail available after hours
Community meeting	Raise grievance during scheduled community engagement meetings (held monthly in each affected sublocation)	Accessible to those who attend meetings
Elected authority	Chief or Ward Administrator (who shall forward to KeNHA within 48 hours)	Accessible to all residents

Third-party representative	NGO, civil society organization, or legal representative acting on behalf of affected person	Available to those who lack literacy or confidence to submit directly

Contact information for CLO (to be confirmed prior to construction):

Field Office	CLO Name	Mobile Number	Languages
Biretwo	To be appointed	TBD	English, Swahili, Kalenjin
Kimwarer	To be appointed	TBD	English, Swahili, Kalenjin, Kipsigis
Chesongoch	To be appointed	TBD	English, Swahili, Kalenjin, Pokot

9.4 Grievance Handling Procedure

The grievance handling procedure consists of five steps:

Step	Title	Description	Responsibility	Timeline
Step 1	Submission	Complainant submits grievance through any channel. Grievance is logged in a numbered register with date, location, complainant details (anonymized if requested), and description.	Complainant or CLO	Day 0
Step 2	Acknowledgment	CLO acknowledges receipt verbally (if in person or by phone) or in writing (if written submission). Complainant receives a reference number for tracking.	CLO	Within 48 hours of submission
Step 3	Preliminary Assessment	CLO and Environmental Specialist visit site, interview complainant, inspect alleged impact. Classify grievance into Level 1, 2, or 3 (see below).	CLO, Environmental Specialist, IEC (for Level 3)	Within 7 days of submission
Step 4	Resolution	Implement resolution appropriate to classification level (see below). Complainant receives written resolution including corrective actions taken.	CLO, Contractor, IEC (as applicable)	Level 1: 14 days; Level 2: 30 days; Level 3: 60 days
Step 5	Closure and Escalation	If complainant accepts resolution, grievance is closed and recorded as resolved. If complainant unsatisfied, they may escalate (see escalation pathway below).	CLO, Complainant	Within 7 days of resolution notification

9.5 Grievance Classification and Resolution

Level	Definition	Examples	Resolution Process	Maximum Timeline
Level 1 (Minor)	Easily resolved at site level; no significant environmental harm; no pattern of repeated complaints	Dust, temporary noise, minor sediment runoff that is immediately corrected, lack of information	CLO and Contractor's Site Manager resolve through informal discussion, apology, or minor corrective action. No formal investigation required.	14 days
Level 2 (Moderate)	Requires documented corrective action; localized environmental harm; potential pattern emerging	Sediment runoff into stream without immediate correction, roadkill hotspot, temporary disturbance to wildlife, failure to conduct required monitoring	CLO, Environmental Specialist, and Contractor develop written Corrective Action Plan. IEC verifies implementation. Complainant notified in writing.	30 days
Level 3 (Major)	Serious non-compliance or harm; violation of law; threat to protected species; human injury from wildlife; repeated Level 2 grievances	Unauthorized clearing of riparian buffer, elephant killed or injured, unauthorized *Ficus* removal, failure to install required crossing structures, human injury from wildlife conflict	Immediately notify KeNHA Project Manager, NEMA, and KWS. Suspend relevant works. Formal investigation by IEC within 7 days. Corrective Action Plan with penalties per Chapter 6, Section 6.7. Resolution report submitted to NEMA and AfDB (upon financing approval).	60 days

9.6 Escalation Pathway

If the complainant is unsatisfied with the resolution, they may escalate as follows:

Level	To Whom	Timeline	Notes
First escalation	KeNHA Environmental & Social Safeguards Unit	Within 30 days of receiving resolution	KeNHA shall review the case and issue a binding determination within 30 days.
Second escalation	National Environment Management Authority (NEMA) Compliance Committee	Within 60 days of KeNHA determination	NEMA has enforcement powers under EMCA 1999, including fines and work stoppage orders.

Third escalation	National Land Commission (for land-related grievances only)	Within 60 days of KeNHA determination	For grievances related to land acquisition, displacement, or property damage.
Fourth escalation (AfDB-financed projects only)	AfDB Independent Recourse Mechanism (IRM)	Upon AfDB financing approval	Complainant may file a complaint with the IRM if they believe the project has violated AfDB Operational Safeguards. The IRM investigates and recommends corrective actions to the Bank.

9.7 Grievance Register and Reporting

The CLO shall maintain a confidential grievance register with the following fields:

Field	Description
Grievance number	Sequential number (e.g., GR-2026-001)
Date received	Day, month, year
Complainant name	(Anonymized if requested)
Contact information	Phone number, address, or village
Channel of submission	Drop box, CLO, community meeting, chief, third party
Description of grievance	Summary in complainant's own words
Location	Chainage, sublocation, or landmark
Classification	Level 1, 2, or 3
Assigned to	CLO, Environmental Specialist, IEC, KeNHA
Resolution date	Day, month, year
Resolution summary	Description of corrective actions taken
Complainant satisfaction	Yes / No (if No, record escalation)
Escalation status	None, KeNHA, NEMA, NLC, AfDB IRM

Reporting requirements:

Report	Frequency	Submitted To	Content
Grievance log (anonymized)	Quarterly	KeNHA, NEMA, County Government	Summary table of all grievances received, classified by level, status (open/resolved/escalated), and resolution outcomes
Grievance log (full, confidential)	Upon request	KeNHA Environmental & Social Safeguards Unit, AfDB (upon financing approval)	Full register with complainant names (protected from disclosure to Contractor)

9.8 Non-Retaliation Commitment

KeNHA and the Contractor commit to zero tolerance for retaliation against any person who submits a grievance in good faith. Retaliation includes:

Prohibited Act	Examples
Intimidation	Threats, harassment, surveillance
Discrimination	Denial of employment, eviction, loss of benefits
Physical harm	Assault, destruction of property

Legal action	Frivolous lawsuits intended to punish complainant

Any Contractor employee found to have engaged in retaliation shall be dismissed immediately and reported to NEMA for prosecution under EMCA 1999.

10 Implementation Schedule

This section presents the implementation schedule for the biodiversity-specific mitigation, monitoring, reporting, and adaptive management activities included in the BMP. The schedule is organised according to the project lifecycle, comprising the pre-construction, construction, post-construction, and operation phases.

The implementation schedule complements the Project Environmental and Social Management Plan (ESMP). Routine environmental mitigation and monitoring measures implemented through the ESMP and the Contractor's Environmental and Social Management Plan (C-ESMP) are not repeated in this chapter unless they include additional biodiversity-specific requirements.

The implementation schedule is binding on all entities responsible for implementing the BMP, including the Contractor during construction and KeNHA during operation. Activities involving other institutions, including the Kenya Wildlife Service (KWS), County Government of Elgeyo Marakwet and the Independent Environmental Consultant (IEC), shall be undertaken in accordance with their respective mandates. Any delay in critical activities exceeding 14 days shall be reported to the Supervising Engineer, IEC and KeNHA Project Manager together with a corrective action plan.

10.1 Schedule Assumptions

Assumption	Value
Pre-construction phase	Months -3 to 0 (3 months prior to construction start)
Construction Phase 1	Months 1–8 (earthworks, drainage, slope stabilization)
Construction Phase 2	Months 9–16 (paving, signage, crossing structures, finishing)
Post-construction	Months 17–24 (one year after construction completion)
Operation	Years 2–5 (monitoring continues at reduced frequency)
Total project duration (including operation monitoring)	5 years from construction start

Implementation responsibilities for each activity are presented in Table 10-1, while the corresponding financing arrangements are provided in Chapter 8.

10.2 Implementation Schedule Matrix

The implementation schedule below identifies the timing and institutional responsibilities for implementing the biodiversity-specific mitigation, monitoring, and adaptive management measures contained in this BMP. Activities that form part of routine environmental management under the Project ESMP and the Contractor's Environmental and Social Management Plan (C-ESMP) are not repeated unless they include additional biodiversity-specific requirements.

Table 10-1: Implementation Schedule for Biodiversity Management Plan Activities

Activity	Related BMP Measure	Related Monitoring Indicator	Responsible Entity	Pre-construction (Months -3 to 0)	Construction Phase 1 (Months 1–8)	Construction Phase 2 (Months 9–16)	Post-construction (Months 17–24)	Operation (Years 2–5)
Demarcate environmentally sensitive areas, root protection zones and wildlife crossing locations	M-BC-01, M-BC-02	MON-BC-VEG-01	Contractor / Supervising Engineer	X				
Conduct baseline biodiversity monitoring	All Chapter 7 indicators	All MON Codes	Contractor / IEC	X				
Conduct biodiversity induction training for Contractor personnel	M-CC-04	Training records	Contractor	X				
Conduct biodiversity refresher training	M-CC-04	Training records	Contractor		X	X		
Establish Human–Wildlife Conflict (HWC) coordination mechanism and community awareness programme	M-CC-01, M-CC-02	MON-BC-HWC-04	KeNHA / KWS / County Government	X	X			
Construct and verify biodiversity	M-BC-02, M-NK-02, M-KE-01	MON-BC-ELE-03,	Contractor / Supervising Engineer			X		

functionality of wildlife crossing structures		MON-NK-WILD-10						
Install wildlife warning signage, rumble strips and biodiversity-specific traffic calming measures in identified high-risk sections	M-BC-13, M-NK-07	MON-NK-RKILL-09	Contractor (construction); KeNHA (operation)			**X**		
Implement habitat restoration using indigenous species in ecologically sensitive areas	M-BC-12, M-KE-06	MON-BC-VEG-01, MON-KE-RIP-15	Contractor		**X**	**X**	**X**	
Construct rock refugia for reptiles in escarpment sections	M-BC-04	Reptile monitoring	Contractor		**X**	**X**	**X**	
Protect keystone species and ecologically important trees (e.g., *Ficus* spp.)	M-KE-06	MON-BC-FIG-05	Contractor		**X**	**X**	**X**	
Protect and relocate termite mounds where necessary	M-CC-03	MON-BC-SOIL-06	Contractor	**X**	**X**			
Implement invasive alien species control programme	M-BC-11	Invasive species monitoring	Contractor / KeNHA			**X**	**X**	**X**
Operationalize Human–Wildlife Conflict Early Warning System	M-CC-01	MON-BC-HWC-04	KeNHA / KWS			**X**	**X**	**X**
Conduct biodiversity monitoring during construction	All Chapter 7 indicators	All MON Codes	Contractor / IEC		**X**	**X**		
Conduct habitat restoration	M-BC-12, M-KE-06	MON-BC-VEG-01	KeNHA				**X**	

performance monitoring								
Conduct weekly roadkill surveys for the first 12 months of operation and implement adaptive mitigation where hotspots are identified	M-BC-13	MON-NK-RKILL-09	KeNHA / KWS				**X**	
Conduct quarterly biodiversity monitoring during operation (wildlife movement, habitat condition, invasive species, keystone species and wetlands)	All Chapter 7 indicators	All MON Codes	KeNHA / KWS / IEC					**X**
Conduct quarterly adaptive management reviews	Adaptive Management Framework	All MON Codes	KeNHA / IEC / KWS		**X**	**X**	**X**	**X**
Prepare annual BMP implementation reports and review effectiveness of mitigation measures	Adaptive Management Framework	All MON Codes	KeNHA Environment Unit				**X**	**X**
Prepare Final BMP Completion Report	All BMP Chapters	All MON Codes	KeNHA / IEC					**X**

10.3 Critical Path Activities

The following activities are on the critical path for BMP compliance. Delay in these activities may result in suspension of related construction works:

Activity	Deadline	Consequence of Delay
Demarcation of road reserve and root protection zones	Before any clearing	No clearing permitted until demarcation complete.
Pre-construction baseline monitoring	Before construction start	No construction permitted until baseline established.
Install silt fences and sediment basins	Before in-stream works	Stop-work order for drainage crossings.
Construct elephant culverts	Before road paving in those sections	Paving delayed until culverts installed.
HWC early warning system	Before peak elephant dispersal season (May–July)	Enhanced speed limits and night-time traffic restrictions imposed.

Binding Statement

Failure to allocate budgeted funds, adhere to the implementation schedule, or properly administer the grievance mechanism constitutes non-compliance with this BMP. Penalties shall be applied as defined in Chapter 6, Section 6.9. The IEC has the authority to verify budget expenditure, monitor schedule adherence, and investigate grievances without prior approval from the Contractor.

11 Conclusion and Recommendation

11.1 Conclusion

11.1.1 Summary of Findings

The ecological assessment of the proposed road upgrading across the Biretwo–Arror–Chesongoch, Nyaru–Kimwarer–Kapkayo, and Kimwarer–Emsea corridors demonstrates that these landscapes are defined by strong spatial variability in topography, drainage systems, soil properties, climate, and land use. This variability underpins biodiversity patterns and ecosystem processes, making the landscape highly sensitive to physical modification.

The key findings of the assessment are:

Finding	Description
Indirect impacts dominate	While direct impacts such as vegetation clearance and habitat disturbance are important, the most significant ecological risks arise from indirect changes to hydrology, slope stability, soil moisture, and microclimatic conditions.
Impacts are spatially concentrated	Ecological impacts are not uniform along the road corridors but are concentrated in specific chainage sections where multiple vulnerability factors coincide: steep escarpment slopes, large drainage catchments, clay-rich soils, high rainfall zones, and areas of ecological importance such as riparian habitats and wildlife movement corridors.
Keystone species are vulnerable	*Ficus sycomorus* (keystone fig tree) and termite mounds (ecosystem engineers) are disproportionately important to ecosystem function and are highly vulnerable to indirect impacts from drainage alteration and soil disturbance.
Elephant corridors require protection	The Biretwo–Chesongoch section forms part of a seasonal elephant dispersal landscape from Rimoi National Reserve. Four high-risk chainage sections (13+000–17+000, 21+000–24+000, 37+000–40+000, 49+000–51+000) require targeted mitigation.
Human-wildlife conflict is seasonal	Conflict is concentrated in the same four chainage sections during the May–July rainy season when elephants move through cultivated areas on well-drained terrain.
Wetlands require special design	The Kimwarer–Emsea section traverses valley-bottom wetlands and floodplains that require bridge preference over culverts and preservation of hydrological connectivity.

11.1.2 Summary of Mitigation Approach

The BMP adopts a mitigation hierarchy (avoid → minimize → restore → offset) applied at spatially explicit chainage locations. The key mitigation elements are:

Element	Reference	Summary
Escarpment slope stabilization	M-BC-01 to M-BC-05	Demarcation, bioengineering, rock refugia, phased construction
Riparian and drainage protection	M-BC-06 to M-BC-10	Buffer retention, fauna-friendly culverts, sediment control, seasonal restrictions
Elephant corridor protection	M-BC-02, M-NK-02	Traffic calming, no permanent lighting
Human-wildlife conflict reduction	M-CC-01, M-CC-02	Early warning system, land-use advisory, starter packs for alternative crops
Keystone species protection	M-KE-06, M-CC-03	*Ficus* root protection zones, termite mound protection zones
Wetland and floodplain protection	M-KE-01 to M-KE-04	Bridge preference, flood-relief culverts, strict sediment control, breeding site protection

11.1.3 Summary of Monitoring and Adaptive Management Framework

The BMP establishes a legally binding monitoring and adaptive management framework to verify compliance and trigger corrective actions. The key monitoring elements are:

Element	Summary
Monitoring indicators	18 indicators across three road sections with chainage-specific locations
Thresholds and triggers	Green/Amber/Red thresholds with mandatory corrective actions for Red
Adaptive management protocol	Five-step decision protocol: monitor → evaluate → decide → verify → review
Reporting requirements	Monthly, quarterly, annual, and event-based reports to KeNHA, NEMA, KWS, WRA, AfDB

11.1.4 Summary of Enabling Framework

The BMP establishes the financial, procedural, and temporal resources required for implementation:

Element	Summary
Costed budget	Total BMP budget: KES 124,315,000 (excluding base construction)
Grievance mechanism	Five-step process with escalation to KeNHA, NEMA, and AfDB IRM
Implementation schedule	Activity matrix across pre-construction, construction, post-construction, and operation phases

11.1.5 Conclusion

The proposed road upgrading can be implemented in an environmentally sustainable manner provided that:

1. **Mitigation measures** (Chapter 6) are implemented as specified, with no deviation from mandatory actions, performance standards, and cost codes.
2. **Monitoring** (Chapter 7) is conducted at the required frequencies, with thresholds enforced and corrective actions triggered automatically.
3. **Enabling resources** (Chapter 8) are allocated in full, including the budget of KES 124,315,000, the grievance mechanism, and adherence to the implementation schedule.
4. **Adaptive management** is applied through the five-step protocol, with annual reviews and BMP amendments as needed.
5. **Stakeholder engagement** is maintained through the grievance mechanism, early warning system, and land-use advisory workshops.

The success of the project will depend on maintaining ecological processes, preserving habitat connectivity, and applying adaptive management to respond to emerging environmental challenges. The BMP provides the legal, technical, financial, and procedural framework to achieve this balance between infrastructure development and biodiversity conservation.

11.2 Recommendations

11.2.1 Overview

This section presents general recommendations for the BMP. These recommendations are based on the findings of the ecological assessment and the structure of the mitigation, monitoring, and enabling frameworks. They are intended to guide decision-making and highlight priority actions, without prescribing specific instructions to individual actors.

11.2.2 Integration of Ecological Considerations into Project Design and Planning

The assessment demonstrates that ecological impacts are not uniform along the road corridors but are concentrated in specific chainage sections where steep slopes, large drainage catchments, clay-rich soils, high rainfall, and ecological sensitivity coincide. Therefore, a spatially explicit approach to environmental management should be maintained throughout all phases of the project.

Drainage design should be treated as the most critical environmental factor, particularly in sections characterised by steep slopes, high rainfall, and large contributing catchments. Cross-drainage structures should be appropriately sized and located to maintain natural flow regimes and prevent concentration of runoff. In escarpment areas, slope stabilisation measures should integrate engineering and bioengineering approaches to reduce erosion and prevent mass wasting while maintaining habitat value.

Road alignment and design should, where feasible, avoid the most sensitive ecological features identified in this assessment, including the four high-risk elephant dispersal zones (13+000–17+000, 21+000–24+000, 37+000–40+000, 49+000–51+000), mapped riparian buffers, and wetland areas in the Kimwarer–Emsea section.

11.2.3 Protection of Sensitive Habitats and Keystone Species

Riparian corridors and wetlands should be prioritised for protection, as these areas play a critical role in maintaining hydrological integrity and supporting biodiversity. Vegetation buffers should be retained along all streams and drainage lines, and disturbance within these zones should be minimised. Where disturbance is unavoidable, restoration should focus on native riparian species to enhance ecological resilience.

Ficus sycomorus trees, which function as keystone species supporting birds, mammals, and invertebrates, should be protected through the establishment of root protection zones extending beyond the canopy dripline. Hydrological regimes that sustain these trees should be maintained, and where trees are lost, compensatory planting in suitable moisture-retaining microhabitats should be undertaken.

Termite mounds, which function as ecosystem engineers regulating soil structure, water infiltration, and nutrient cycling, should be protected from soil compaction and altered drainage. Areas with high termite mound density, which coincide with elephant dispersal zones, should be treated as ecologically sensitive and avoided for construction camps and material storage.

11.2.4 Maintenance of Wildlife Connectivity

The Biretwo–Chesongoch section forms part of a seasonal elephant dispersal landscape from Rimoi National Reserve. Maintaining functional connectivity across the road corridor is essential. Wildlife crossing structures, including oversized culverts and open-span bridges, should be aligned with natural movement pathways and drainage lines. Traffic calming measures, including rumble strips and wildlife warning signage, should be installed in identified crossing zones.

Permanent road lighting should be avoided within elephant crossing zones, as continuous illumination can deter wildlife from using crossing structures. Where lighting is required for safety, motion-sensor, downward-directed fixtures should be used to minimise light spill.

Guiding structures, such as low fencing or earth berms, may be used strategically to direct wildlife toward designated crossing points. However, continuous fencing that would fragment habitat or restrict broader landscape connectivity should be avoided.

11.2.5 Reduction of Human-Wildlife Conflict

Human-wildlife conflict along the Biretwo–Chesongoch corridor is concentrated in the same four chainage sections where elephant dispersal routes intersect cultivated land. Conflict risk can be reduced through land-use planning that discourages cultivation of highly palatable crops (such as maize) within approximately 200 metres of known elephant crossing approaches. Alternative cropping systems, including less palatable crops or buffer plantings, should be promoted in these zones.

Community-based early warning systems should be established to provide timely information on elephant presence, enabling farmers to take preventive action. These systems should be aligned with the seasonal movement patterns of elephants, which peak during the May–July long rains.

Coordination among wildlife authorities, local government, and communities should be strengthened to ensure rapid response to conflict incidents and to maintain trust between stakeholders.

11.2.6 Soil and Water Management

Soil management should be tailored to local conditions, with particular attention given to clay-rich and erosion-prone soils. Measures to reduce compaction, enhance drainage, and stabilise exposed surfaces should be implemented to maintain soil structure and prevent degradation. Topsoil should be conserved and reused during rehabilitation to support vegetation recovery and soil biological activity.

Sediment control measures, including silt fences, sediment basins, and check dams, should be implemented at all drainage crossings before any in-stream work begins. These measures should be inspected regularly, particularly during rainfall events, and maintained or upgraded as needed to prevent sedimentation of water bodies.

Drainage systems should be designed to disperse runoff across the landscape rather than concentrate it at single discharge points. This approach reduces gully formation, limits downslope erosion, and maintains natural infiltration patterns that support riparian and wetland vegetation.

11.2.7 Construction Practices

Construction activities should be managed to minimise ecological disturbance. Phased construction should be adopted to avoid continuous disturbance along long stretches of the road, allowing wildlife to move through undisturbed areas and reducing cumulative impacts.

Construction camps, material storage areas, and borrow pits should be located away from ecologically sensitive habitats, including riparian zones, wetlands, elephant corridors, and areas with high termite mound density or mature *Ficus sycomorus* trees. These areas should be rehabilitated promptly after use.

Night-time construction should be minimised in ecologically sensitive areas, particularly during peak wildlife movement periods, to reduce stress on nocturnal species and maintain natural behavioural patterns.

All construction personnel should receive training on biodiversity protection, including the identification of protected species, prohibitions on hunting and collecting, and procedures for encountering wildlife. Training should be refreshed periodically throughout the construction period.

11.2.8 Monitoring and Adaptive Management

A robust monitoring and adaptive management framework should be established to track ecological changes over time. Monitoring should include both species-based indicators and ecosystem-level metrics, allowing for early detection of impacts and timely implementation of corrective measures.

Quantitative thresholds should be used to distinguish acceptable performance from conditions requiring corrective action. When thresholds are exceeded, pre-defined corrective actions should be triggered without delay. Monitoring results should be reported regularly to all relevant stakeholders, including regulatory authorities and affected communities.

The monitoring framework should be reviewed annually, and thresholds or mitigation measures should be adjusted based on new ecological data. Any amendments to the BMP should be submitted to the relevant regulatory authorities for approval.

11.2.9 Financial and Institutional Sustainability

Adequate financial resources should be allocated to implement all mitigation and monitoring measures specified in the BMP. The budget should be ring-fenced from other project costs to ensure that environmental measures are not compromised by cost overruns elsewhere.

The BMP should be appended to the construction contract, making it legally binding on all parties. Clear roles and responsibilities should be defined for implementation, verification, and enforcement.

Coordination among implementing agencies (KeNHA), regulatory authorities (NEMA, KWS, WRA), local government (County Government of Elgeyo Marakwet), and affected communities should be maintained throughout the project lifecycle. Regular review meetings should be held to discuss monitoring results, address grievances, and adapt management as needed.

A grievance mechanism should be maintained to receive, investigate, and resolve complaints related to biodiversity impacts, non-compliance, or human-wildlife conflict. The mechanism should be accessible to all affected persons at no cost, and retaliation against complainants should be prohibited.

11.2.10 Long-Term Outlook

The proposed road upgrading can be implemented in an environmentally sustainable manner provided that the mitigation, monitoring, and enabling measures in this BMP are fully implemented. The success of the project will depend on maintaining ecological processes, preserving habitat connectivity, and applying adaptive management to respond to emerging environmental challenges.

Investment in biodiversity protection should be viewed not as a cost but as an investment in long-term sustainability. The ecological systems traversed by the road provide essential services—water regulation, soil fertility, pollination, and wildlife habitat—that support local livelihoods and national heritage. Protecting these systems ensures that the benefits of road development are not undermined by environmental degradation.

The BMP should serve as a model for future road projects in ecologically sensitive landscapes. Lessons learned from implementation, monitoring, and adaptive management should be documented and shared to improve environmental outcomes across Kenya's infrastructure sector.