Blantyre-Mulanje Watershed Investment Programme

Feasibility Study Report

July 2025

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List of Acronyms

AIP	Alien invasive plant
BaU	Business as Usual
BCR	Benefit-Cost Ratio
BMPs	Best Management Practices
BWB	Blantyre Water Board
CBA	Cost-benefit Analysis
DEM	Digital Elevation Model
DFI	Development Finance Institutions
GDP	Gross Domestic Product
GIS	Geospatial Information Systems
Ha	Hectares
HRU	Hydrologic response unit
HA	Hectare
IC	Index of Connectivity
ICF	International Crane Foundation
IRR	Internal Rate of Return
LOE	Level of Effort
LULC	Land Use Land Cover
MCDA	Multi-criteria Decision Analysis
MoE	Ministry of Energy
MRV	Monitoring, Reporting and Verification
MWR	Ministry of Water Resources
MWS	Ministry of Water and Sanitation
MWK	Malawian Kwacha
NbE	Nature-based Enterprises
NbS	Nature-based Solutions
NDVI	Normalized Difference Vegetation Indices
NGO	Non-governmental organisation
NPV	Net Present Value
NWRA	National Water Resource Authority
PMU	Project Management Unit
PV	Present Value
ROI	Return on Investment
RUSLE	Revised Universal Soil Loss Equation
SDR	Sediment Delivery Ratio

SRWB	Southern Region Water Board
SWAT	Soil Water Assessment Tool
SY	Sediment yield
TNC	The Nature Conservancy
USD	United States Dollar
CIP	Catchment Investment Program
WRM	Water Resources Management (Act)
WSP	Water Service Provider
WUA	Water Users Association

Executive Summary

Project Overview

The Mudi-Ndirande sub-catchment in Blantyre and the Likhubula sub-catchment in Mulanje are two strategic water source areas contributing cumulatively, up to 25% of Blantyre's water supply. Both catchments are subject to ongoing degradation, threatening water resources, community livelihoods and, in Likhubula specifically, biodiversity and species endemicity. Water for People (WFP), with indirect support from Blantyre Water Board (BWB) and Mulanje Mountain Conservation Trust (MMCT) is working to understand how Nature-based Solutions (NbS) can contribute to long-term water security while maximising benefits and outcomes for society at large, local communities, the national and local economy and the environment.

NbS are actions to protect, sustainably manage and restore natural or modified ecosystems that address water security challenges effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits (Trémolet et al. 2019).

Effective implementation of NbS requires a sustainable mechanism for collective action that brings together different water users to invest in ecosystem protection and upstream communities within the catchments they depend on. A Catchment Investment Programme (CIP) – alternatively known as a Watershed Investment Programme (WIP) in other parts of the world – is an initiative designed to deliver long-term water security and ecosystem services by investing in the protection and/or restoration of nature through the implementation of NbS.

The overarching **objectives of the feasibility study** are two-fold, namely:

1. To assess the feasibility of NbS to address water security challenges (WSC) in Mudi-Ndirande and Likhubula sub-catchments.
2. Conceptualise sustainable mechanisms and potential gaps to address that would enable the funding and implementation of NbS at scale through a Catchment Investment Programme.

This report forms the final product of the Feasibility Study and contains:

- An overview of both catchments' contexts, the associated challenges in each catchment and the specific socio-economic, governance and environmental considerations in Malawi as a whole.
- A detailed assessment of the institutions, stakeholders and beneficiaries within the landscape, to ascertain their understanding of the key water security challenges as well as their potential commitment to supporting NbS implementation through a coordinated CIP mechanism.
- Rigorous scientific modelling to determine the most suitable NbS to address the water security challenges in both catchments.
- A Return on Investment (RoI) analysis that compares the costs and benefits of implementing and maintaining NbS in both catchments.
- A high-level assessment of opportunities for collaboration, potential funding avenues and viable delivery models for NbS interventions that could yield long-term water security through a scaled approach.
- Lastly, this report consolidates key findings and proposes next steps for further investigation and implementation of NbS that would maintain the momentum behind the establishment of a CIP and address water security challenges in source water catchments in Malawi.

The Mudi-Ndirande and Likhubula Sub-catchments

Mudi-Ndirande:

The Mudi Dam, constructed in 1953 with a capacity of 1.4 million cubic meters, is strategically positioned on the eastern edge of the greater Shire River catchment on the outskirts of Blantyre City. This water source is fed by streams that originate in the southern tip of the Ndirande Hills and forest reserve. Despite its critical location as the closest, most economical, and readily available water source for Blantyre, the Mudi-Ndirande catchment (shown on the left of Figure 1 below) faces severe environmental degradation. The forest reserve has been almost completely deforested due to multiple pressures: high demand for charcoal and timber for fuel, agricultural expansion, and urban development. This deforestation has significantly compromised the catchment's ability to function effectively.

Likhubula:

The Likhubula River originates on the western slopes of Mulanje Mountain in Southern Malawi, formed by the convergence of three primary streams and numerous smaller tributaries flowing downhill. After taking shape, the river flows southward through Chitakale before merging with the Lichenya River, which originates from the southern part of Mulanje Mountain. Together, these waters join the Ruo River, continuing southward into Mozambique before ultimately reaching the Indian Ocean. This vital water system serves as a critical resource for diverse stakeholders. Although the water resource only provides approximately 10% of Blantyre's water supply, it provides water to over 300,000 people beyond the district borders (Blantyre Water Board, 2020) and approximately 25,000 residents within Mulanje District itself (Southern Region Water Board, Mulanje Office 2023). The river supports essential domestic, agricultural, and industrial uses, functioning as a lifeline for communities both within and beyond the immediate region. The Likhubula catchment (shown on the right of Figure 1 below) is constrained by irregular rainfall patterns and unsustainable land use practices, including forest conversion to agriculture and deforestation for charcoal production, which leads to increasing soil erosion within the catchment and sediment load entering into the Likhubula River.

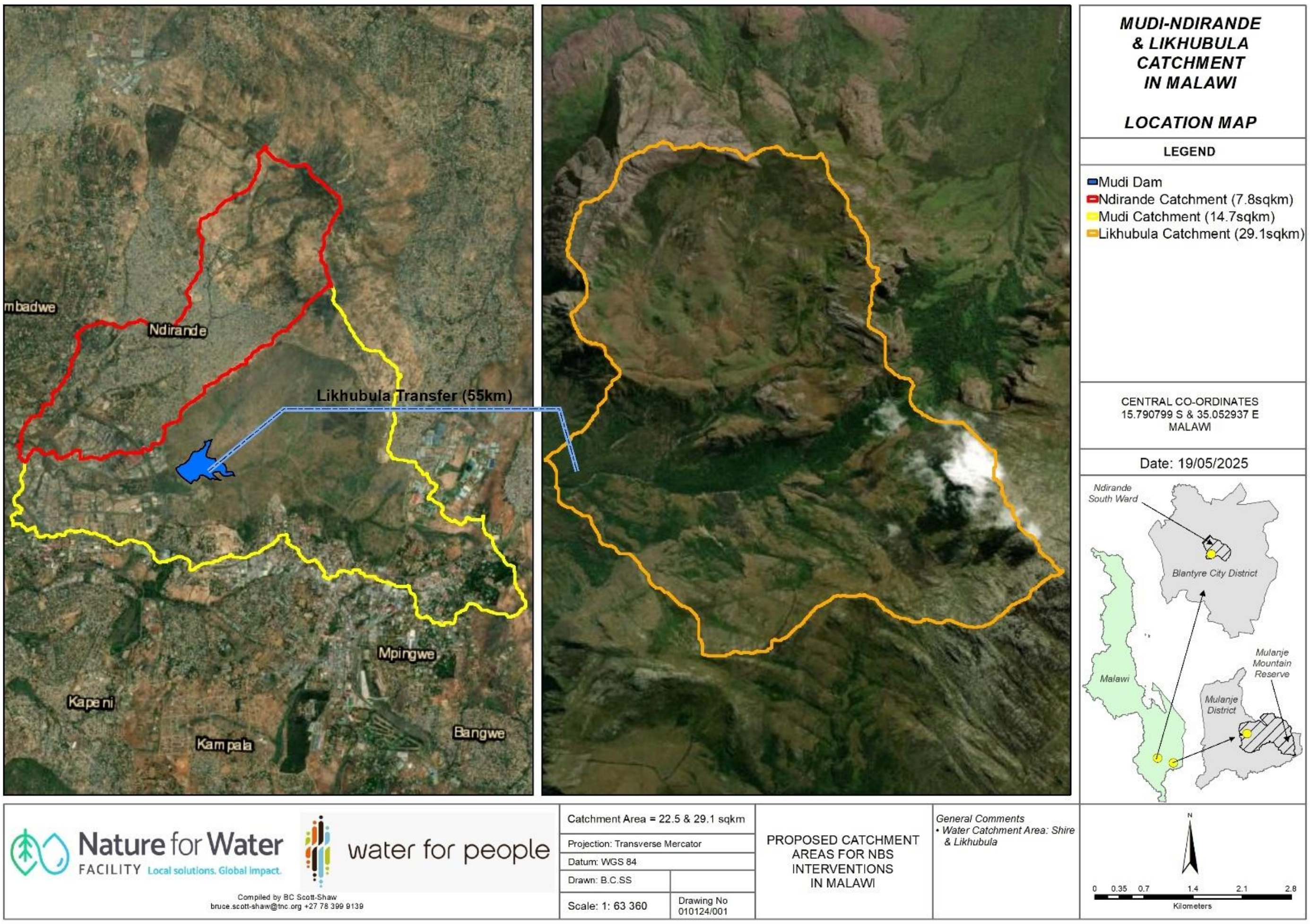


Figure 1: The Mudi-Ndirande (left) and Likhubula (right) sub-catchments (study area)

Priority Nature-based Solutions to address the water security challenge

Four priority NbS were identified to address water quantity and quality challenges alongside promoting sustainable livelihood opportunities that reinforce community uptake and engagement with NbS implementation and maintenance:

Rangeland best management practices, in this case, encompass three interventions (live firebreak maintenance, invasive alien plant clearing and training on regenerative practices) that focus on restoring rangeland or grassland to their natural state. These interventions aim to protect the natural landscape from both environmental/climatic threats as well as anthropogenic threats.

Agricultural Best management practices including **terracing and cover cropping** to reduce soil loss and enhance growing conditions for plants and crops.

Reforestation, which focuses on the planting of indigenous tree species to assist in restoring the catchment to its original state**.** Indigenous species have a lower water demand and support biodiversity in the catchments.

Nature-based enterprises to support catchment management activities (which are aligned to regenerative practices). These enterprises, that for this study include tree nurseries and bee-keeping, aim to create economic opportunities for local economies where communities generate an income through involvement in the provision of materials and services for a CIP.

The science analysis identified key hydrological benefits, with the overall water yield being increased through the interventions. Of importance, **the baseflow could be improved by 40% in the Mudi catchment and 52 % in the Likhubula catchment.** This would significantly improve the water levels in Mudi dam and the supplementary supply by the Likhubula transfer. Due to increased cover and attenuated flow in the catchment, a significant reduction in sediment loads could also be achieved.

The comparative differences between the scenarios showed that the **Mudi catchment would experience a 4% reduction in water loss during the drought period**. Similarly, the **Likhubula catchment would experience a 3.5% reduction in water loss during the drought period.** Through a Catchment Investment Programme (CIP), the following benefits could be achieved after full implementation (abstractable yield-not total flow increase):

- **Mudi Dam could increase its yield by 4.6 million ℓ/day** through increased inflow and avoided storage loss.
- **Mudi Dam lifespan would be increased to beyond 2050**.
- **Likhubula offtake could increase its yield by 6.01 million ℓ/day.**

The increasing frequency and severity of tropical cyclones and extended droughts, attributed to the broader impacts of climate change emphasises the need for NbS to provide long-term benefits that are effective in climate adaptation.

The Investment Case

The Feasibility Study assessed the financial and economic viability of a Catchment Investment Programme through the implementation of NbS.

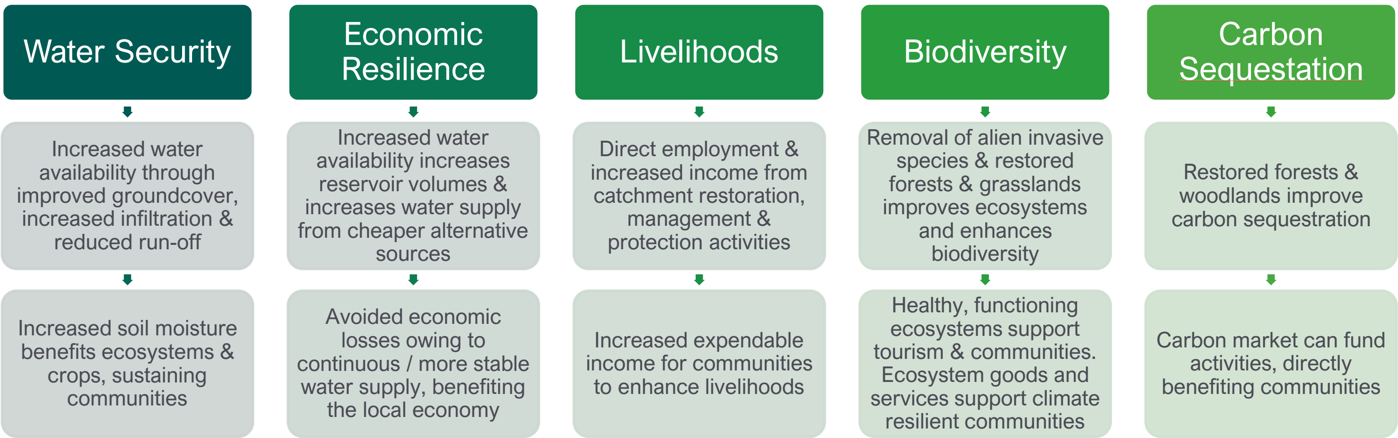


Figure 2: Benefit evaluation framework

The overarching benefits (summarised in Figure 2 above) that arise from the implementation of NbS include water security, economic resilience, livelihoods, biodiversity and carbon sequestration. However, not all benefits are easy to quantify, e.g. increased resilience to drought, improved crop productivity, improved livelihoods, healthy ecosystems, avoided economic losses as a result of continuous / more stable power supply, biodiversity, etc. Therefore, this study quantified six key benefits using the outputs of the scientific modelling, applied data and assumptions from desktop research, stakeholder engagements and direct engagements with beneficiaries to conduct an economic analysis for a 30-year programme. The high-level results of this analysis are shown in Table 1 below.

Table 1: Results of economic analysis showing total benefits over 30 years

Benefit description	Present value (USD thousands)
Alternative Water Supply	1,282
Water treatment cost savings	206
Extension of dam lifespan	140
Employment	248
Bee-keeping	517
Carbon	142
Total Present Value of Benefits (incl. carbon)	**2, 535**
Total Present Value of Benefits (excl. carbon)	**2,392**

To determine the financial feasibility of the CIP, the NbS benefits were offset against the associated costs, including both programmatic (i.e. implementation costs) and non-programmatic (i.e. operational and management costs). The value of future flows of benefits and costs is determined in present terms. As the impact of NbS interventions take time to be realised and the realisation of benefits are delayed.

The present values for each intervention and the benefits to each beneficiary across the entire implementation area of the CIP are presented in Figure 3.

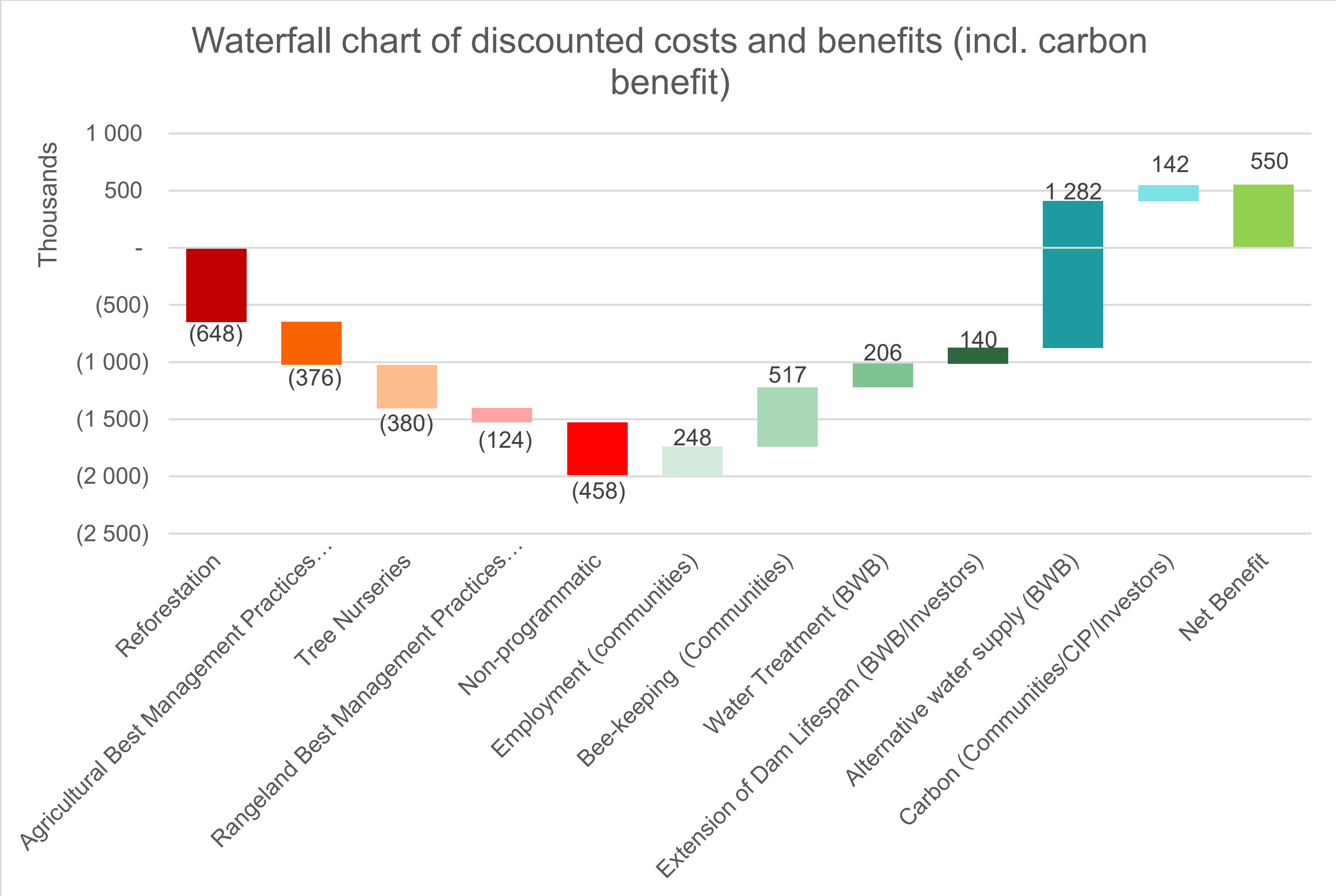


Figure 3: Waterfall chart showing discounted costs compared to benefits including the CIP Net Present Value (benefit).

Where the carbon benefit is included there is a positive NPV of **USD 550 thousand**. The BCR indicates that **for every USD 1 invested there will be a return of USD 1.3**. The internal rate of return is **2.29%.**

Where the carbon benefit is excluded there is a positive NPV of **USD 407 thousand**. The BCR indicates that **for every USD 1 invested there will be a return of USD 1.2**. The internal rate of return is **2.18%.**

The economic analysis provides positive results for the CIP and the metrics indicate:

- Positive returns under both carbon benefit scenarios
- Multiple co-benefits that enhance resilience and sustainability
- Long-term value creation that exceeds initial investment costs
- Risk mitigation through diversified benefit streams

While the carbon benefit significantly enhances project economics, the analysis demonstrates that the core NbS interventions are economically sound even without carbon monetisation.

However when critically evaluating the results, although the assessment is positive, the return is smaller than what is typically expected when conducting feasibility studies in larger catchment areas compared to Likhubula and Mudi-Ndirande sub-catchments. Adopting a scalable approach to a CIP model that can include surrounding sub-catchments and other priority water source catchments in Malawi could result in both an increase in the value of benefits and a decrease in costs through economies of scale (in particular this could greatly improve the investment case for carbon monetisation). A scalable approach would, therefore, provide a stronger investment case and likely attract more opportunities for long-term sustainable funding for NbS in Mudi-Ndirande and Malawi as a whole.

Feasibility Study Outcomes

This Feasibility Study demonstrates that NbS provide a host of direct and co-benefits to various stakeholder groups. Importantly this study shows that appropriate NbS interventions could have a significant impact in addressing water security challenges in the Mudi and Likhubula catchments. However, due to the scale of these two sub-catchments, the findings suggest that long-term financial sustainability of a CIP model depends on a strategy that could scale to priority water catchments throughout the country. This would allow for greater economies of scale both in terms of reducing costs and, importantly, unlocking funding mechanisms that could sustain long-term restoration and protection of critical landscapes that support fresh water availability and quality. The adoption of a CIP model that can scale to larger and greater numbers of catchments across Malawi could allow for greater coordination of local funding that goes toward reforestation, catchment management and livelihood programmes whilst creating sufficient project portfolios that could access international carbon funding markets and other international climate-related funding mechanisms.

While this study shows positive water security and livelihood outcomes from the implementation of NbS in Mudi-Ndirande and Likhubula, it is recommended that **further study to assess the feasibility and/or design of a CIP (or CIPs in other areas of Malawi) critically assess the potential opportunities for scaling interventions and benefits as part of an overarching strategy that can coordinate international and national funding sources and intermediaries**. Moreover, it is rather recommended that:

1. Existing catchment management-related activities leverage the momentum gathered through this project to continue to coordinate local and national stakeholders around shared objectives for landscape restoration and water security.
2. The findings of this study are used to develop a case for National Government stakeholders to leverage national initiatives and pursue international funding opportunities to ensure the safeguarding of water security through landscape restoration/protection in priority source water catchments where there is strong local leadership and coordinated stakeholders (such as Likhubula and Mudi-Ndirande).
3. Collaboration with the World Bank on the development of payment for ecosystem services frameworks and refurbishment of the Mudi dam is critical and offers the opportunity for further collective action to implement and maintain NbS for catchment restoration.

Next Steps

Following on from the positive Feasibility Study findings, a set of next step activities has been developed to outline and guide the next steps towards establishing a CIP. This section outlines key follow-on activities across three strategic areas, namely 1) Local implementation, 2) Scaling and replication and 3)Governance development.

Strategic Area 1: Local Implementation

Activity	Continued efforts in the local sub-catchments (Mudi and Likhubula).
Steps	Continued stakeholder engagement and coordination of NbS activities leveraging the momentum gained through the project and noting the benefits that are demonstrated through this study to encourage collective action across stakeholders.

Activity	Ongoing engagements across the multiple workstreams to ensure that stakeholders are consulted, are able to provide valuable input and that the Steering Committee plays a central role in moving the CIP forward.
Steps	• Detailed engagements with communities to test delivery models, implementation partners, key governments (local, district and national levels) as the CIP is developed. • Support and guide the Steering Committee as the vehicle that will drive the creation of the CIP. • Continue to build and foster relationships within the catchment.

Strategic Area 2: Scaling and Replication

Activity	Ensure that other pre-feasibility and/or feasibility studies for CIPs in other source water catchments of Malawi assess the scalability and potential linkages with other catchments in Malawi in order to strengthen national-level strategy for carbon and other foreign funding mechanisms.
Steps	• N4W and SRWB are undertaking a pre-feasibility study in Mulunguzi catchment, Zomba. As part of this study, the team will seek to build upon the key recommendations of this study and further assess opportunities for scalable benefits and funding sources. • Support national stakeholders in maintaining ongoing dialogue around the importance of scale as a means to secure funding opportunities to address landscape challenges that are driven by systemic challenges.

Activity	Confirm funding and financing opportunities where alignment has already been identified.
Steps	• Continue to engage with the project teams developing World Bank projects (Water resources and Payment for Ecosystem Services) • Engage other funders using supportive materials • Leverage national level initiatives (national carbon trading framework supported by UNDP and the Climate Promise initiative)

Strategic Area 3: Governance development

Activity	Ensure continued Steering Committee Meetings.
Steps	• Coordinate key stakeholders and decision-makers to identify opportunities for catchment restoration and the use of NbS • Guide the focus on critical matters and areas where NbS can have significant impact and support with scaling of activities.

1 Introduction

The Mudi-Ndirande sub-catchment in Blantyre and the Likhubula sub-catchment in Mulanje are two strategic water source areas contributing cumulatively, up to 25% of Blantyre's water supply. Both catchments are subject to ongoing degradation threatening the water resources, livelihoods of communities and, in Likhubula in particular, the biodiversity and species endemicity within. Water for People (WFP), with indirect support from Blantyre Water Board (BWB) and Mulanje Mountain Conservation Trust (MMCT) is working to understand how Nature-based Solutions (NbS) can contribute to long-term water security while maximising benefits and outcomes from society and communities, the economy and the environment.

Grey and Sadoff (2007) specifically define water security as "*The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments and economies*".

NbS are interventions that are able to provide multiple benefits to both biophysical and socio-economic environments, with NbS for water security best described as "*Actions to protect, sustainably manage and restore natural or modified ecosystems that address water security challenges effectively and adaptively, simultaneously providing human wellbeing and biodiversity benefits*" (Trémolet et al. 2019).

A Catchment Investment Programme (CIP) is an initiative designed to deliver water security ecosystem services by investing in the protection and/or restoration of nature. A CIP aims to set up a sustainable mechanism for collective action that brings together different water users to invest in ecosystem protection and upstream communities within the catchments they depend on. Water security and a range of associated co-benefit outcomes are then delivered via NbS within a defined service area. A CIP also provides a means to create an effective governance system for the management, prioritisation and funding of these NbS initiatives. Water security is a complex, multi-layered, and interconnected societal and environmental issue. To succeed, solutions need to be equally holistic, well-informed, multi-layered, and adaptive, which a CIP aims to address.

WFP subsequently submitted an application to the Nature for Water (N4W) Facility as part of the facilities Call for Proposals for technical support to help determine the feasibility of setting up a Catchment Investment Programme (CIP) for long-term water security across both the Mudi-Ndirande and Likhubula sub-catchments. This application was successful, with the N4W Facility supporting with a Feasibility Study that commenced in June 2024.

1.1 Objectives and Scope of the Feasibility Study

The overarching **objectives of the feasibility study** are two-fold, namely:

1. To assess the feasibility of NbS to address water security challenges (WSC) in Mudi-Ndirande and Likhubula sub-catchments.
2. Conceptualise sustainable mechanisms and potential gaps that would enable the funding and implementation of NbS at scale through a Catchment Investment Programme.

This feasibility study looks to address the objectives through various assessments, namely:

- **Stakeholder Assessment**:
    - Is there clear indication that stakeholders understand the water security challenges facing the Mudi-Ndirande and Likhubula sub-catchments and the need to conserve them?
    - Are there compelling indications that a multi-stakeholder governance mechanism can be designed owing to stakeholder buy-in?
    - Is there commitment to a collaborative approach that leverages distinct strengths of various stakeholders to support implementation of NbS at scale?
    - Is there NbS implementation experience within the catchment?

- **Scientific Assessment**:
    - Is there strong evidence that priority NbS significantly contributes to reducing the impact of key water security threats, specifically declining water levels, by increasing water availability and better sustaining dry season flows?
    - Where in the Mudi-Ndirande and Likhubula sub-catchments do these NbS interventions need to be located to maximise impact?

- **Financial and Economic Assessment**:
    - Is there clear evidence that the benefits of NbS outweigh the costs of implementation?
    - Can the economic benefits be clearly articulated to stakeholders, partners and funders?
- **Benefits of NbS**:
    - Is there evidence from the catchment to showcase that priority NbS are accepted by communities and that benefits are being realised?
    - Are there proven delivery models that can be scaled up?
- **Governance, implementation and sustainability:**
    - Is there a case for a continuum towards a scaled programme for implementation and funding of landscape restoration in Malawi?
    - What is the existing governance arrangement related to catchment management? What local governance structures and capacity exist?
    - What funding opportunities exist both locally and nationally? Is there a high level of confidence in potential funding streams, with funds identified to kick start initial activities? What is needed to enable sustainable funding of a CIP model?

The above questions should be adequately answered and with favourable outcomes for a project to confidently confirm that there is the right enabling environment for further consideration of a CIP in the local landscape.

1.2 Project Team

The project team was a partnership between WFP and N4W. The N4W team provided the technical assistance and input needed to drive the engagement, bringing in science, geospatial information systems, economic, finance and stakeholder experts. WFP was the Local Lead, which is a key role required to help run the engagement from the ground, bringing in local expertise and experience. Although WFP was the local lead, BWB, Southern Region Water Board (SRWB), National Water Resources Authority (NWRA) and MMCT, were all closely involved in the development of the project outputs and deliverables, engaging local stakeholders and testing solutions.

Figure 1: Project Partnership Organogram.

1.3 Purpose of this report

The Feasibility Assessment marks the movement from determining the high-level NbS potential to achieve impact in a catchment (typically assessed during a Pre-Feasibility Study, or through experience gained on the ground) to developing and evaluating the costs and benefits associated with a specific portfolio of NbS. This Report provides insight to understanding the characteristics and broader context of the Mudi and Likhubula sub-catchments as well as detailing the methodology followed in the assessment of the feasibility of developing a catchment investment programme. The Report provides a detailed technical scoping and aims to enhance the credibility and thoughtfulness, culminating in an overall view on the feasibility of the project and recommended NbS investment portfolio put forward.

The purpose of this report is threefold: (1) focus and prioritise efforts and areas around a defined portfolio of NbS and sustainable interventions in the sub-catchments, (2) identify target beneficiaries and other potential partners who will invest in implementing shortlisted NbS, and (3) clearly articulate the feasibility of the shortlisted NbS investment portfolio recommendation. It is essential to ensure alignment among key stakeholders and effectively communicate the value to both beneficiaries and investors. Furthermore, the report aims to outline next steps based on the feasibility conclusions to ensure the study provides a meaningful basis on how to proceed in terms of implementation of NbS in these sub-catchments, but also in Malawi as a whole.

2 Background Context

2.1 Genesis of Catchment Investment Programme Study

In 2019, WFP and The Nature Conservancy (TNC) conducted a study to understand the feasibility of establishing a water fund primarily using NbS to improve Blantyre's water security. The study was completed in 2022. The Feasibility Report concluded on the prevailing context in the Shire, Mudi-Ndirande and Mulanje Mountain source water areas and suggested a phased approach that prioritises the potential demonstration catchments where NbS are likely to have the most impact, and where the collective action mechanism is emerging most clearly among key stakeholders. In doing so, it provides a detailed profile of the landscape upon which more detailed focused Water Fund development phases could build (Shire not shown here as not included in this study)[1]:

*"The **Mudi-Ndirande catchment** hosts the City of Blantyre's closest and cheapest water source, the Mudi Dam. Land encroachment, urban pollution and deforestation are leading to deteriorating water quality and reduced storage capacity of this critical water source for the city. Nature-based Solutions (NbS) and alternative land use provide the option to also nest an "urban park" around the dam and river, allow for improved liveability and agriculture within the catchment, and support community woodlots in the upper catchment. Rehabilitation of check dams and other silt trap structures within the catchment will also reduce siltation of the Mudi dam. This catchment will see a positive impact from a much smaller NbS investment and as such, there is greater potential to use the Mudi-Ndirande site and a demonstration catchment to initiate the Water Fund development process."*

*"The **Mulanje Mountain Catchments** remain forested and biodiverse in comparison but face increasing pressure from growing populations and high rates of poverty fuelling deforestation. The areas in which Nature-based Solutions hold strong potential for effective water resources management also host high biodiversity value. This overlap creates a desirable context in which a Water Fund would engage. Catchment conservation in the Mulanje Mountain catchments would also benefit other regional water users. Within the Mount Mulanje region it is important to focus on the LikhubulaLikhubula sub-catchment to address current uncertainty and conflicts over water security and to investigate the potential for NbS to improve water yields and quality. The sub-catchments upstream of the existing hydropower plants and the tea estates located in the headwaters of the Ruo River stand to benefit from NbS targeting alien invasive clearing as well as soil and water conservation measures. These sites also hold better potential as demonstration catchments, given the relatively smaller implementation area and the greater likelihood of visible positive impact."*

Further to these contexts, the feasibility study findings indicated strong alignment among stakeholders regarding the need for catchment conservation in the identified source water areas. It established that consensus exists that Nature-based Solutions (NbS) for catchment conservation and water resource management offer numerous mutual benefits for key stakeholders. This alignment is favorable for establishing a shared vision for the proposed CIP. The establishment of one or multiple CIPs could significantly enhance existing partnerships by strengthening coordination of ongoing and planned NbS activities. Additionally, it could improve resource mobilization and financial sustainability, address gaps and expanding the impact of current efforts.

These conclusions provided a strong basis for continued work on assessing the feasibility of CIPs in these areas. Leading on from this work, an application to develop a feasibility study for a CIP in the Mudi-Ndirande and Likhubula sub-catchments was submitted by WFP, with support from Mulanje Mountain Conservation Trust (MMCT), National Water Resources Authority (NWRA), Blantyre Water Board (BWB), Catholic Relief Services (CRS), Ministry of Natural Resources and Climate Change and Department of Land Resource Conservation.

[1] Add pre-feasibility report reference here.

2.2 Locality

2.2.1 Mudi-Ndirande:

The Mudi Dam, constructed in 1953 with a capacity of 1.4 million cubic meters, is strategically positioned on the eastern edge of the greater Shire River catchment on the outskirts of Blantyre City. This water source is fed by streams that originate in the southern tip of the Ndirande Hills and forest reserve. Despite its critical location as the closest, most economical, and readily available water source for Blantyre, the Mudi-Ndirande catchment (shown on the left of Figure 2) faces severe environmental degradation. The forest reserve has been almost completely deforested due to multiple pressures: high demand for charcoal and timber for fuel, agricultural expansion, and urban development. This deforestation has significantly compromised the catchment's ability to function effectively.

2.2.2 Likhubula:

The Likhubula River originates on the western slopes of Mulanje Mountain in Southern Malawi, formed by the convergence of three primary streams and numerous smaller tributaries flowing downhill. After taking shape, the river flows southward through Chitakale before merging with the Lichenya River, which originates from the southern part of Mulanje Mountain. Together, these waters join the Ruo River, continuing southward into Mozambique before ultimately reaching the Indian Ocean. This vital water system serves as a critical resource for diverse stakeholders. Although the water resource only provides approximately 10% of Blantyre's water supply, it provides water to over 300,000 people beyond the district borders (Blantyre Water Board, 2020) and approximately 25,000 residents within Mulanje District itself (Southern Region Water Board, Mulanje Office 2023). The river supports essential domestic, agricultural, and industrial uses, functioning as a lifeline for communities both within and beyond the immediate region. The Likhubula catchment (shown on the right of Figure 2) is constrained by irregular rainfall patterns and unsustainable land use practices, including forest conversion to agriculture and deforestation for charcoal production, which leads to increasing soil erosion within the catchment and sediment load entering into the Likhubula River.

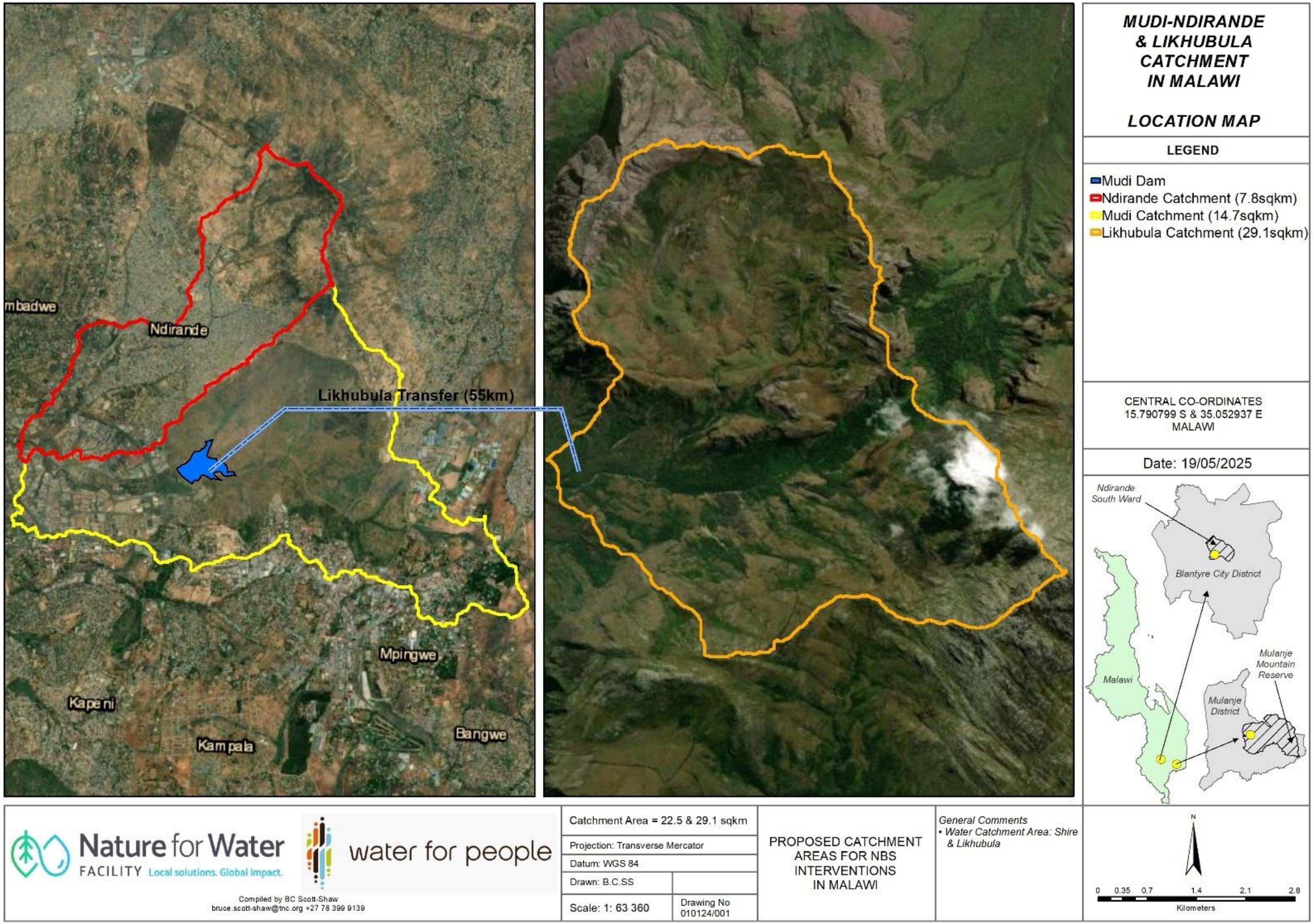


Figure 2: Location of the two focus catchment areas in Malawi

2.3 Catchment Characteristics

2.3.1 The Mudi-Ndirande Catchment

Over the years, the Blantyre Water Board (BWB) and various non-governmental organizations have implemented reforestation efforts and farmer compensation programs within the catchment area. However, these initiatives have largely failed to restore the forest cover, likely due to inadequate funding and lack of program continuity. Urban encroachment continues to advance into the catchment, further threatening its ecological integrity.

Water quality issues remain a persistent concern due to the dam's proximity to the city. Consequently, traditional sediment management interventions, such as dredging, would still be necessary alongside any ecological restoration efforts to maintain the dam's functionality and water quality.

Biophysical Characteristics and vegetation

Natural vegetation in this area consists of miombo woodlands, dominated by *Brachystegia, Julbernardia*, and *Isoberlinia* species, and natural grassland (e.g. *Hyparrhenia spp*. and shrubs). These unique ecosystems are biodiversity hotspots, providing critical habitat for flora and fauna while delivering essential ecosystem services. However, there is little to no natural vegetation left in this catchment area. Miombo woodlands, which have been cleared for charcoal use have been replaced by invasive alien species. Although these exotic species are still utilised, they provide little biodiversity value and use the catchment limited water resources.

Nature-based solutions for water security outcomes

The Mudi Dam presents a unique opportunity for nature-based solutions (NbS) with relatively modest investment requirements compared to interventions needed in the larger Shire basin. Although the dam supplies only a small percentage of Blantyre's water demand, its strategic importance makes it a valuable asset worth protecting. Effective implementation of NbS could have significant positive impacts on water security.

Water Resource - Mudi Dam

The Mudi dam, downstream of the Mudi-Ndirande catchment, is the closest, most economical, and readily available water source for Blantyre. It is one of three water sources that make up Blantyre-Water Board's (BWB) total supply to Blantyre City. The dam was originally built with a capacity of 1.4 million m3 and the Mudi water treatment plant at a capacity of 17 000 m3 per day, however, now, according to BWB, it only provides 6000m3 per day. The loss in capacity of the dam is attributed to high rates of sedimentation in streams within the Mudi-Ndirande catchment as a result of ongoing degradation of the catchment. According to a report on urban water supply in Blantyre City by JICA (JICA, 2022), average water production from Muid Dam over the period 2003 to 2020 is 5 767 m3 per day.

Figure 3: Mudi Dam taken from dam wall (Source: N4W)

Figure 4: Mudi Dam Spillway (Source: N4W)


Figure 5: Mudi Water Treatment Plant (Source: N4W)

Water Quality
Water quality tests carried out by JICA (JICA, 2022) concluded that although safe for use, the samples from all 4 sites had Biochemical Oxygen Demand (BOD) that exceeded environmental standards. The turbidity results of the sample indicated that turbidity levels were low throughout three sample locations apart from one taken in a wetland. In general, ferrous iron and manganese were not almost detected, with some elevations in chemical oxygen demand.

Land-Use Activities and livelihoods

The Mudi catchment is significantly transformed. There have been attempts to rehabilitate the catchment area above the dam, which have had limited success. Tree mortality rate is high through a combination of human pressures and follow-up maintenance. This area, which used to be natural woodland, is now heavily invaded with alien tree species that are utilised for firewood and charcoal.

2.3.2 The Likhubula Sub-catchment

The Likhubula River's flow is constrained by irregular rainfall patterns and unsustainable land use practices, including forest conversion to agriculture and deforestation for charcoal production. These activities significantly impact both water quantity and quality. Additionally, the re-infestation of pine trees and other invasive alien species throughout the catchment threatens to reduce annual runoff, creating further pressure on the already strained water supply.

Despite being the newest water source for the Blantyre Water Board (BWB) and having relatively minimal water quality issues due to its headwater location, the Likhubula catchment is currently yielding only 30% of its expected volume. This underperformance has created tension with downstream users who report water shortages, particularly during dry seasons, and accuse BWB of excessive abstraction. Several non-governmental organizations are already engaged in conservation work around Mount Mulanje, highlighting the need for coordinated efforts to ensure effective catchment restoration and management.

Biophysical Characteristics and vegetation

Much of the catchment area, historically characterized by grasslands, has been transformed first by commercial plantation activity and subsequently invaded by pines and other non-native species. Catchment restoration efforts, including the removal of these invasive trees and improved land management practices, could potentially increase water yield benefiting both BWB operations and downstream users while enhancing baseflow for ecosystem health.

Flooding remains a significant concern, particularly in neighbouring catchments like the Ruo where tea estates and small hydropower installations share an interest in improved catchment management. A comprehensive hydrological study and ongoing monitoring would be necessary to determine the sustainable yield of the Likhubula catchment.

Mount Mulanje represents an extraordinary biodiversity hotspot characterized by remarkable levels of endemism, with over 1,100 documented plant species including at least 69 strict endemic species found nowhere else on Earth. This exceptional biological uniqueness encompasses diverse groups including trees, orchids, grasses, and sedges. The mountain's ecological significance is highlighted by four endemic forest tree species, notably the iconic Mulanje Cedar (Widdringtonia whytei). Furthermore, Mount Mulanje harbours diverse fauna with notable endemism across several groups. Though larger mammals are sparse, the mountain supports klipspringers, hyrax, Samango monkeys, leopards, and one near-endemic rodent species. In terms of bird life, the mountain is home to the endemic Yellow-throated Apalis and two endemic subspecies. Reptile diversity features the strictly endemic Mulanje Cross-barred Tree-snake, Mulanje Dwarf Chameleon and several endemic lizards and skinks.

Nature-based solutions for water security outcomes

The Likhubula catchment represents a unique case where effective efforts are already being implemented in the catchment. NbS in this context focuses on the continued efforts with improvements represented by scaling up of existing efforts. These efforts (alien tree clearing, fire management and reforestation) will enhance the delivery of water in the catchment, particularly in the dry season, while attenuating extreme events.

Water resource - Likhubula River

The Likhubula River, fed by the Likhubula sub-catchment on Mount Mulanje is another key water source for Blantyre City. Beyond Blantyre City, the Likhubula river is also used as a source by Southern Region Water Board and local Water User Associations (WUAs). The Blantyre Water Board (BWB) initiated the Likhubula Water Supply System project to address water shortages in Blantyre by tapping into this river. The supply project to Blantyre is attractive due to the significantly greater elevation of the resource (1066m a.s.l) compared to Blantyre, enabling a gravity fed system supplying a total dynamic head of 340m over a distance of 49km. According to the feasibility study for the supply project conducted by BWB (Blantyre Water Board, 2014), the system is expected to produce at least 8,000 m3 of water per day. The main areas that will benefit from this source are Bangwe, Namiyango BCA (Traditional) and BCA (planned) and Nguludi which currently are some of the critical areas within the BWB supply area. The demand for these areas is estimated at 6,600 m3 per day based on projections by BKS Limited under medium demand scenario (Blantyre Water Board, 2014). Furthermore, it was noted that the river has a capacity to supply 9 000 m^3 per day without significant environmental consequence, including biodiversity/habitat impact and environmental flows (VEI, 2023).

Water Quality

Raw water samples form the Likhubula river concluded that the water is of good quality and within acceptable limits across all Malawi Bureau of standards permissible levels. These positive results were critical in proving the feasibility of the Likhubula as a source for supply for Blantyre Water Board.

Land-Use Activities and livelihoods

The Likhubula catchment, although within a protected reserve, has experienced a past invasion of exotic pine species, which has spread into the grassland areas. These species are high water users and provide no biodiversity value. However, the threes have in part supplemented the local community need for firewood. The agriculture and illegal harvesting have gradually encroached the outskirts of this catchment, sustaining a growing population.

The existing efforts by MMCT have largely returned the catchment to a near natural state, although this state is reliant on continued funding and efforts by local conservation groups. If these groups do not continue, the catchment is at risk of returning to a degraded state.

2.4 Understanding Water Supply and Use in Blantyre

2.4.1 Water Supply and Distribution

The Mudi and Likhubula sub-catchments are critical water resources contributing approximately 25% of Blantyre's Water Supply cumulatively. The balance of Blantyre's water demand is met through abstraction from Walker's Ferry in the Shire River. The map below in Figure 6 shows the Blantyre supply area as well as the key intakes, reservoirs, pump stations and treatment plants.

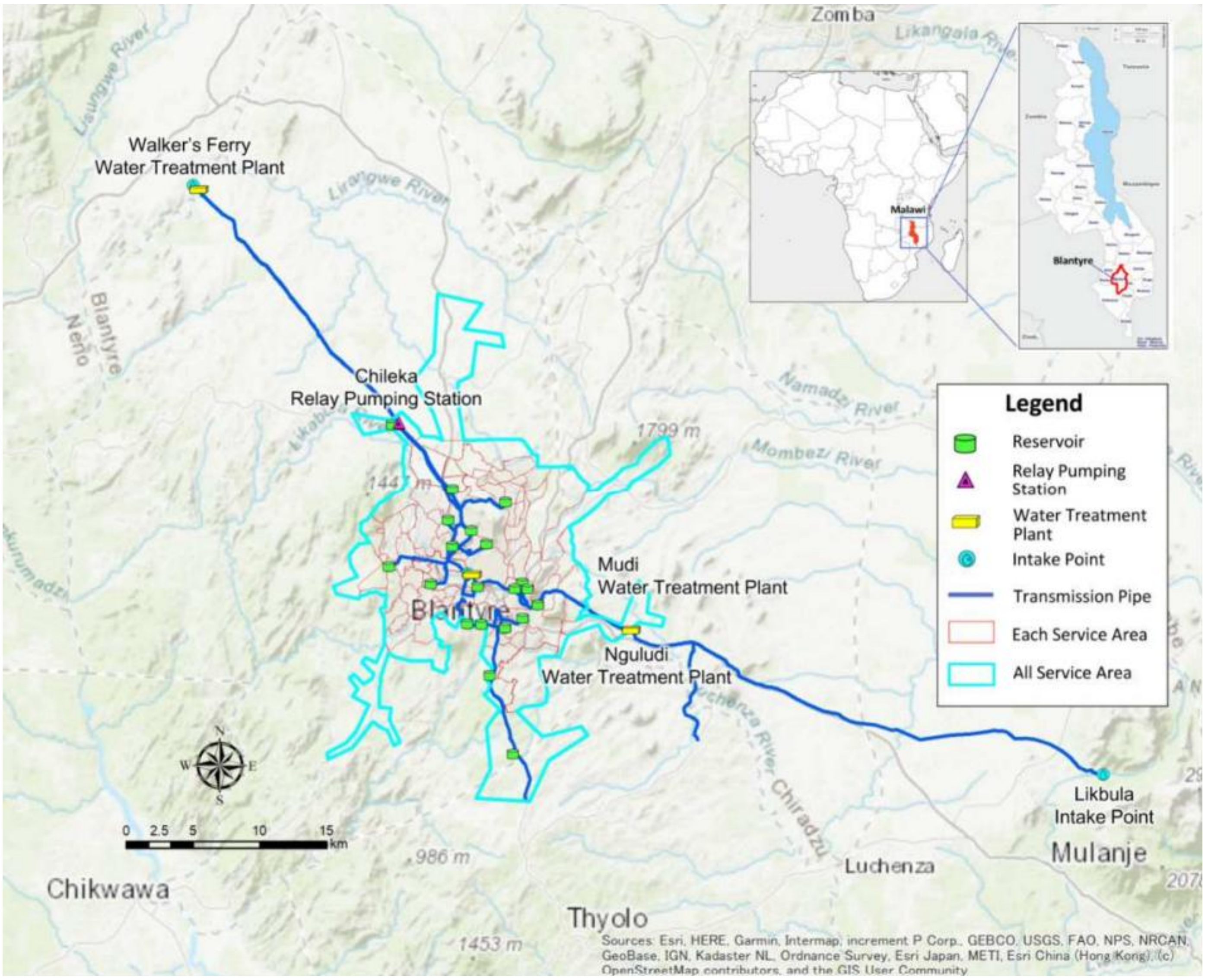


Figure 6: Map showing location of reservoirs, pump stations and treatment plants supplying Blantyre (JICA, 2022)

The opportunity offered by Mudi as an affordable water resource should not be understated. Mudi Dam would be the most cost-efficient and energy-effective water supply source for Blantyre City due to its central location, but it lacks sufficient capacity and its water treatment plant (WTP) is deteriorating. As a result, Blantyre Water Board (BWB) relies heavily on Walker's Ferry WTP, located 40km away and 800m lower in elevation, requiring substantial pumping costs to deliver water uphill to the city centre. As such, energy costs for approximately 75%-85% of BWBs supply volume are very high. Likhubula is situated at a higher elevation than Blantyre, enabling a gravity-fed system supplying a total dynamic head of 340m over a distance of 49km. However, it operates at less than half its 20,000 m³/day capacity (under 10,000 m³/day as of May 2021) due to seasonal water level drawdown issues, making it an unlikely candidate for expansion as an alternative solution.

Annual and daily water production from the three offtakes for the Shire River (Walker's Ferry), Mudi Dam (Mudi) and Likhubula (Nguludi) are shown in Table 1.

Table 1: Annual and daily water production from Shire River, Mudi Dam and Likhubula offtakes, respectively

Year	Water Production Volume (Million m³)				Daily Water Production (m³/day)			
	Walker's Ferry	**Mudi**	**Nguludi**	**Total**	**Walker's Ferry (96,000)**	**Mudi (17,000)**	**Nguludi (20,000)**	**Total (133,000)**
2003	30.61	3.25	-	33.86	83,863	8,904	-	92,767
2004	26.52	2.25	-	28.77	72,658	6,164	-	78,822
2005	27.03	3.57	-	30.60	74,055	9,781	-	83,836
2006	26.90	2.09	-	28.99	73,699	5,726	-	79,425
2007	25.48	3.90	-	29.38	69,808	10,685	-	80,493

2008	26.64	2.00	-	28.64	72,986	5,479	-	78,466
2009	27.47	2.40	-	29.87	75,260	6,575	-	81,836
2010	28.07	1.97	-	30.04	76,904	5,397	-	82,301
2011	28.68	2.23	-	30.91	78,575	6,110	-	84,685
2012	28.24	2.42	-	30.66	77,370	6,630	-	84,000
2013	25.30	2.90	-	28.20	69,315	7,945	-	77,260
2014	21.33	2.37	-	23.70	58,438	6,493	-	64,932
2015	20.60	1.60	-	22.20	56,438	4,384	-	60,822
2016	28.18	2.12	-	30.30	77,205	5,808	-	83,014
2017	26.30	1.40	-	27.70	72,055	3,836	-	75,890
2018	26.30	2.10	-	28.60	72,603	5,753	-	78,356
2019	-	-	-	33.50	77,012*	6,295**	-	85,085
2020	-	-	-	33.50	80,904*	7,142**	7,422***	95,468
Average water production in the past 5 years (m3/day)(2016 & 2020)					75,969 (85.2%)	5,767 (6.5%)	7,422 (8.3%)	89,145 (100%)
Rate of actual water production (Average between 2016 ad 2020) to design capacity (%)					79.1	33.9	37.1	67.0

2.4.2 Water treatment

Three Water Treatment Plants (WTPs) service Blantyre. Walker's Ferry treats water abstracted from the Shire River, Mudi from Mudi Dam and Nguludi from the Likhubula River. The extent of treatment required is based on the respective water quality from each source. The water quality from Nguludi was found to be the best and therefore has the lowest treatment requirements and cost. The quality of water from Mudi has declined over time, and along with aging treatment infrastructure, has resulted in high treatment costs for BWB. The water from the Shire is reasonable quality however, the cost of supply is high due to the far distance and 800m head that is needed to be able to distribute the water. The treatment plant specifications for each source is shown in Figure 7.

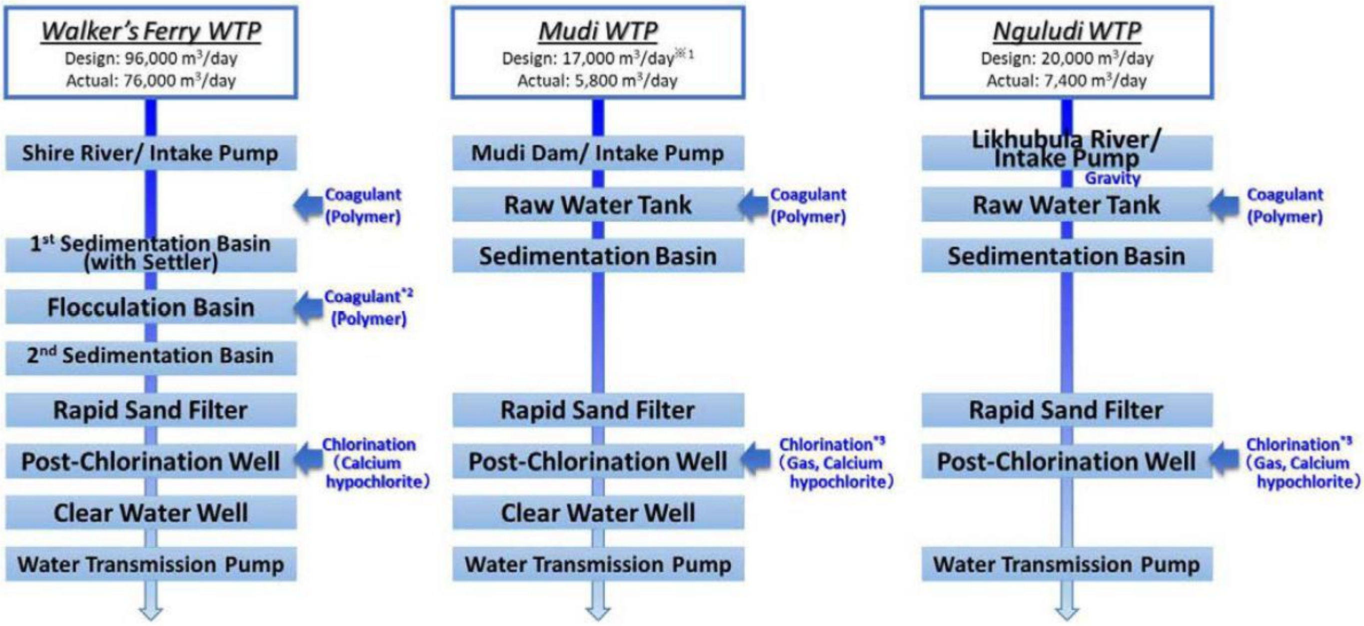


Figure 7:Treatment process flows for each water source supplying Blantyre (JICA, 2022)

2.4.3 Water Use In Blantyre

The Blantyre Water Board (BWB) service area demonstrates distinct patterns of water consumption across various user categories. Daily domestic water usage through house connections averages between 66-77 liters per capita per day (LCD), based on data collected from 2018 to 2020. Interestingly, homes with prepaid water meters show noticeably higher consumption rates of 80-90 LCD compared to those with postpaid meters. Looking ahead, BWB has adopted a planning figure of 100 LCD for future domestic consumption projections through house connections.

Water kiosks, which serve as community water access points, show significantly lower consumption rates of just 10-11 LCD. This figure falls well below the Water Resource Management Guideline recommendation of 40-50 LCD. BWB attributes this discrepancy to residents supplementing their water needs with alternative sources such as wells due to service shortages. Field research by the Jica Survey Team revealed that each kiosk typically serves about 28 households or approximately 230 individuals. Based on these usage patterns, BWB has established 25 LCD as the planning benchmark for future kiosk-based consumption.
Beyond residential use, non-domestic consumption, encompassing institutional, commercial, and industrial users, constitutes a substantial portion of Blantyre's water demand, ranging from 36.4% to 42.5% of total consumption between 2018 and 2020. For future planning purposes, BWB has standardized this at 40% of projected total water demand. The specific distribution among institutional, commercial, and industrial categories will maintain the same proportional breakdown observed in 2020 data (JICA, 2022).

2.4.4 Projected and future water demand in Blantyre

Blantyre faces a severe water deficit, with daily demand reaching 140 million litres while the Blantyre Water Board (BWB) can provide a maximum of only 122 million litres per day. The situation is further exacerbated by substantial distribution inefficiencies, with approximately 40% of water lost before reaching consumers. This infrastructure challenge transforms the already concerning supply gap into a critical shortfall exceeding 70 million litres daily. BWB expect demand to grow to 158,220 m^3 by 2027 and to 202,33 m^3 by 2030 (Water Network Research, 2014). In a study by the Malawi Priorities Project investigating the costs and benefits of improving water services reliability in Blantyre, the deficit will reportedly increase in future as a result of population growth and other drivers, even with proposed intervention as illustrated in Figure 8 (The Malawi Priorities Project, 2021).

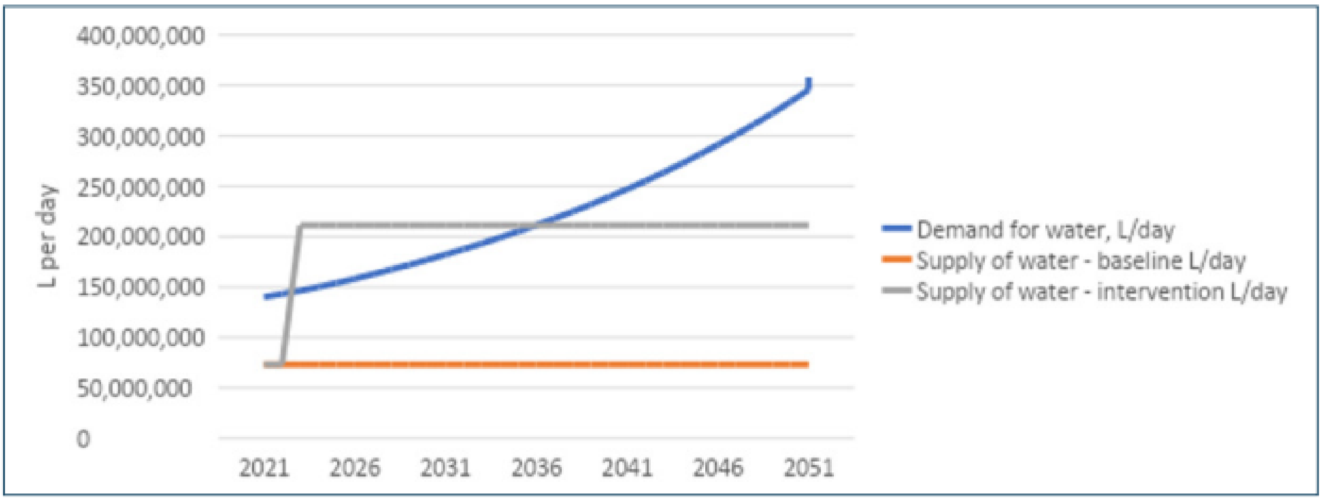


Figure 8: Demand, Supply of water per day with and without intervention (The Malawi Priorities Project, 2021)

To resolve this pressing issue, the BWB has proposed developing a new water source by tapping the Shire River. This strategic infrastructure project would add approximately 230 million litres per day to Blantyre's water supply capacity, effectively eliminating the current deficit and creating sufficient reserves to accommodate the city's projected growth and water needs through 2036. Although investment in grey infrastructure supportssupports water resource development and supply, itit also demonstrates that inginvesting in Nature-based solutions presents an opportunity for long-term sustainability of supply and reduces risks of water scarcity under the projected future supply deficit scenario.

2.5 Water Security Challenges

Both the Mudi and Likhubula sub-catchments experience significant water security challenges. Although the two catchments display some similarity in terms of their respective challenges, there are critical differences as a result of the respective location and biophysical characteristics of each. The challenges experienced in Mudi are largely driven by encroachment and other anthropogenic impacts and stresses (illustrated in Figure

9) that might be expected from settlements within close proximity to natural landscapes. On the contrary Likhubula experiences challenges both driven by anthropogenic impacts (deforestation) but also bears the brunt of the impacts of climate change, including variable rainfall patterns, flooding and fires. A critical challenge across both catchments is deforestation. Deforestation has significant impacts on water quality and to some extent on water availability. Deforestation is driven largely by a national energy security crisis, where communities across the country have become reliant on wood for fuel both in the form of firewood and for charcoal production.

Figure 9: Drivers of water security challenges in Malawi

The specific catchment challenges are listed below and further illustrated in Figure 10.

- Human **ENCROACHMENT** is increasingly pressurizing the catchment areas and is acutely severe on Ndirande Mountain
- Severe **DEFORESTATION** of both catchment areas for firewood is driven by energy insecurity
- Catchment degradation is causing higher rates of **SEDIMENTATION** and worsening water retention and abstraction rates
- Worsening **WATER QUALITY** in Mudi River is driven by poor sanitation and solid waste disposal
- Ongoing catchment degradation has led to worsening **FLOODING** and increasingly extreme weather events

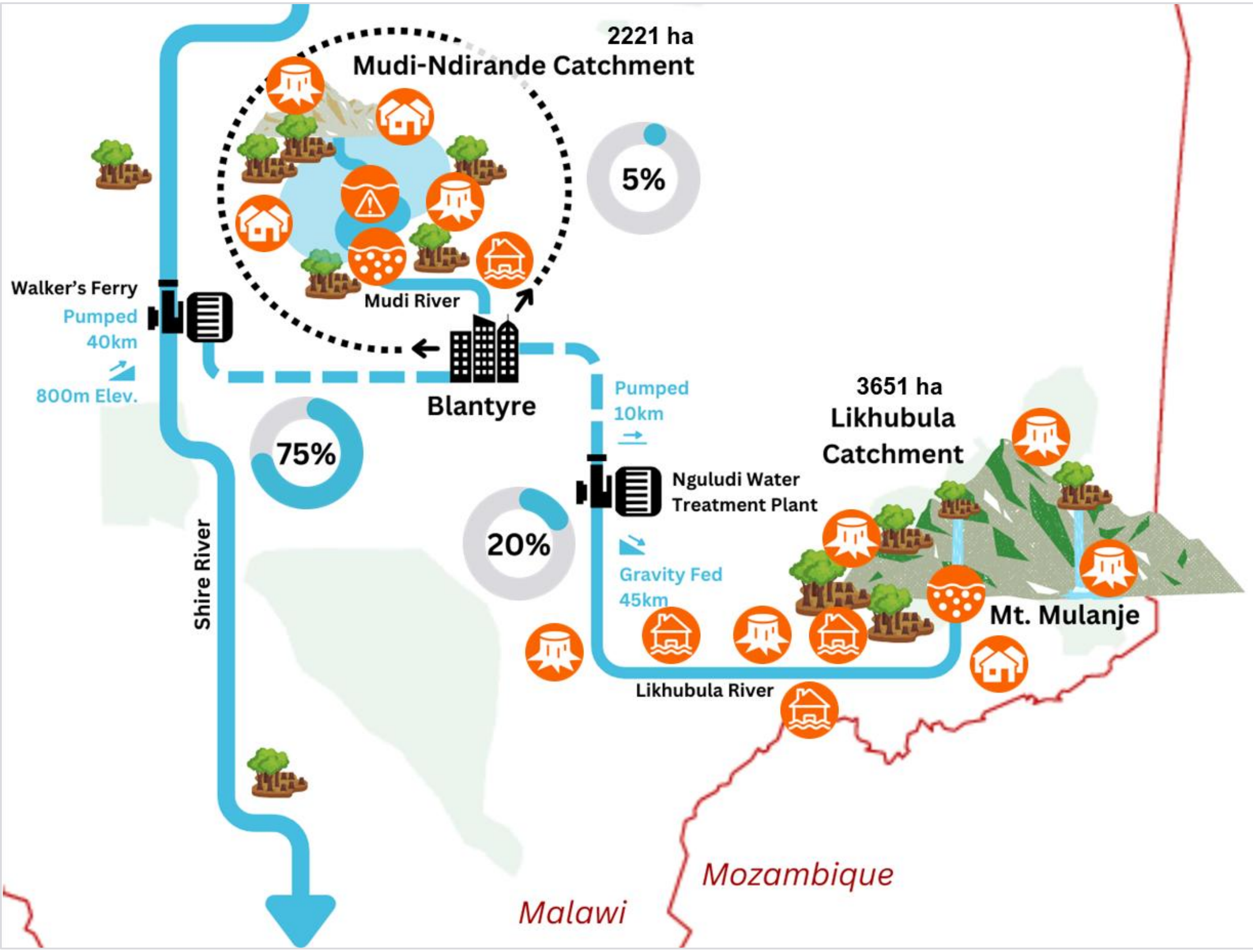


Figure 10: Illustration of water security challenges in each catchment

Table 2 provides greater detail on the water security challenges and their drivers. Some of these challenges can be addressed through NbS, however, many are systemic in nature and require a seismic shift. For example, continued energy insecurity across Malawi will continue to result in deforestation, and the impacts that result from this make forested areas in source water catchments particularly vulnerable. Additionally, many of these issues are not limited to the two areas investigated through this study. Many of these challenges are faced across landscapes in Malawi. Of course, there are idiosyncratic challenges that exist within each catchment within Malawi that would need to be investigated further, however, this study certainly provides some points of departure for further investigation.

Table 2: Summary of challenges, drivers and impacts in both the Mudi and Likhubula sub-catchments

Water security challenges	Primary Drivers	Impact	Comments
Deforestation	Energy insecurity	• Lower reliability of supply • Increased sedimentation and run-off • Flooding/low attenuation capacity of landscape	Deforestation was found to largely be driven by those seeking to harvest fuel. However, it is also understood that there is a market for timber products, particularly the timber found in Mulanje Mountain.

Water security challenges	Primary Drivers	Impact	Comments
Encroachment	Population Growth	• Water quality issues • Illegal abstraction • Dumping/pollution	As communities expand, particularly in urban centres where opportunities exist, communities either clear and settle within catchments or place more pressure of catchment resources. It is also the case that as demand for agricultural land increases, areas such as the Likhubula catchment come under greater threat.
Alien Invasive Vegetation	External	• Lower reliability of supply • Increased sedimentation and run-off	Alien invasive plant species, particularly pine, have historically spread in both catchments having impacts on both water quality and quantity.
Variable rainfall and dry season drought	Climate Change	• Dry season droughts • Wet season flooding	Climate change is causing rainfall patterns to change, often more erratic and less predictable leading to significant issues related to reliability of supply and flooding

2.6 Existing Initiatives in the Mudi and Likhubula Sub-catchments

2.6.1 Tree-planting Initiatives in the Mudi sub-catchment

Tree-plating initiatives in the Mudi sub-catchment have been taking place for some years. These initiatives have been led by various stakeholders and institutions and demonstrate an understanding of water security challenges as well as the need and commitment for catchment restoration. The initiatives are listed below:

- **Water for People & BWB:** In March 2024, Water for People, in collaboration with stakeholders, planted indigenous trees around the Mudi Catchment Area. This effort aims to increase water levels and ensure sustainable water supply for the community. The initiative also seeks to control siltation in Mudi Dam, thereby reducing water purification costs for a significant portion of the city's population.

- **Blantyre Water Board (BWB) Annual Tree Planting:** In early 2025, BWB led a tree planting exercise at the Mudi Catchment Area, planting 2,000 indigenous tree seedlings. The event, graced by the Minister of Water and Sanitation, Hon. Abida Mia, underscores the government's commitment to environmental conservation and water resource management.

- **Castel Malawi's Corporate Reforestation:** Castel Malawi has been actively involved in reforestation efforts, having planted over 30,000 seedlings between 2016 and 2018. In a recent initiative, the company replanted 2,500 trees at Mudi as part of its broader reforestation program, aiming to restore and manage critical water catchment areas.

- **Wildlife and Environmental Society of Malawi (WESM):** Since 2008, WESM has been a key partner in the restoration of the Mudi catchment area. The organization has sourced and planted more than 10,000 seedlings annually, engaged in invasive plant species removal, and conducted birdwatching activities to promote biodiversity. WESM has also collaborated with corporate entities like Castel Malawi to support these restoration efforts.

2.6.2 Mulanje Mountain Conservation Trust

The Mulanje Mountain Conservation Trust (MMCT) stands at the forefront of Malawi's efforts to conserve one of its most ecologically significant landscapes – Mulanje Mountain. Established with seed funding from the Global Environment Facility (GEF), MMCT operates as an independent trust dedicated to protecting the mountain's globally significant biodiversity while fostering sustainable livelihoods for the surrounding communities.

At the heart of MMCT's work is the conservation of the critically endangered Mulanje Cedar (*Widdringtonia whytei*), Malawi's national tree, which is found nowhere else in the world. Through extensive reforestation, propagation, and forest restoration efforts, MMCT is not only rehabilitating this iconic species but also restoring broader ecosystems under increasing pressure from climate change, illegal logging, and encroachment.

MMCT's impact extends far beyond tree planting. Its comprehensive forest and watershed management programs help protect vital water catchments across the Mulanje Mountain. This includes stream monitoring, riparian restoration, and collaboration with local and national institutions to ensure sustainable water extraction and long-term hydrological stability.

Community engagement is central to MMCT's conservation strategy. Through initiatives such as eco-tourism development, beekeeping, sustainable agriculture training, and environmental education, the Trust promotes alternative livelihoods that reduce dependency on forest resources. Programs like the MOBILISE initiative, funded by the Government of Norway, integrate biodiversity conservation with income generation, climate resilience, and policy advocacy.

Climate change resilience is another priority. MMCT is actively assessing vulnerability in mountain communities and promoting adaptive strategies such as sustainable farming, clean energy adoption, and climate-smart forest restoration. These actions not only mitigate environmental risks but also strengthen community capacity to respond to emerging challenges.

The organization also plays a vital role in ecological research and conservation innovation. From long-term biodiversity monitoring and invasive species management to the use of drones, GIS, and mobile data collection tools, MMCT is applying cutting-edge technology to enhance its conservation impact. This evidence-based approach supports national policy advocacy and strengthens co-management systems with local communities and government agencies.

Despite progress, MMCT continues to navigate complex challenges: increasing population pressure, persistent illegal activities, and the ongoing search for sustainable funding. In response, the Trust is working to develop new funding streams – such as ecosystem service payment schemes – and to deepen community ownership of conservation goals.

MMCT's work has contributed to the protection of key conservation areas on Mount Mulanje. The result has been the preservation of watersheds serving hundreds of thousands of people, the regeneration of endemic species populations, and the creation of livelihood opportunities across the Mulanje region. Its integrated, community-centred approach is widely recognized as a national and regional model for mountain ecosystem management.

As environmental threats mount and development pressures grow, MMCT remains a vital institution safeguarding one of Malawi's most precious natural assets (Mount Mulanje) and the well-being of the people who depend on it and the biodiversity value within. The organisation is extremely well-positioned as a critical implementing partner for a Water Fund or CIP model. The knowledge and experience held within the organisation is exemplary and extremely important for the sustainability of Mulanje Mountain and potentially conservation in Malawi more broadly.

MMCT has had some recent big wins for the area. The Mount Mulanje Cultural Landscape has been inscripted, as of 2025, as UNESCO world Heritage Site. In addition, MMCT has been involved in key activities to move protection of the area forward. They have hosted key stakeholder meetings on the Mount Mulanje situation, and co-launched Castel Sapitwa Beer, a beer made with water originating from the mountain. The team has reached the final PPA tariff decision stage with ESCOM for offtake from small-scale hydro generation, initiated tea landscape restoration efforts with various companies, welcomed an incoming CNN team for a Mount Mulanje Cedar documentary, and begun discussions with the World Bank for a new project.

3 Regulatory Environment

3.1 Overview of the regulatory and policy environment

Malawi has a number of policies, plans, strategies and Acts relevant to water resources management. The Water Resources Act (No. 2 of 2013) provides a comprehensive legal framework for the management, conservation, use, and control of surface and groundwater. The National Water Resources Authority (NWRA) is the designated authority responsible for managing water resources and has the power to designate Catchment Management Committees (CMCs) who are responsible for developing and implementing Catchment Management Strategies and facilitating local stakeholder participation and coordination for the protection of water resources. This overarching framework creates the potential for effective water resource management if CMCs are designated and have sufficient technical and financial capacity to adequately coordinate stakeholders and implement restoration and conservation activities for water resources.

Table 3 lists some of the most relevant policies, strategies and Acts relating to water resources, while a more comprehensive list is included in Annex A (noting that these lists are not exhaustive).

Table 3: Policies, strategies and Acts relating to water resources management.

No.	Item	Key Function	Overview
Water			
1	National Water Resources Act, No. 2 of 2013	Provides the overarching legal framework for the management, conservation, use, and control of Malawi's water resources.	Establishes the National Water Resources Authority (NWRA), outlines procedures for water rights and permits, addresses water quality and pollution control, and provides for the establishment of Catchment Management Committees for decentralized water governance. It aims to ensure the sustainable and equitable use of water resources for all purposes.
2	Water Resources Regulations, 2018	Details the implementation of the Water Resources Act, 2013, providing specific procedures and standards.	Provides detailed rules for surface and groundwater management, development, administration, and quality control; and strategies for the conservation of riparian and catchment areas through protected area designations. Offers practical guidelines for enforcing the Water Resources Act, covering aspects like water abstraction licensing, pollution control, and dam safety.
3	National Water Policy, Revised 2023	Provides the guiding principles and framework for the sustainable development and management of water resources.	The 2023 revision addresses emerging challenges and aligns with current national development priorities and international best practices in integrated water resources management. It aims to guide sustainable development and management of water resources for multipurpose use and provision of potable water and waterborne sanitation services for socio-economic development while enhancing the country's natural ecosystems. It also focuses on disaster risk management, institutional arrangements and capacity development, sectoral coordination, financing and investment; legal, regulatory and governance framework, and other crosscutting issues (gender, equity and inclusion, climate change; research and ICT).
4	National Water Resources Master Plan, 2017	Outlines the long-term strategy for the development and management of Malawi's water resources to meet present and future needs.	Assesses the country's water resources, identifies current and future water demands across various sectors, and proposes infrastructure development, management strategies, and investment plans to ensure water security and sustainable utilization. It provides a roadmap for the sustainable development and management of Malawi's water resources over the long term.
5	National Sanitation Policy, 2008	Framework for sanitation development, addressing hygiene and waste management to improve public health.	Aims to improve sanitation coverage and hygiene practices to reduce waterborne diseases and environmental pollution. The policy promotes the development of appropriate sanitation technologies, capacity building, and community participation in sanitation programs. It also emphasizes the integration of sanitation into water resources management and environmental protection strategies.
6	Integrated Water Resources Management and Water Efficiency Plan (2008–2012)	Provides a comprehensive national framework to promote sustainable management, development, and use of water resources.	Aligns with Malawi's development goals and international commitments, including the Millennium Development Goals (MDGs) and Agenda 21, to address water security, economic development, and environmental sustainability. The plan emphasizes integrated water resources management (IWRM) principles, promoting coordinated development and management of water, land, and related resources to maximize economic and social welfare without compromising the sustainability of vital ecosystems.
Environment			
7	Environmental Management Act, No. 19 of 2017	Provides the overarching framework for the sustainable management of all natural resources, including water, and the protection of the environment.	Serves as the coordinating statute for all environmental and natural resource management and utilization. The act defines sustainable use of natural resources and guards against their extinction. While not solely focused on water, the Act includes provisions for environmental impact assessments, pollution control measures, and legal, monitoring, and auditing procedures that influence water resource management.
8	National Environment Policy, 2004	Provides overall guidance for environmental management and sustainable development.	Addresses issues such as water pollution, the degradation of water catchments, and the need for integrated planning to ensure the sustainable use of water and other natural resources for present and future generations. The policy promotes the efficient utilization and management of natural resources, rehabilitation of essential ecosystems, and enhancement of public awareness on environmental management. It also encourages cooperation among government, local communities, NGOs, and the private sector in environmental conservation efforts.

No.	Item	Key Function	Overview
9	National Biodiversity Strategy and Action Plan II (NBSAP II) for Malawi (2015–2025)	Provides strategies and action plans for the management of biodiversity from 2015–2025.	Aims to enhance the conservation and sustainable use of biodiversity for environmental and human well-being. Strategic objectives include improving capacity and knowledge on biodiversity issues, mainstreaming biodiversity management into sectoral and local development plans, reducing direct pressures on biodiversity, safeguarding ecosystems, species, and genetic diversity, and enhancing access and benefit-sharing from biodiversity and ecosystem services. The strategy also targets increasing forest cover by 4% by 2025 and promoting alternative energy sources to reduce pressure on forest resources.
10	National Environmental Action Plan (NEAP), 2002	Serves as a foundational document outlining environmental strategies, measures, and programs necessary for promoting the conservation, management, and sustainable utilization of natural resources.	Describes the environmental situation in Malawi and recommends actions to address environmental degradation. The NEAP provides a basis for integrating environmental concerns into national development planning and has influenced subsequent policies and strategies aimed at sustainable environmental management.
11	Malawi National Guidelines: Integrated Catchment Management and Rural Infrastructure (2015)	Provides guidelines for integrated catchment management and rural infrastructure development.	Addresses environmental issues such as soil erosion, deforestation, water resources degradation, and biodiversity threats. The guidelines promote sustainable land and water management practices, aiming to restore and expand Malawi's natural resource assets and manage ecosystems effectively.
12	District Environmental Action Plans: Mulanje (2002), Phalombe (2001)	Outline district-level environmental issues and strategies for sustainable natural resource management.	Developed under the Local Government Act of 1998, these plans identify key environmental challenges such as land degradation, deforestation, and water pollution. They serve as tools for integrating environmental considerations into district development planning and promote community participation in environmental management.
13	National Charcoal Strategy 2017–2027	Promotes sustainable charcoal production, aims to reduce deforestation, and supports alternative energy sources.	Focuses on reducing the demand for charcoal and firewood by promoting alternative cooking fuels, adoption of efficient stoves, and working with local communities to ensure sustainable firewood harvesting and charcoal production. The strategy also emphasizes the development of sustainable forest management practices to mitigate deforestation.
Forestry			
14	Forestry Act, 1997	Provides for the management, conservation, and sustainable utilization of forests and trees.	Regulates forest management, harvesting, trade in forest products, and the establishment and management of forest reserves. The act promotes sustainable forest management practices and the involvement of local communities in forest conservation efforts.
15	National Forest Policy, 2016	Provides the guiding principles and framework for the sustainable management and development of Malawi's forest resources.	Emphasizes participatory forest management, the role of forests in environmental protection (including water catchment protection), and the contribution of the forestry sector to socio-economic development. The policy advocates for the restoration of degraded forest areas and the promotion of alternative livelihoods to reduce pressure on forest resources.
16	National Forest and Landscape Restoration Strategy, 2017	Provides a strategic framework for restoring degraded forest and landscape areas to enhance ecosystem services and livelihoods.	Aims to address drivers of deforestation and land degradation by promoting forest landscape restoration (FLR) activities such as reforestation, agroforestry, and sustainable land management. The strategy supports Malawi's commitments to the Bonn Challenge and the African Forest Landscape Restoration Initiative (AFR100), targeting the restoration of 4.5 million hectares of degraded land by 2030.
Other			
17	National Resilience Strategy (2018–2030)	Aims to create a country resilient to economic and environmental shocks, sustaining inclusive growth, food and nutrition security, and improved well-being for all Malawians.	Comprises four pillars: (1) Resilient Agricultural Growth; (2) Risk Reduction, Flood Control, and Early Warning and Response Systems; (3) Human Capacity, Livelihoods, and Social Protection; and (4) Catchment Protection and Management. The strategy promotes integrated watershed management, sustainable land use practices, and the development of forest-based enterprises to enhance resilience and reduce vulnerability to climate-related shocks.

No.	Item	Key Function	Overview
18	Land Act, 2016	Governs land tenure and management in Malawi, with implications for water and forest resources management, particularly	

3.2 Comments on the Regulatory and Policy Environment

Malawi has an evolving policy framework that, although supports the establishment of a Water Fund or Catchment Investment Programme, has not yet been coherently implemented on the ground through the coordination of various stakeholders. The National Water Resources Act (2013), its supporting regulations (2018), and the National Water Policy (2023) all emphasize integrated catchment management, stakeholder participation, and sustainable financing – key pillars of a Water Fund model. Critical gaps in realising the potential of the regulatory framework at present is coordination between responsible and implementing institutions and the lack of operational funds to undertake catchment restoration and protection.

Nature-based Solutions (NbS), such as reforestation and erosion control, are well-recognized in national strategies including the National Forest and Landscape Restoration Strategy, the National Biodiversity Strategy and Action Plan, and the Integrated Catchment Management Guidelines. These strategies provide a clear mandate for ecosystem restoration to secure water resources and build climate resilience.

A major driver of catchment degradation in the Mudi and Likhubula catchments is deforestation linked to unsustainable charcoal production. This is directly addressed by the National Charcoal Strategy (2017–2027), which promotes alternative livelihoods and forest restoration – interventions that can be financed and coordinated through a Water Fund. It should be noted however that despite such policies being in place, deforestation for fuel continues to be a critical challenge and a potential barrier to the success of NbS efforts if not addressed.

The feasibility study of a CIP in these sub-catchments provides an opportunity to demonstrate how NbS and a water fund model can assist in achieving various policy and strategic objectives as well as achieving institutional mandates. A CIP or water fund approach could serve as a replicable model to expand across catchments or into a basin-wide fund, helping translate Malawi's policy ambitions into tangible outcomes on the ground.

4 Stakeholder Landscape

4.1 Identifying Stakeholders

A high-level desktop review of existing reports, studies and information was carried out to obtain a better understanding of the stakeholder landscape as it relates to catchment management and water resources in the region. The local presence and existing connection of Water for People, the local lead, was also leveraged to gather an in-depth understanding of the stakeholder landscape and profile beyond what was discovered during desktop research. This helped to identify key beneficiaries and stakeholders that would need to be engaged with. Following this work, a field visit was undertaken, which included one-on-one stakeholder meetings, field investigations and community engagements. The field trip helped to generate an interest in the programme and to start to build relationships with stakeholders.

For further details on initial stakeholder engagements, as well as the field trip, refer to Annex A.

4.2 Recognising Core Stakeholders

To ensure the success of a Catchment Investment Program (CIP) it is important to identify the main stakeholders that have both an interest in and capacity to progress the CIP through the programme development lifecycle. A number of key questions typically need to be answered, as outlined below (TNC, 2022):

- Which stakeholders have a direct influence over, or are required to participate in, decisions to address water security, climate adaptation and mitigation, human development and/or biodiversity challenges?
- Which stakeholders are in a position to directly or indirectly support the CIP in addressing the identified challenges?
- Which stakeholders can contribute expertise, knowledge and advice in refining the CIP's SMART[2] Objectives, NbS implementation portfolio, M&E plan, etc.?
- Which stakeholders will experience benefits or negative externalities associated with the CIP's potential execution?
- Which stakeholders have an interest in the process or its outcomes, even if they may not have a specific role to play in problem solving or execution (e.g., elected officials may want to be consulted on large infrastructure projects in their jurisdiction)?
- Which stakeholders might express conflicts with specific roles or responsibilities of a CIP, thereby limiting potential activities of a CIP?

Other aspects to consider include identifying other conservation-related projects and programmes in the region to ascertain if a CIP would be complementary making use of new or previously underutilised resources, or if it would redirect existing resources away from other conservation projects leading to limited net outcomes at a landscape scale. Additionally, it should be considered whether or not a CIP can leverage existing initiatives either by embedding into ongoing interventions or through the scaling of existing initiatives.

4.2.1 Key Stakeholders

After detailed stakeholder engagements, as well as a regulatory review, a number of key stakeholders within both the public and private sectors were identified, due to either their mandatory responsibilities or commitment shown to the long-term protection of water resources within the Mudi-Ndirande and Likhubula sub-catchments. A high-level stakeholder map is shown in Figure 11, providing a diagrammatic view of the roles and direct proximity to undertaking rehabilitation and conservation activities or supporting functions in CIP.

[2] Smart, Measurable, Agreed, Realistic, Time-bound

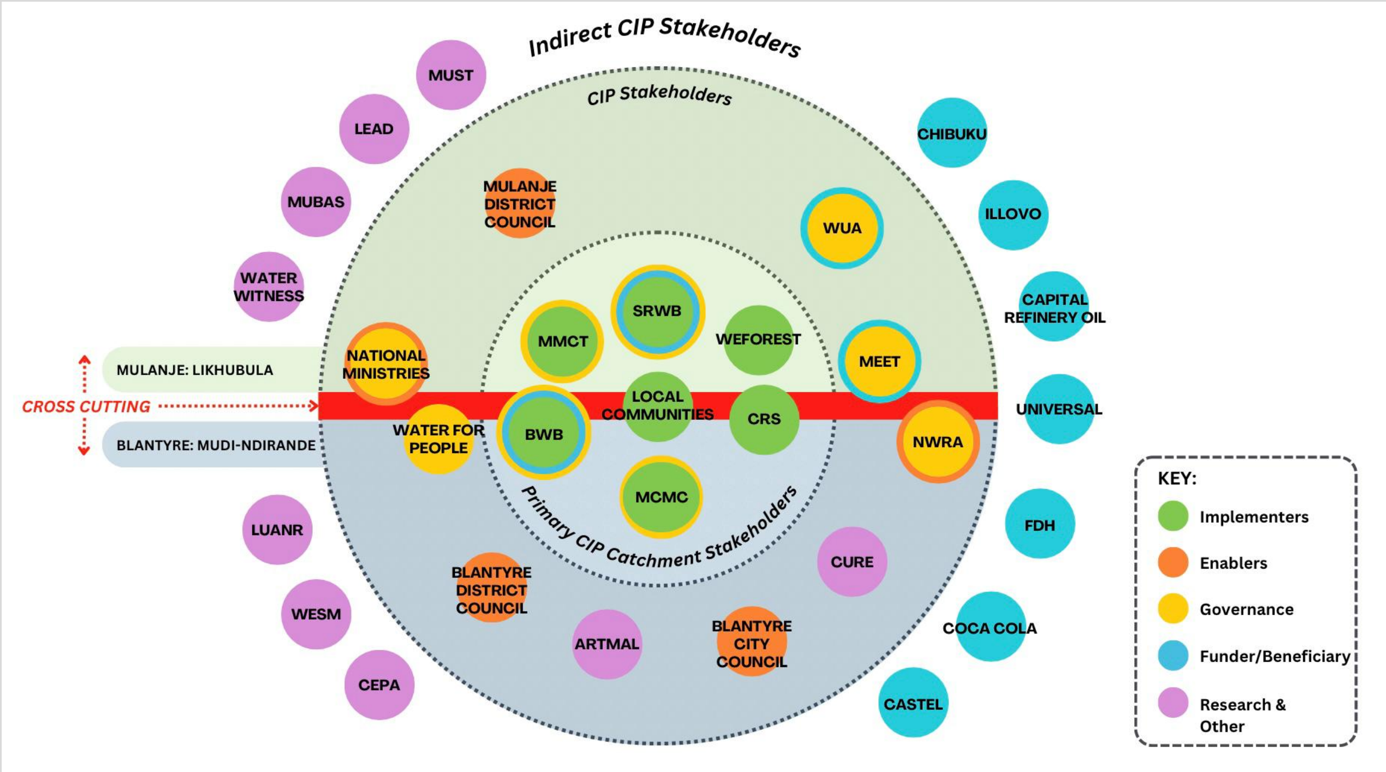


Figure 11: Blantyre-Mulanje CIP Key Stakeholder Map

Table 4 below provides a more detailed summary of the responsibilities of each of the key stakeholders and their respective mandates around water resources management.

Table 4: Key public and private sector stakeholders

Key Stakeholders	Responsibilities or interests in terms of water resources management and protection
Ministries	
Ministry of Natural Resources and Climate Change	Focuses on the protection and sustainable management of the country's natural resources, including water, forests, and environmental affairs. It is responsible for policy formulation, coordination, and monitoring in these sectors. Departments: • Environmental Affairs Department • Forestry Department • Department of Climate Change and Meteorological Services
Ministry of Water and Sanitation	Focuses on water resources management, water supply services, and sanitation and hygiene. While the Ministry of Natural Resources and Climate Change has an overarching role in water resources, the Ministry of Water and Sanitation is dedicated to the development, management, and provision of water and sanitation services. Departments: • Environmental Affairs Department • Department of Water Resources
Ministry of Agriculture	Focuses on boosting agricultural productivity, ensuring food security, and contributing to economic growth and poverty reduction. Its interests lie in promoting sustainable agricultural practices, supporting farmers in adopting modern technologies, and facilitating access to markets to improve livelihoods and the nation's overall agricultural sector performance.
Ministry of Lands	Focuses on management, and sustainable use of land resources, ensuring equitable access and secure tenure for all citizens. Its interests include developing and implementing land policies and legal frameworks, managing land registration and

Key Stakeholders	Responsibilities or interests in terms of water resources management and protection
	surveys, and promoting orderly physical development and land use planning for socio-economic growth.
Government Agencies and Parastatals	
National Water Resources Authority (NWRA)	Responsible for the overall management, development, conservation, and sustainable utilization of the country's water resources, ensuring equitable allocation and access for various uses. Its interests include implementing the national water policy and the Water Resources Act, issuing water use permits, monitoring water resources, and promoting integrated water resources management across all sectors and stakeholders.
Blantyre Water Board (BWB)	Parastatal organization responsible for providing potable water and sanitation services to the city of Blantyre and its surrounding areas. Its interests lie in ensuring a reliable and affordable supply of clean water for domestic, commercial, and industrial use, while contributing to the national economy and environmental sustainability within its service area.
Southern Region Water Board (SRWB)	Parastatal organization mandated to construct, maintain, and extend waterworks for the purpose of supplying potable water to urban and peri-urban areas in the southern region of Malawi, excluding the city of Blantyre. Its interests lie in ensuring a reliable provision of quality and safe water to its customer base across its designated supply areas, contributing to public health and socio-economic development in the region.
Non-governmental Organizations (NGOs)	
Mulanje Mountain Conservation Trust (MMCT)	Environmental endowment trust mandated to conserve the biodiversity and ecosystem health of the Mulanje Mountain Forest Reserve, a critical water catchment area and home to unique species like the Mulanje Cedar. Its interests lie in facilitating responsible management of the mountain's natural resources through community involvement, promoting sustainable livelihoods, and ensuring the long-term ecological integrity of this globally significant area.
Water For People (WFP)	Non-governmental organization focused on achieving lasting access to safe water and sanitation solutions across the country. Their responsibilities include partnering with communities, local governments, and the private sector to build and maintain sustainable water and sanitation systems, ensuring that every family, clinic, and school in their target areas has reliable access now and in the future.
Malawi Environment Endowment Trust (MEET)[3]	The Malawi Environmental Endowment Trust (MEET) is the product of a Working Group established in 1998 comprising the United States Agency for International Development (USAID) Malawi, the Danish International Development Agency (DANIDA), the Government of Malawi (GoM), the University of Malawi and other local environmental and natural resource management experts to find sustainable solutions to environmental problems. The major recommendation of the Working Group was the formation of an endowment fund as a practical solution and answer to Malawi's late and often inadequate funding to environmental programs. The Trust was registered on the 5th March 1999 under the Trustees Incorporation Act of 1962 of the Laws of Malawi (MEET, 2025).
Coordination Unit for the Rehabilitation of the Environment (CURE)[4]	Coordination Union for Rehabilitation of the Environment (CURE) is an apex environmental institution established in 1994. Registered under the Trustees Incorporations Act in 1999 as a Non-governmental organization (NGO), CURE aims to provide technical support and enhance networking among NGOs, the Malawian Government, donors, and other entities working in the field of environment and natural resources management in Malawi (CURE, 2025).
Catholic Relief Services	We work with organizations around the world to help poor and vulnerable people overcome emergencies, earn a living through agriculture and access affordable health care (CRS, 2025).
LEAD	LEAD is an entity that aims to promote & strengthen leadership & resilience in Malawi's ecosystems & communities and to be a leading center promoting leadership in environment & natural resource management (LEAD, 2025).

3 https://www.naturetrust.mw/en/index.php/background/
4 https://cure-mw.org/who-we-are/

In addition, several important corporate stakeholders who produce and provide consumer goods and services in Malawi have a vested interest in securing long-term water supply from the Mudi and Likhubula sub-catchments. These stakeholders who participated in engagements during this feasibility study and expressed an interest in contributing towards NbS and long-term water security are listed in Table 5.

Table 5: Corporate stakeholders with an interest in long-term water security.

Key Stakeholder	Responsibilities in terms of water resources management and protection
Castel	No direct responsibilities in terms of water but they rely on water to process raw materials and produce final product.
Capital Oil Refineries	No direct responsibilities in terms of water but they rely on water to process raw materials and produce final product.
Chibuku	No direct responsibilities in terms of water but they rely on water to process raw materials and produce final product.
Universal	No direct responsibilities in terms of water but they rely on water to process raw materials.
Illovo	No direct responsibilities in terms of water but they rely on water to irrigate crops to grow sugar cane, as well as have high water needs as part of production process.
Coca-cola	No direct responsibilities in terms of water but they rely on water to process raw materials and produce final product.
FDH Bank	No direct responsibilities in terms of water but have interest in stewardship programmes.

It should be noted that there are a number of other government departments, organisations and development partners, not listed above, that support or have an interest in restoration activities within the catchments. The stakeholders identified above, are those that were identified and engaged during this feasibility study. Should this initiative progress further engagement with complementary stakeholders is encouraged.

Communities surrounding catchments in Malawi are reliant on the natural resources within for livelihoods and subsistence. As a result, they are considered a core stakeholder with high levels of both interest and influence in the catchments. During the feasibility study, community stakeholders from both Mudi and Likhubula were engaged. The engagements were facilitated by local organisations that are experienced in the field of environment, climate and water and have existing relationships with the communities. These engagements were done due to the fact that it is well known that these communities are reliant on these areas for livelihoods and as such to solicit an understanding of their relationships with these areas and their views on a potential programme for restoration of these areas. Communities surrounding the catchments need to be engaged with sensitivity and solutions need to be co-developed with communities to ensure success and sustainability. The communities, engagement facilitators and key findings from the engagement is presented in Table 6 below.

Table 6: Findings from engagements from communities surrounding the Likhubula and Mudi sub-catchments

Sub-catchment	Traditional Authority	Group Village Head	Villages	Key findings from Engagement
Likhubula	Nkanda	Nakhonyo	Nakhonyo	• Community Reliance on the Catchment: The Likhubula catchment is both a vital water source and income generator for local communities through diverse activities including farming, tourism, and resource extraction. • Environmental Changes and Challenges: The catchment faces serious environmental degradation including declining water quality/quantity, irregular rainfall patterns, deforestation, and over-extraction of resources. • Root Causes of Unsustainable Practices: Unsustainable practices stem from increasing population pressure, poverty, and a lack of perceived ownership over the catchment resources. • Current Conservation Practices: Some conservation efforts exist, including fire breaks, tree planting, and conservation agriculture, but they appear insufficient to counter degradation. • Cultural Context: Traditional conservation practices that once protected the forest have largely disappeared, with only graveyards maintaining consistent tree protection. • Important Vulnerable Areas: Several tourist attractions and water sources are identified as particularly vulnerable, including Dziwe la Nkhalamba, Chambe Hut, and areas experiencing significant water reduction. • Community Needs and Recommendations: The community prioritizes permanent employment opportunities in catchment management with appropriate tools, training, and local accountability systems. • Interest in Alternative Livelihoods: There is willingness to adopt alternative livelihoods if they provide formal employment and income security, particularly in tourism, catchment management, and climate-smart agriculture.
		Mandanda	Demula; Mwanamvula; M'bwina; Mandanda; Matchuwambo; Mponda; Tchaluwa	
		Matwika	Matwika; Joseph; Miano; Nalifu; Geregere	
		Kazembe	Kazembe; Mangombo; Muhiyo; Nkanda; Chemaliro; Mlava; Mwawalo; Mphuphira; Mcheziwa; Livetere; Mphaya; Mbendera; Msikita	
	Mabuka	Tchete	Gibisani; Mbewa; Kalilombe; Kumwamba; Tchete	
Mudi	Kapeni	Matope	Chakana; Mtambalika; Mlanga	• Communities rely on the catchment for farming, construction materials (sand and stones), trees, and recreational space (football ground). • Environmental degradation has been observed, including reduced water levels, soil erosion, and vegetation loss. • Unsustainable practices are driven by population growth, market demands, and lack of alternative livelihoods. • Current land and water resource management practices exist but may need updating or reinforcement. • Communities are generally open to alternative livelihoods such as beekeeping, tree nurseries, and sustainable agriculture. • Nature-based solutions (NbS) are known to some community members, and they are open to adopting them with proper support. • Traditional and cultural ties to the catchment exist and could support conservation efforts. • Key vulnerable areas include those near Makhetha Primary School, now affected by waste dumping. • There is a need for job creation and alternative income sources to reduce pressure on the catchment. • Communities request support such as training, tools, and funding to improve catchment management.
		Chinupule	Chinupule	

				• Incentives like market access, training, and protective equipment would encourage sustainable practices. • Key concerns about NbS include waste from nearby companies, theft, land availability for nurseries, and market access for products. • Suggested capacity-building measures include employing permanent workers, training in waste separation, and awareness that the catchment benefits everyone, not just BWB.

4.3 Potential Roles and Responsibilities

The stakeholder analysis involved understanding who the key institutions and organisations are within the Mudi-Ndirande and Likhubula sub-catchments, and at the National level, and how they could potentially contribute to the success of a Catchment Investment Programme. The different roles that would need to be filled by the various stakeholders were identified, such as enablers, implementers and funders.

Based on the team's understanding of the key stakeholders, they were assigned various roles (see Figure 12). As can be seen, input from some stakeholders is needed across various roles to facilitate a successful CIP. It is also key to note that a collaborative approach is needed, whereby multiple stakeholders all contribute to the collective action mechanism of a CIP. The process also helped to identify what aspects each organisation could bring to a CIP. It should be noted that this list is not exhaustive – there are likely to be other key stakeholders identified as work continues towards establishing a CIP.

Key stakeholder role definitions:

- **Enabler:** An entity/organisation that provides a conducive environment, allowing others to achieve a desired outcome (i.e. catchment management activities).
- **Implementing Partner:** An entity/organisation that organises, manages or oversees the implementation of catchment management activities.
- **Executing Entity:** An entity/organisation that carries out catchment management activities.
- **Funders & Financing:** An organisation (private, government, industry, etc.) that provides or donates money for catchment management activities.

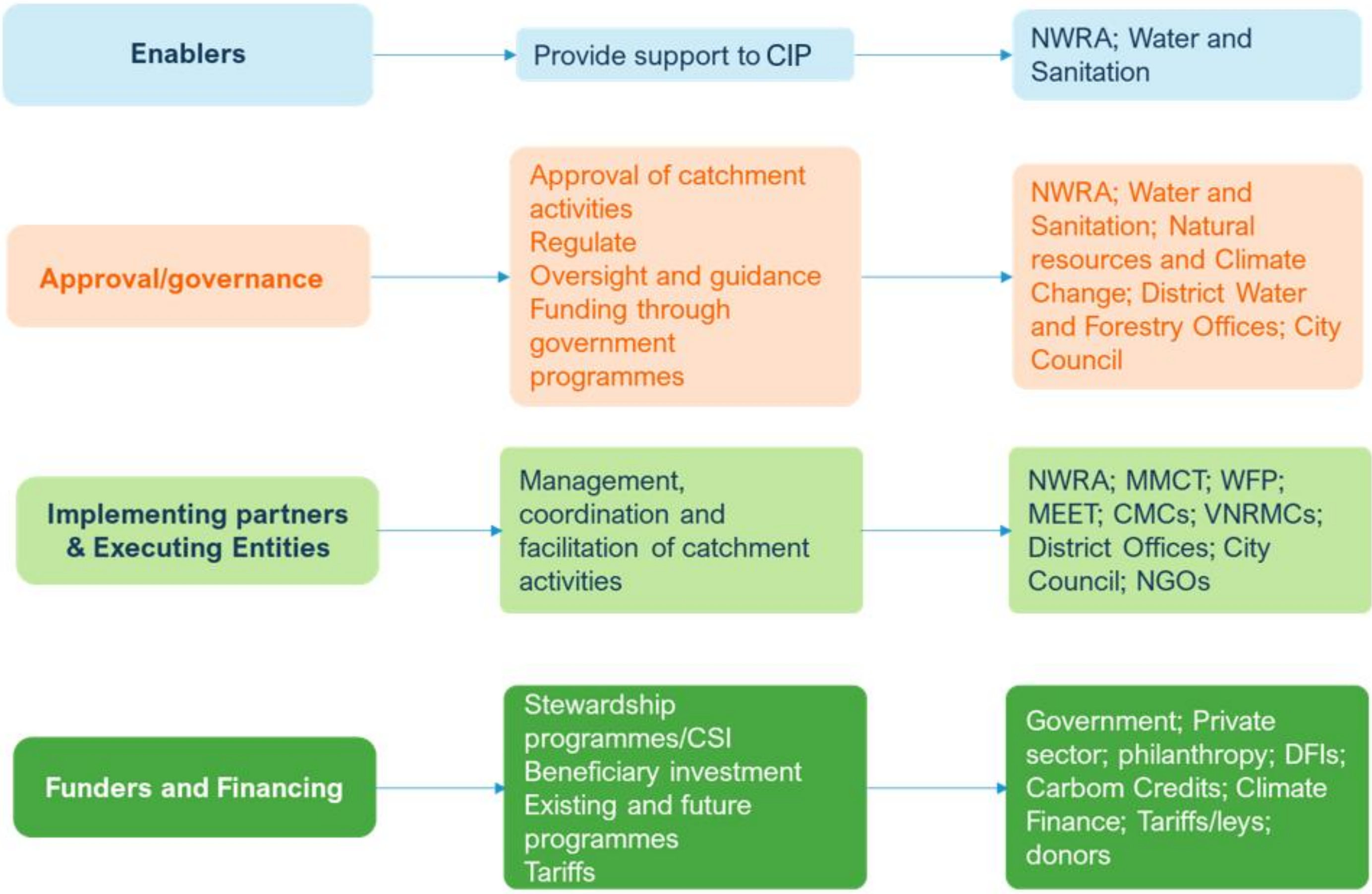


Figure 12: Potential roles and responsibilities of the various stakeholders and corresponding activities.

4.4 Establishing a Stakeholder Committee

To ensure that a participatory approach was followed that encouraged collaboration across key organisation and stakeholders, a Steering Committee, and four technical working groups were established. Stakeholders with a vested interest in water and its long-term availability, were approached and invited to be on the committee in a voluntary capacity. The intention of the committee was to help guide the Feasibility Study to ensure that outputs were co-created with local stakeholders.

A total of three meetings were held where the project team presented on progress, requested input and feedback on the direction of the study and to obtain broad buy-in, providing a platform for questions to be answered and to clarify or address any concerns. It is important that there is a sense of co-creation amongst the stakeholders to improve long-term buy-in and uptake of a CIP. The Steering Committee comprised of the following organisations in Figure 13 were represented by one individual each.

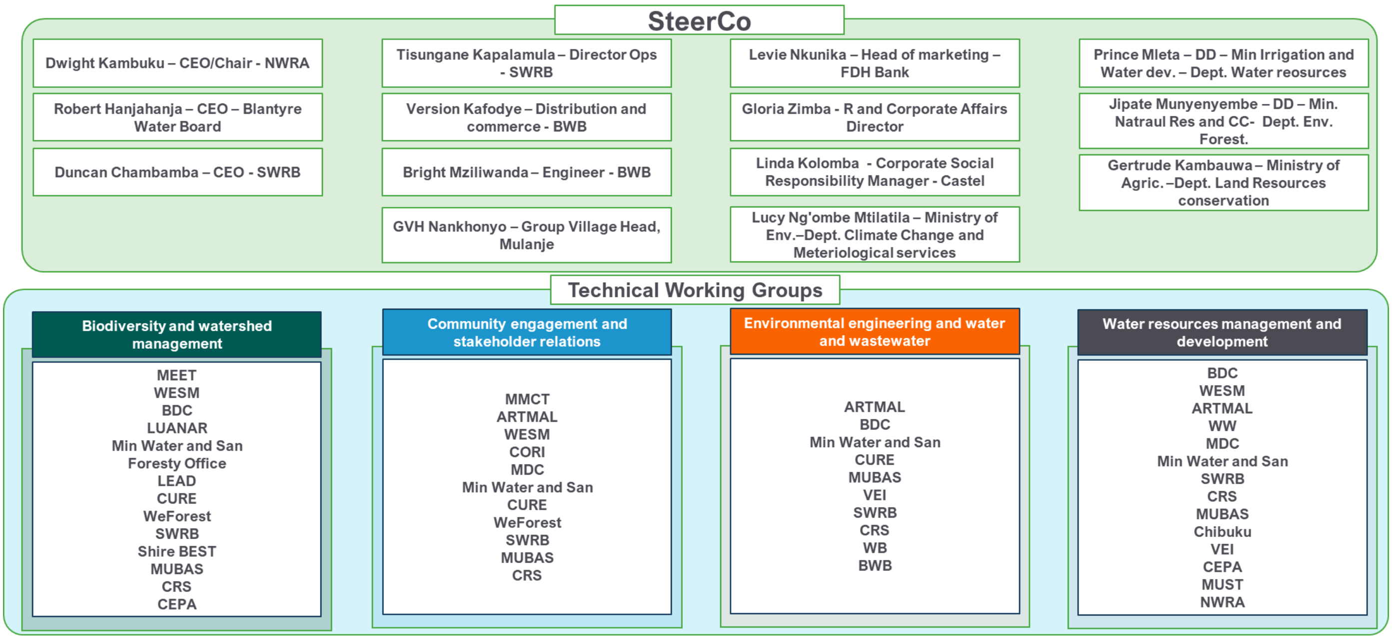


Figure 13: Steering Committee and Technical Working Group Stakeholders

Given the phase of the project, the steering committee was not acting in a decision-making capacity. However, it is encouraging, and a useful finding, that there is clear commitment from key stakeholders across private, public and NGO sectors. The steering committee should continue to discuss issues and make decisions around catchment management going forward. If not for the creation of a CIP at this moment in time, the forum is a helpful coordination mechanism for ongoing initiatives, funding and general alignment between stakeholders in the two sub-catchments.

5 High-Level Governance Overview

The governance process is defined as: *assembling and aligning stakeholders with political influence, vested interest and societal trust that bring credibility to the Catchment Investment Program (CIP) and help the CIP make decisions and implement interventions* (TNC, 2022).

The process can involve stakeholders from all sectors – public, private, civil society, academia – to varying degrees, where stakeholders may become technical or implementing partners, champions for the CIP, or funders and allies.

A clear governance structure should ensure transparency, accountability, and effective decision-making. This may include members, board of directors, and advisory committees. Governance is underpinned by systems of rules, practices and processes, which gives confidence to stakeholders, partners, funders, etc. In addition, good governance can provide a method to balance interests between stakeholders.

In terms of documentation, the governing principles and standards are typically captured in charters, governance documents, bylaws, Constitution, Memorandum of Incorporation, or articles of association.

It is helpful, particularly in the context of Malawi, to understand the existing institutional arrangement, roles and responsibilities as it relates to catchment and water resources management. The section will begin by describing the existing institutional arrangement with a brief analysis of it. This will be followed by a presentation of potential governance structures for a CIP in Malawi. It should be noted that the exact institutional composition appropriate for a CIP would require a more detailed analysis that would need to take consideration of scale, capacity and the objectives of the programme, should a CIP be deemed feasible to go ahead in the future.

5.1 Water resources governance in Malawi

There are several government institutions in Malawi with mandates that are either, directly or indirectly, related to water resources. At the National level, the 3 key ministries include Water and Sanitation, Agriculture and Natural Resources and Climate Change. The National Water Resources Authority, a designated authority under the Ministry of Water and Sanitation is arguably the most critical government stakeholder due to its mandate for implementing integrated water resources management in designated source water catchments. The responsibility for catchment restoration and development is devolved from the NWRA to catchment and sub-catchment management committees. These committees act as local participatory catchment governance units. At the district level, Water Offices play a critical role in district service delivery and implementation and water and sanitation programmes and are therefore directly reliant on the mandates of those responsible for managing resources.

Similarly to other Southern African and developing states, engagement with various stakeholders and literature on the topic suggests that there is a lack of policy implementation and coordination amongst various authorities with overlapping mandates with respect to water resources and catchment management. The results of this are outdated policy and legislation as well as a lack of enforcement of the regulatory/legislative framework. Critically, the National Water Resources Act makes provision for the devolution of catchment management to CMCs, water user associations and Water Tribunals, however, only 1 CMC has been legally gazetted and as such there is very little capacity to coordinate and manage catchment restoration and development programmes. It is understood that bureaucratic processes, limited financial resources and limited coordination of local stakeholders may be key factors, among others, that have limited the designation of further CMCs (Chunga, et al., 2022).

Table 7 provides a summary of the roles and responsibilities of key water sector institutions and provides a high level assessment of their capacity to fully enact undertake their mandates.

Table 7: Roles, responsibilities and capacity assessment of water sector institutions

Institution	Role	Key Responsibilities	Capacity Status
Ministry of Water and Sanitation (MoWS)	Lead policymaker and sector coordinator	• Develop water policies and strategies Coordinate sector institutions Engage donors and mobilize resources	Moderate capacity; policy leadership strong but stretched on coordination and monitoring
National Water Resources Authority (NWRA)	Regulator of water resources	• Issue water use permits Monitor abstraction and discharge • Maintain hydrological data • Promote catchment planning	Moderate but growing; human and technical capacity constraints, especially at decentralized levels
Catchment Management Committees (CMCs)	Local participatory water governance units	• Facilitate catchment planning Resolve local water conflicts Promote conservation at community level	Weak; legally mandated but not fully operational or funded
District Councils & District Water Offices	Decentralized service delivery and planning	• Implement district-level water and sanitation programs Coordinate with local NGOs and communities	Limited; highly resource-constrained, lacking technical personnel and planning capacity
Ministry of Agriculture (MoA)	Oversees irrigation and water for agriculture	• Implement irrigation policy Develop and manage irrigation schemes	Strong presence but coordination with NWRA on water permits and sustainability is inconsistent
Department of Forestry, Ministry of Natural Resources and Climate Change	Oversees forest resources and catchment protection	• Manage forest reserves and forest policy Implement reforestation and catchment protection programs Regulate land use in forested catchments	Critical but underfunded; strong policy intent but limited field enforcement and intersectoral integration
Environmental Affairs Department (EAD)	Regulates environmental impact of water use	• Conduct and review EIAs Monitor water pollution Enforce environmental standards	Moderate; national-level capacity stronger than local enforcement capability
Malawi Energy Regulatory Authority (MERA)	Regulates hydropower-related water use	• Ensure compliance with water/environmental standards in energy projects	Adequate; coordination with NWRA on water allocation is a gap
Development Partners & NGOs	Technical and financial support for governance and implementation	• Fund infrastructure, data systems, and restoration Pilot governance models (e.g., catchment committees)	High influence; provide innovation and support, but often operate parallel to formal institutions

The Malawi Water Resources Master Plans discusses the need for alignment to Integrated Water Resource Management (IWRM) for successful preservation and development of Malawi's water resources (JICA, GoM, 2017). The master plan outlines a coordination mechanism to enable IWRM as shown in Figure 14. Although this structure relates to IWRM, this type of coordination is critical for the success of a CIP. It should be noted that coordination at the local/catchment-level is also critical and would need strengthening in order to implement or scale CIPs in different catchments and sub-catchments across Malawi.

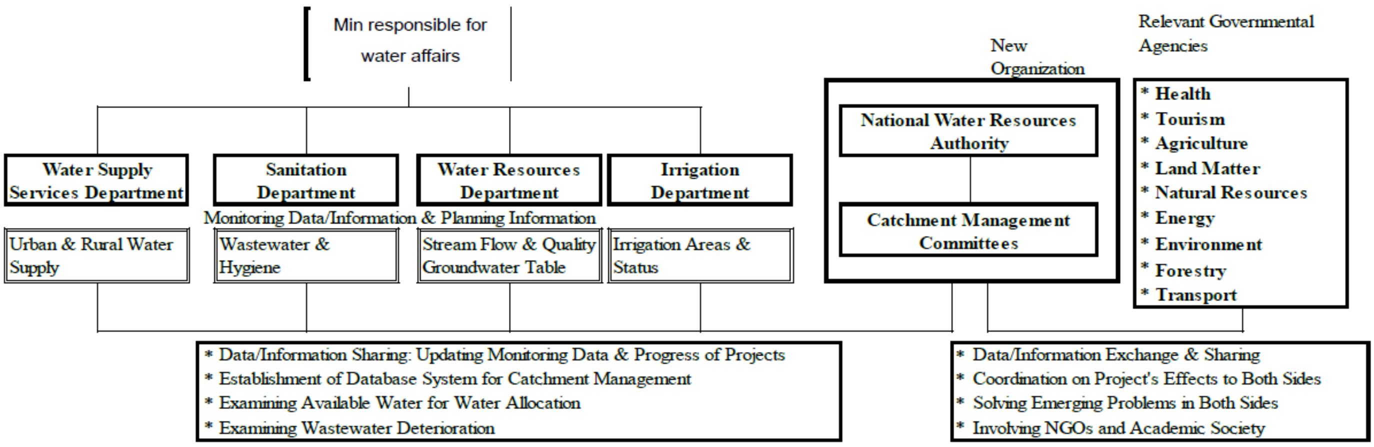


Figure 14: Institutional structure and necessary coordination for IWRM in Malawi (JICA, GoM, 2017)

5.2 Common Governance Models

Three common governance models that are typically considered for a CIP include:

1. Umbrella Agreement
2. Hosted Programme
3. Dedicated Vehicle (Independent Entity)

However, the final governance arrangement will need to reflect the local context and be acceptable to key stakeholders. The governance arrangements may also evolve over time as the CIP develops. A brief outline of these models is provided below.

5.2.1 Umbrella Agreement

An Umbrella Agreement is usually an MoU or collaborative charter between multiple parties, which outlines how they will and will not work together to accomplish a shared goal. Stakeholders often execute their own, separate implementation plans based on their own theory of change. Signatories agree to loosely coordinate with one another on certain aspects; most commonly sharing data around implementation and monitoring and evaluation. Signatories do not usually work together to mobilize funding and each party manages their own finances / funding separately.

In an umbrella agreement, there may or may not be a steering committee depending on the desired degree of coordination among parties and, in some cases, an organization, permanent or rotating, may serve that coordinating function as the chair. Their roles may include the following (TNC, 2022):

- Convening and co-designing an annual meeting for signatories, including those who are not on the steering committee;
- Coordinating organizations interested in advocating for policy change that could widely benefit the CIP;
- Collecting, synthesizing and publicly publishing data for all signatories to access; and
- Reporting the CIP's impact.

Figure 15 provides an example of a typical organisational structure of an Umbrella Agreement.

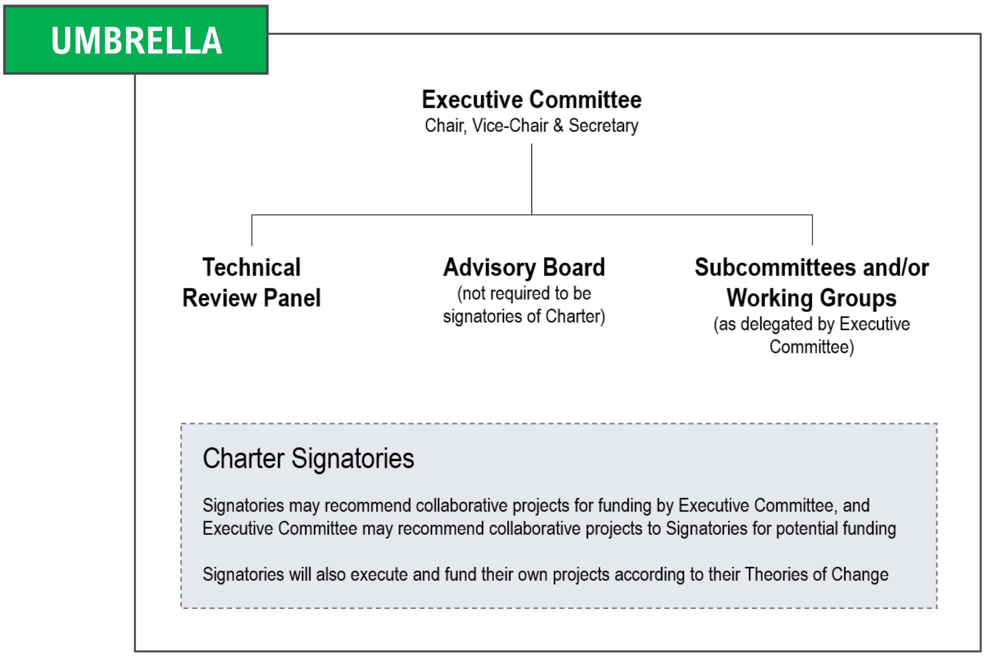


Figure 15: Example of an Umbrella Agreement organisational structure.

5.2.2 Hosted Programme

In a Hosted Programme, one organization primarily manages the development of the CIP but is usually guided by a steering committee comprised of relevant partners. Roles, responsibilities and programme details are typically defined in Memorandum of Understanding (MoU).

The steering committee's role is to give direction to the CIP and act as a consultative forum for partners, while the hosting organization is responsible for keeping the CIP on track. To assist the operational aspects, the hosted programme may establish technical working groups or sub-committees, focusing on specific aspects requiring dedicated attention, such as monitoring and evaluation, resource mobilization, funding, etc.

The size of a steering committee is important, as too many individuals may lead to decision-making paralysis, while the opposite may mean that crucial stakeholders are left out. To assist with achieving the right balance, ad-hoc members or advisory groups of subject matter experts could also be a consideration.

Implementation can either be executed by the hosting organization or contracted out to other entities. It is important that the hosting organization fosters transparency among all implementing organisations around aspects like data sharing, funding, execution plans, etc. This will be important to ensure the programmes' efforts are additive to one another and to track impact at scale, even if they are not formally engaged with the CIP.

A hosted program can be nested within a number of entities, including a catchment authority, utility, corporation and/or nonprofit. The hosting organization should be aware of the commitment, dedicated capacity, time and resource requirements needed to host a successful CIP.

Figure 16 provides an example of a typical organisational structure of a Hosted Programme.

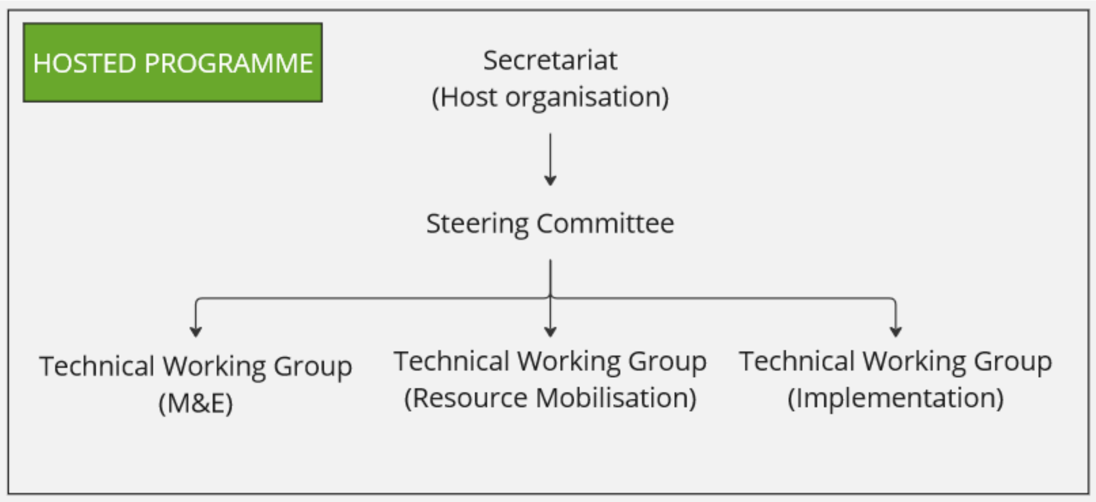


Figure 16: Example of an organisational structure for a Hosted Programme.

5.2.3 Dedicated Vehicle / Independent Entity

A Dedicated Vehicle is an autonomous, legal entity with its own staff and standard operating procedures. The most common dedicated vehicle is a tax-exempt organization, also commonly referred to as a not-for-profit, nonprofit or public benefit organization, which can take from 6 to 18 months to establish, depending on the country. Due to the time taken to establish such a legal entity many CIPs wait until they have executed for a few years before exploring the potential for a dedicated vehicle.

Dedicated vehicles are required to adhere to local regulations and laws impacting how they operate and as such it is important to understand the positive and negative aspects of such a model.

Within a dedicated vehicle, there are several common models to consider, with the following being the two most common (TNC, 2022):

- *Dedicated vehicle managed by a separate organization through a management contract or an MoU* – In this case, the dedicated vehicle could have a group of founding members, but a separate entity would be contracted by or enter into a mutual agreement with the board to perform select functions on behalf of the dedicated vehicle.

- *Dedicated vehicle managed by in-house staff that functions as an independent entity* – In this case, the dedicated vehicle usually has a group of founding members, a board, and its own staff, including a managing or executive director who reports to the board. The director is responsible for executing on the CIP's strategic plan. This can include hiring staff, implementing either in-house or through contractors, delivering annual impact reports, securing funds and more.

Figure 17 provides an example of a typical organisational structure of a Dedicated Vehicle / Independent Entity.

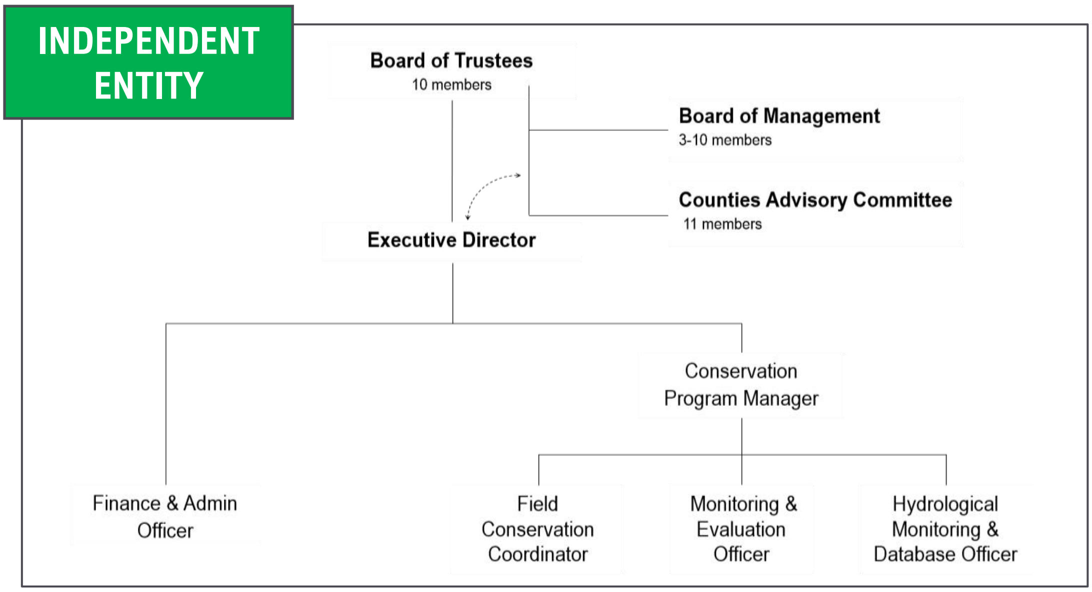


Figure 17: Example of an organisational structure for a Dedicated Vehicle / Independent Entity.

5.3 Comments on CIP Governance in Malawi

While the above-presented options could all work to varying degrees, these options need be considered in more detail and within the local context. As such, further in-depth discussions are needed with NWRA, the Ministry of Water and Sanitation, Catchment Management Committees, NGOs and private sector to better understand the role that these key entities can, should or want to play.

5.3.1 A view of CIP governance in Malawi

Through the feasibility project, investigation on existing institutions, capacities and capabilities was conducted. The aim was to try and understand, at a high level, what a potential governance structure might look like. An illustrative CIP governance model is presented in Figure 18 which provides an overview of the governance mechanisms required from a national governance level down to the local catchment-level. This illustrative governance model takes into consideration institutional mandates and the respective interests of each entity. Given the provisions of the Water Resources Act, it is recommended that local, catchment-level CIPs and associated governance structures are congruent and contribute to successful implementation of the act through supporting the enablement of the various institutional mandates, whilst ensuring the intended impacts and outcomes of the CIP (Water Security, community upliftment and livelihood opportunities, climate mitigation/adaptation and biodiversity preservation/upliftment) are achieved.

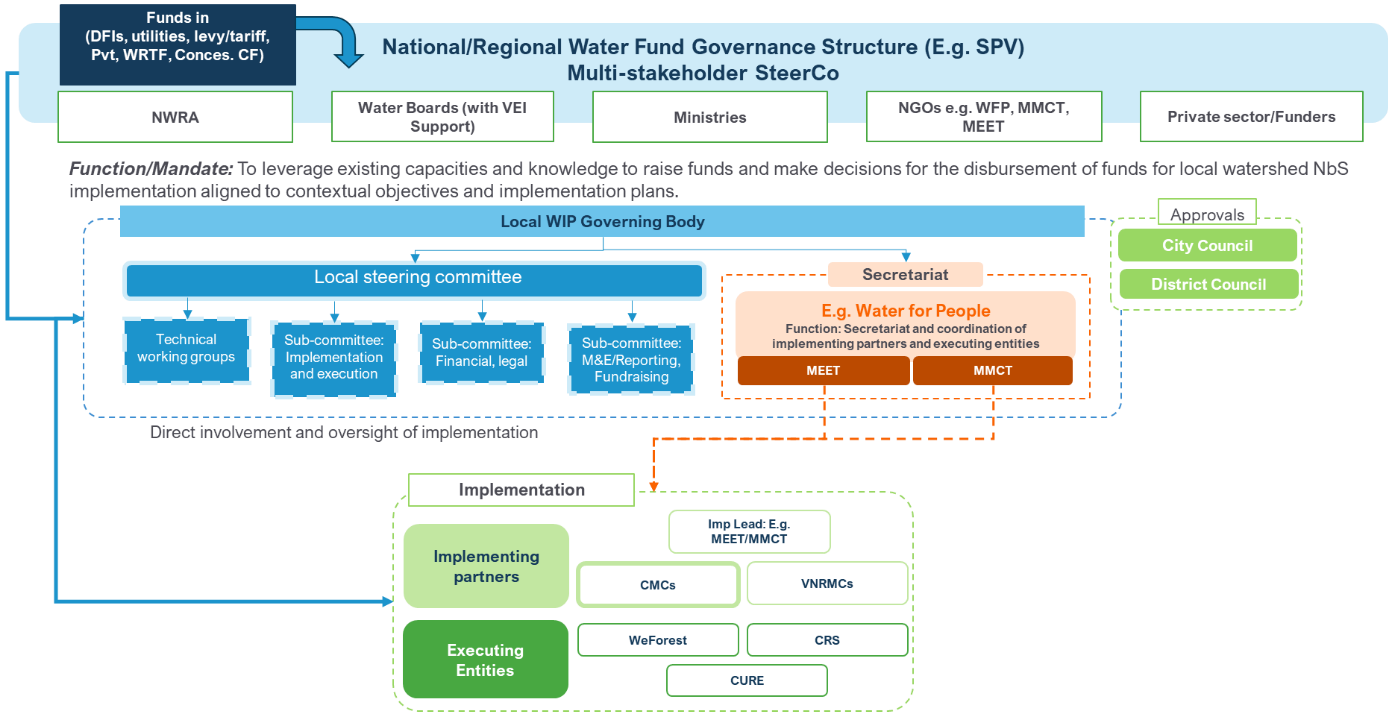


Figure 18: Illustrative CIP governance model

In order to progress beyond this feasibility study, towards the establishment of a CIP, the key organisations illustrated in this governance model should continue engagement to refine specific governance roles and responsibilities. In other contexts, through N4W's experience, formal Steering Committees have been useful vehicles for refining and implementing appropriate governance structures. The intention for this CIP, and others in Malawi, would be to work with the current Steering Committee and other key stakeholders to understand who would be willing and able to remain involved and to identify additional roles and responsibilities needed within this governance structure, whilst ensuring that it remains a suitable mechanism for achieving intended outcomes. The purpose of a Steering Committee would be to help move and guide the programme forward, towards the establishment of a CIP. This will assist in moving towards establishing an appropriate structure that can support a CIP and be replicable and scalable to other source water catchments in Malawi.

6 Science Analysis and Approach

6.1 Scientific Analysis Preparation

In order to mobilize stakeholders to invest in a catchment investment programme, a strong and realistic financial case is needed. To achieve this, a comparison is needed of the conservation (intervention) scenario against a Business as Usual (BaU) scenario. Due to the complex landscapes in Malawi and the lack of observed data, hydrological models were adopted to model the potential gains that may result from rehabilitating the landscape. The modelling approach was undertaken in parallel with the identification of suitable NbS. The most cost-effective locations for investment were identified through modelling the spatial outputs of the hydrological benefits.

The scientific analysis followed a step-by-step process that collated available data, identified the key challenges in the landscape, what the natural landscape should or could look like and the impact upon communities and livelihoods. This feeds into the economic analysis, where some benefits are monetised and some are assessed qualitatively. An additional modelling approach was undertaken to model habitat quality in the catchment.

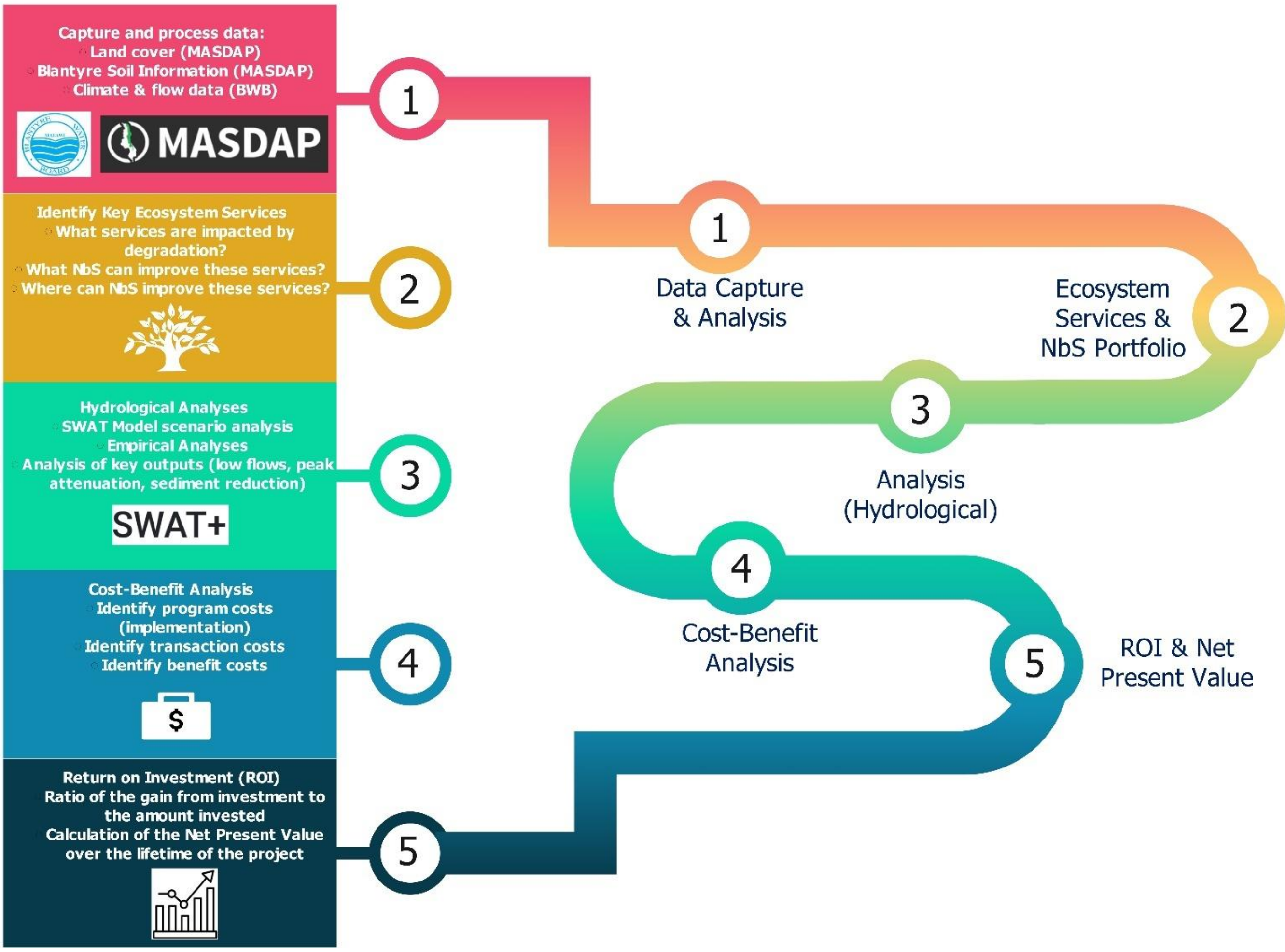


Figure 19: Roadmap of the integration of data collection, scientific modelling and the economic analysis

6.2 Model Selection

In Malawi, models such as the Soil Water Assessment Tool (SWAT), WEAP, MIKE SHE, HEC-HMS and the WFLOW model are just some of the models that have been used for catchment-scale investigations. Each model has its own advantages and disadvantages, largely linked to data requirements and model complexity. In order to model NbS implementation scenarios, the following are required:

- The model needs to be spatially explicit to the extent of capturing land use changes and buffers.
- The model needs to integrate land and water management.
- It must allow for climate process flexibility.
- It needs to incorporate water quality including, inter alia, suspended solids or turbidity.

Due to the limited data at the sites of interest, the recent development of the SWAT GIS interface and the level of land use information required for the scenario modelling, SWAT was chosen as the most appropriate model to use. The input required for SWAT is spatially explicit soils data, land cover and land management information, and elevation data to drive flows and direct sub-basin routing (Arnold, 2005). SWAT lumps the parameters into hydrologic response units (HRU), effectively over-riding the underlying spatial distribution. These HRUs are grouped according to the topography, soils (type/structure/depth/chemical properties), land cover and slope (Figure 20).

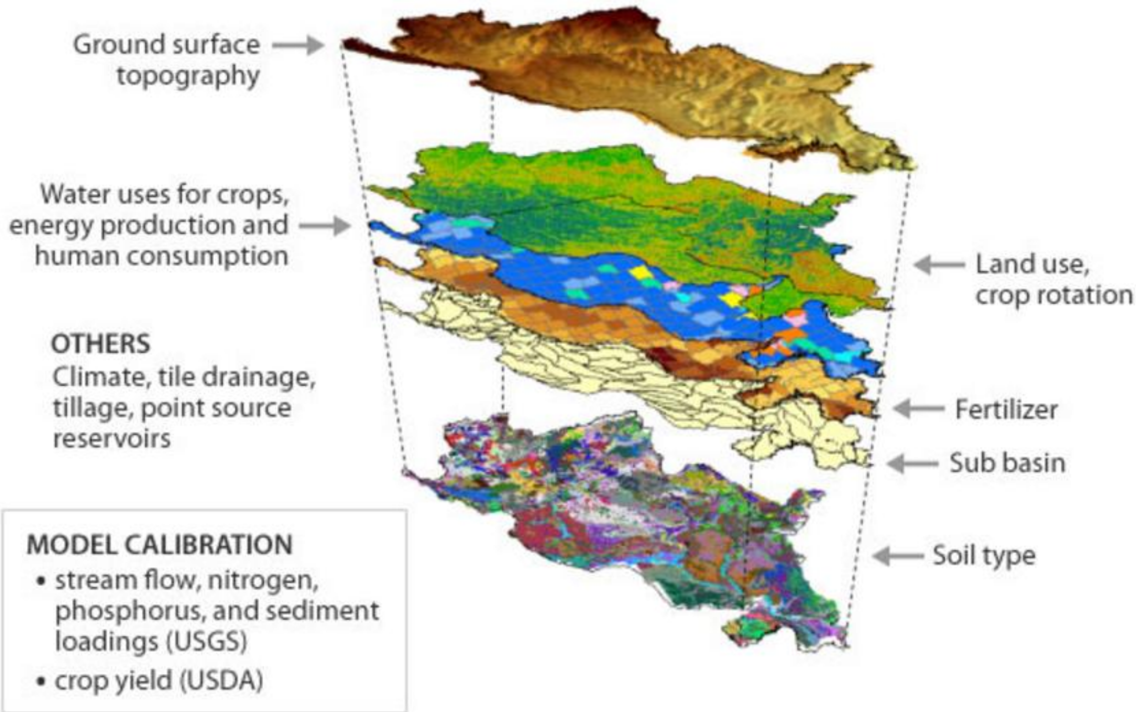


Figure 20: Conceptual layout of the SWAT model setup (Arnold et al., 2012)

One of the most important drivers for hydrological simulations is the meteorological data, which has been vastly improved in this model over recent years. SWAT has options to use measured solar radiation, wind speed, relative humidity and evaporation data. Daily rainfall and temperature data may be generated if unavailable or missing for the simulation period and there are no limitations to the number of rainfall and temperature gauges that can be used in the simulation (Neitsch et al., 1999).

6.3 Data Collation

A key component of sound hydrological modelling is the collection, analysis and validation of observed data. Hydrological models require sufficient lengths of data (preferably 30 years or more) in order for the simulation results to be considered to be realistic. This section details the data used to setup the SWAT model.

6.3.1 Climate Data

Weather Data Definitions were modified to allow for user defined data to be included. All the data was obtained from a combination of datasets including the following:

- Global Climate Hazards Group Infrared Precipitation with Stations (CHIRPS). Quasi-global satellite and observation based precipitation estimates over land, 1981 to near-real time.
- Global CHIRTS-daily is a quasi-global (60°S – 70°N), high-resolution (0.05° x 0.05°, approx. 5km) data set of daily maximum and minimum temperatures.
- Ndirande Hill Daily Rainfall (2017 to 2021) – Department of Water, Malawi.
- Chichiri Daily Rainfall (2010 to 2021) – Department of Water, Malawi.
- Chichiri Monthly Rainfall (1955 to 2017) – Department of Water, Malawi.
- Mt Mulanje weather station (African Mountain Research Foundation).

Due to the small size of the catchments, relationships were derived to synthesise a new rainfall record. A table was created for the rainfall station including the Station ID, location and altitude. This was edited into the SWAT database. Individual .csv files containing daily rainfall and temperature.

6.3.2 Elevation Data

Digital elevation models (DEMs) were used to configure the catchment by dividing it into sub-basins or sub-catchments. The automatic watershed delineation tool, which is the first step undertaken in the model, allows for the creation and selection of outlet nodes and the determination of sub-catchment properties and river reach attributes. Depending on the resolution of the DEM used, either a manual or automatic setup can be chosen.

The 30 m Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global DEM was used as the point of departure for the catchment delineation. The resolution of this DEM is 30 m by 30 m. However, this DEM does not provide accurate heights in areas of tall vegetation. Verified point and contour data was used to correct any errors and interpolate a higher resolution model. WGS 1984 UTM Zone 36S was used as the projection for this area (SWAT requires all layers to be projected uniformly and UTM is the most commonly used projection for hydrological studies).

6.3.3 Land Use/Land Cover Data

The land-use landcover (LULC) mapping process is a central component used to understand the catchment characteristics, which then guide identifying potential NbS priorities. The interrogation high-resolution satellite imagery allows for the refinement of existing landcover databases, which are often mapped at a crude resolution. Furthermore, the use of historical images allows for temporal changes to be captured, such as the progression of degradation and land use change. Of importance, if imagery is available prior to human intervention, the natural state can be determined which forms the best possible intervention target. The following approach was taken:

a) The MASDAP database was used to obtain the digitised 2016 landcover.
b) Landsat 8 imagery was used to digitise a new landcover dataset for different time periods. The existing dataset was used to populate the vegetation types.

c) A site visit was undertaken to 'ground-truth' the newly derived dataset. This was undertaken in conjunction with local partners to ensure that data was accurately captured.

6.3.4 Soils Data

The major soil types in southern regions of Malawi are Luvisols, Lixisols, and Cambisols, with the latter being more common in the southern region. Cambisols and Luvisols generally have good natural nutrient characteristics but are susceptible to exploitation through agricultural activities.

The input of soils for hydrological modelling is one of the more difficult definitions to translate outside of the United States. The soils .csv database was edited to include attributes for each soil type identified in the spatial layers obtained through MASDAP. A 'lookup' file was used to code the data from the spatially explicit polygon to match the code in the database. Soils data was checked using the GIS interface and modified if required. Soil properties that influence runoff potential are those that impact the minimum rate of infiltration for bare soil after prolonged wetting and when not frozen (Everson *et al*., 2006). These properties include:

- Depth to seasonally high water table;
- Saturated hydraulic conductivity; and
- Depth to a very slowly permeable layer.

Soil may be placed in one of four groups of increasing runoff potential: A (low stormflow potential), B, C, and D (high stormflow potential), or three dual classes, A/D, B/D, and C/D. Some of the soils information collected for the catchment is provided in Figure 21. However, further detail was used for soil depth and texture.

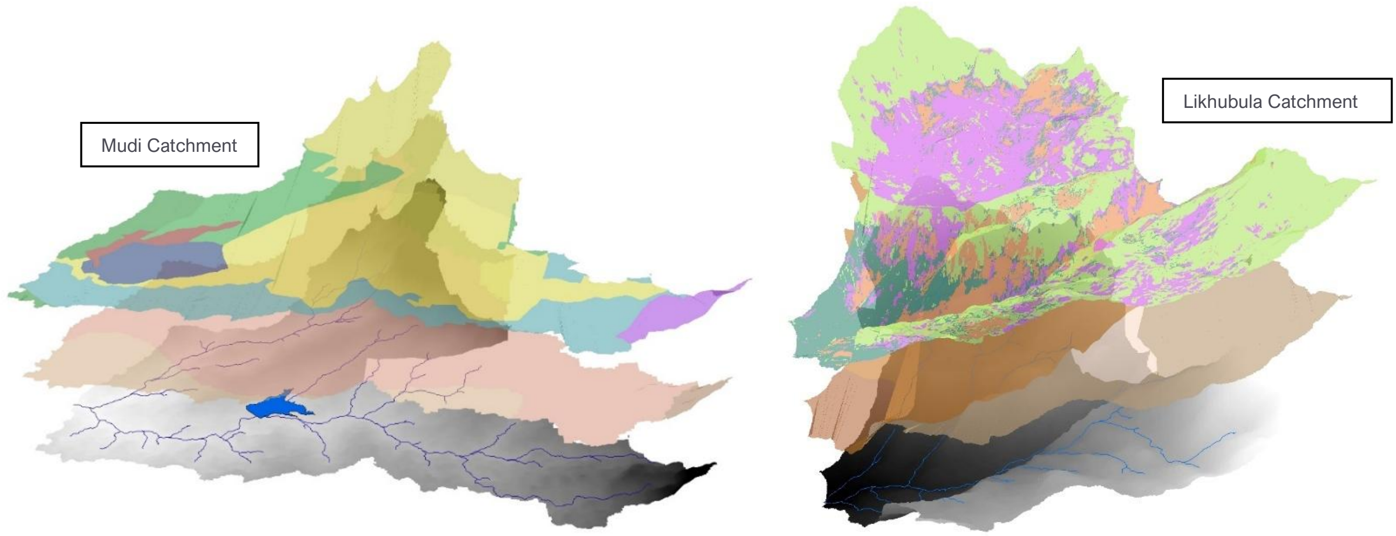


Figure 21: Elevation, soils and land use data used to derive hydrological response units for each catchment.

6.3.5 Flow Data

Flow data, which is a key requirement for accurate hydrological modelling, was obtained from limited sources. The Department of Water Resources, Ministry of Agriculture, Irrigation and Water Development have undertaken handheld flow measurements (Braystroke meter) below Mudi dam intermittently since 2019. As the flow out of the dam has become non-perennial, these measurements were only taken during periods of flow.

a) Mudi/Ndirande Catchment: Scribed records (DWR).
b) Likhubula Catchment: Very limited data was available.

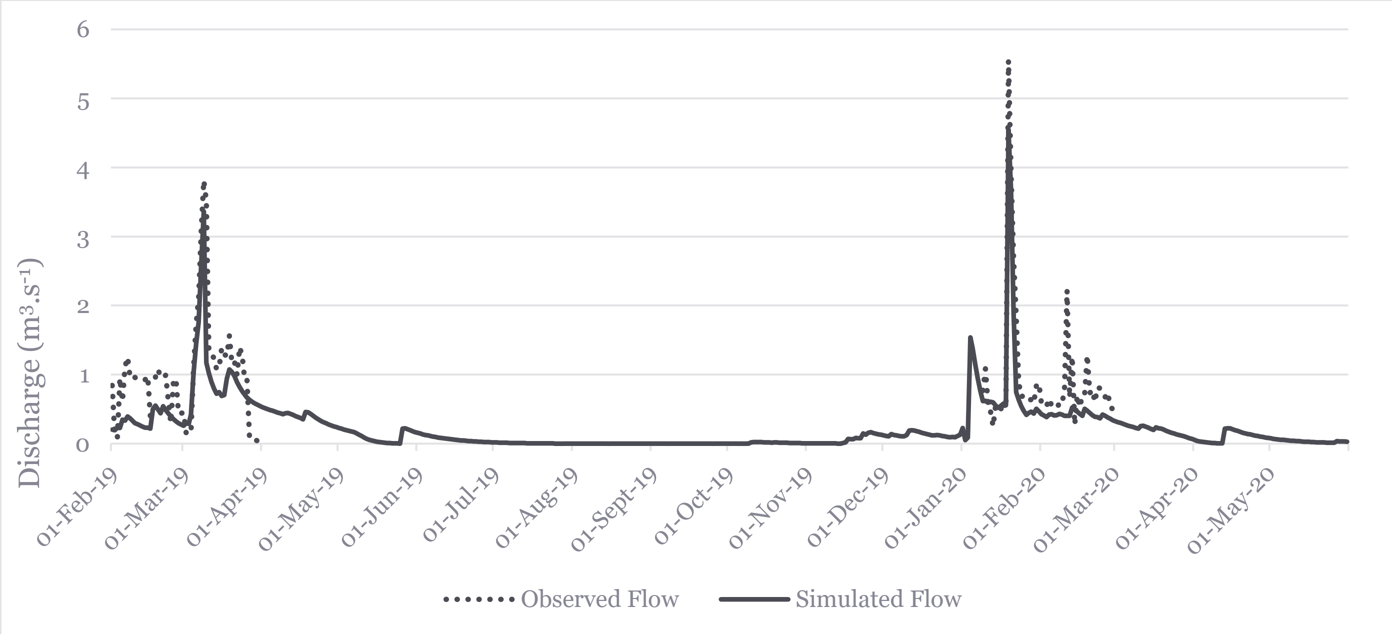


Figure 22: Simulated versus observed flow out of the Mudi catchment.

6.4 Reservoir Modelling

There are three ways that a reservoir/lake can be added in QSWAT+. The adopted approach used a digitised shapefile of the dam footprint. The volumes of the dam were later corrected in the SWAT+ Editor. The reservoir simulations were aimed at evaluating the changes in volumes and sediment of the dam under a BaU and intervention scenario, thereby quantifying the potential benefits in reliability and longevity/sustainability.

The Mudi Dam was built in 1953 at a capacity of 1.4 million m^3 at FSC. Sediment load at this point was assumed at 0. A projection was undertaken beyond the SWAT simulation using average sediment loads trapped in the dam. The simulated loss of storage was in alignment with the present-day estimates (65% loss of volume).

The outputs from the dam simulations are estimates and therefore are indicative results. Actual reservoir operations data is still needed from BWB to implement operating rules and validate volumes with a bathymetric survey.

6.5 Scenario Analysis

In order to appropriately capture the water security challenges identified in the selected catchments and the subsequent interventions to address these challenges, a set of scenarios have been derived to capture and quantify the potential benefits. Interventions are quantified through comparisons with an implementation against a ‘Business as Usual (BaU)’ future scenario. These scenarios are summarised as:

1. **Scenario 1** (Baseline scenario): This scenario is the reference scenario to represent the status quo, allowing for model calibration and validation to be performed. It represents the current or historical conditions within the study area including present-day land cover and land management conditions and historical climate data (2000 to 2024).
2. **Scenario 2** (Business as Usual scenario): This scenario is the reference scenario to represent the likely projection, against which all other scenarios can be compared to allow for the quantification of realised benefits through the various interventions identified. It represents the likely future land cover and management conditions (2000-2024).
3. **Scenario 3** (Intervention scenario): This scenario involves intervention scenarios of the NbS (2000-2024):
    a. Landscape restoration involves the return of miombo woodland and riparian buffers.

b. Agricultural Best Management Practices (AgBMPs) involves the inclusion conservation tillage, cover cropping and mulching.

6.6 Sensitivity Analysis, Calibration and Validation

The effectiveness of the SWAT+ parameter sensitivity and optimization model (Abbaspour, 2015) was tested using a very small observed dataset. Streamflow data was compiled for the outlet of the Mudi catchment. Initial plant growth input parameters were derived based on expert opinion and documented literature. A sensitivity analysis was performed for 12 parameters that were identified as being crucial in the simulation of streamflow.

The plant uptake and soil evaporation compensation factor (EPCO and ESCO), initial SCS runoff curve number for moisture condition II (CN2), maximum canopy storage (CANMX), the maximum potential LAI and decline of LAI (BLAI and DLAI) and SOL_AWC had a high sensitivity and thus an impact of the streamflow. The groundwater delay time (GW_DELAY) and "revap" coefficient (GWREVAP) also influenced the water yield component of the sites.

Given that limited observed data was available, a manual calibration was undertaken to improve the closeness of fit of the simulated data with the observed data. However, this did not allow for the assurance that peak events are appropriately captured. As such, the model was not validated. The lack of data indicates the need for monitoring and evaluation in the area to improve pre-implementation estimates and provide post-implementation metrics.

7 Unpacking the Priority Nature-Based Solutions

Following successful site-based and satellite-based mapping of degradation areas in each catchment, a refined list of NbS was derived that were conceptually applied to the relative degradation area. These interventions were discussed at length with various stakeholders throughout the lifespan of the project.

As identified in Section 2, the Mudi-Ndirande and Likhubula catchments are currently under threat of urban expansion, illegal logging, unsustainable land-use activities, variability in climate conditions, and increasing water demand from population growth and economic activities. These compounding threats have compromised the already strained water supply in the area. Four priority NbS interventions were identified – reforestation, Rangeland Best Management Practices (RBMPs), Agricultural Best Management Practices (AGBMPs), and nature-based enterprises. These are further explained in the following sections.

7.1 Reforestation

Malawi faces a significant deforestation problem and proliferation of alien invasive species continues to remain a problem in many catchment areas. Reforestation efforts will focus on planting of indigenous tree species to assist restoring the catchment back to its original state. Indigenous species have a lower water demand and support the biodiversity in the catchments. By ensuring indigenous trees are dominant, the catchment can expect better water yields, the strengthening of plant and animal habitats and better overall catchment health.

7.2 Rangeland Best Management Practices

Rangeland best management practices, in this case, encompasses three interventions that focus on restoring rangeland or grassland to their natural state. The three interventions include:

1. Firebreaks
2. Invasive Alien Plant Clearing
3. Training on regenerative practices (including sustainable timber harvesting)

These interventions aim to protect the natural landscape from both environmental/climatic threats as well as anthropogenic threats. In some cases, these issues can be viewed as drivers of on another. For example, with increasing population growth and encroachment of settlements in or closer to catchment areas, the risk of deforestation and fire outbreaks increases. Intervening to reduce this risk is critical for success. Of course, increasing prevalence of wildfires is also driven by longer dry seasons and climate change.

Both catchments are vulnerable to the proliferation of alien invasive tree species. Pine, in particular, has had a significant impact on the catchments in Mulanje. These species have significant impact on water yield and on the ability for indigenous tree species to regenerate.

7.3 Agricultural Best Management Practices

Due to poor land-use practices, such as loss of vegetation and deforestation, rainwater is able to run-off the land as opposed to infiltrating into the ground. As such, overland flows lead to erosion and run-off with many gullies and erosion channels dotted around the landscape.

The installation of terraces strategically located over agricultural lands in the catchments will help to not only slow down overland water, facilitating greater infiltration, impacting groundwater recharge and dry season water availability. Terracing also helps to reduce soil loss and enhance growing conditions for plants and crops. This is particularly important in these catchments where agricultural practices are taking place on steep slopes with high sediment yields.

The interventions also include cover-cropping. Cover cropping involves planting species such as grasses or brassicas during fallow periods to improve soil conditions. These crops provide ground cover that reduces wind and water erosion, particularly on exposed or sloped fields. Their root systems improve soil structure by breaking up compaction and enhancing water infiltration, which supports better moisture retention. As the cover crops decompose, they contribute organic matter that improves soil health and long-term productivity.

7.4 Nature-based Enterprises

Communities surrounding catchments are reliant on the resources within and as such, developing solutions that provide economic benefit to the communities is critical. This study investigated the development of tree nurseries and bee-keeping to create livelihoods and economic activities that support catchment restoration. By equipping community members with the materials and skills to grow tree seedlings, a local value chain around reforestation can be created where communities receive income for the seedlings used to reforest the catchments. Similarly, bees play an important role in pollination, supporting the proliferation of plant species. By equipping communities with materials and skills for bee-keeping, they will support the health of the catchment and be able to generate income from honey and wax produced by the bees. It should be noted that the design of livelihood solutions is critical to ensure that unintended consequences are avoided. It was noted in past engagements that communities have been granted permission to conduct, or have been involved in, catchment activities which have led to further degradation, particularly through agricultural activities within the catchment areas.

7.5 Delivery Model

Given the context of the two catchments and the socio-economic context of Malawi, it is worthwhile exploring how interventions such as these would be implemented. The overarching framework for implementation suggested by this study includes:

1. Employment/cash for work to community members to undertake activities and implement interventions. This will likely take a **contract-management model** where individuals are employed for a period to undertake activities.
2. The programme would need to supply all materials, equipment and training.
3. Officers would need to have their mandates/responsibilities expanded to include specific monitoring and oversight responsibilities related to the specific interventions in the catchment.
4. The CIP governance structure will be responsible for ensuring that implementation is guided and overseen, funds are received, managed and disbursed and be responsible for all planning, engagement and administration.

8 Scenario Modelling of Nature-based Solutions

Modelling of NbS is a relatively new component of hydrological modelling, with limited empirical data to support scenario testing. The application of NbS in models ranges from crude approaches (changing basin wide parameters) to more complex approaches, such as specific interventions applied to certain landscapes. SWAT is highly suitable for NbS scenario modelling due to the ease of changing land-uses, the detailed land use management inputs and built-in approaches for the simulation of NbS. A summary of the SWAT modifications for NbS has been provided in Annexure C. The benefits of implementation are estimated based on the difference between a future "Implementation" scenario and an alternative "business-as-usual" (BaU) or a "Do Nothing" scenario, high level intervention areas are shown in Figure 23.

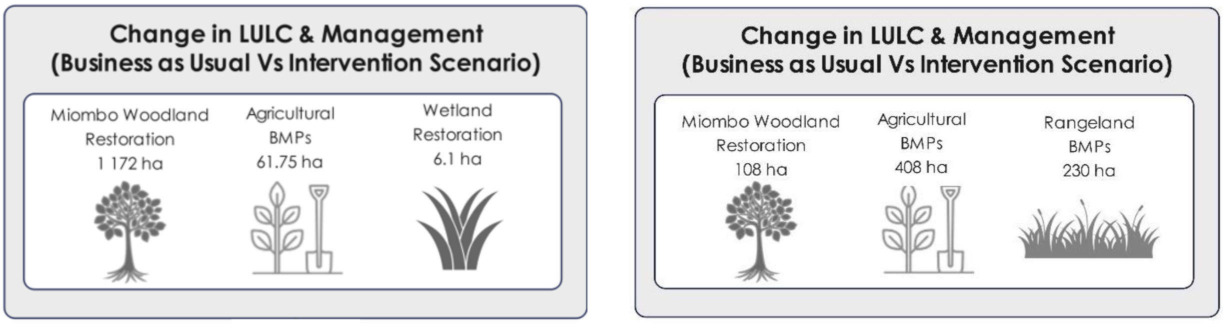


Figure 23: Priority NbS are the intervention areas for the Mudi/Ndirande catchment (left) and the Likhubula catchment (right)

8.1 Benefits of a Catchment-Level Investment Programme

The highlighted water security challenges, such as settlement expansion, deforestation, invasive alien plant (IAP) species, poor fire management, and unsustainable agricultural practices, have led to reduced baseflow, increased sediment loads and declining water quality in many of the country's rivers. These issues are further aggravated by the region's high rainfall and steep terrain, which accelerate soil erosion and sedimentation processes. The relative difference is captured through hydrological benefits (modelled) and landscape benefits (spatially and empirically calculated).

8.1.1 Hydrological Benefits

A large area of the Mudi/Ndirande catchment is not available for intervention due to the urban nature of the catchment. However, most of the area upstream of Mudi dam could be rehabilitated. This would require community buy-in and alternatives to the demand for firewood and charcoal.

The analysis identified key hydrological benefits (Table 8). The overall water yield is increased through the interventions. This is largely attributed to the removal of high water using exotic species, that have dominated the landscape. Of importance, the baseflow could be improved by 40%. This would significantly improve the water levels in Mudi dam. Annually, an increase of 5 million m3 could be gained after full implementation is achieved. Due to increased cover and attenuated flow in the catchment, a significant reduction in sediment loads could also be achieved.

Table 8: Annual water balance summary for the Mudi/Ndirande catchment.

Annual Water Balance Summary				
Partition	**Business as Usual**	**Improved State**	**Change**	**% Change**
Surface Runoff (mm)	827	988,03	161,03	19,47
Base Flow (mm)	224,39	315,46	91,07	40,59

Percolation (mm)	256,18	339,71	83,53	32,61
Aquifer Recharge (mm)	12,69	16,83	4,14	32,62
Water Yield (mm)	1051,39	1303,49	252,1	23,98
Channel Sediment Load (ton)	39440	14982	-24458	-62,01
Streamflow (MCM)	23,34	28,937	5,597	23,98

The Likhubula catchment is in a largely natural state. However, the ongoing interventions need to be quantified (these interventions are partially in action under the leadership of MMCT). The modelled improvements show the benefits of the removal of alien plant species, the improvement of miombo woodland areas and the improvement of rangeland areas through BMPs.

The results for this high rainfall catchment indicate that there are elevated improvements in streamflow (up to 38% increase), with a significant portion of this being comprised of improved baseflow (Table 9). This is as a result of improved vegetative cover, which promotes infiltration and increased return flow. This improves the sustainable flow, particularly in the low rainfall periods.

Table 9: Annual water balance summary for the Likhubula catchment.

Annual Water Balance Summary				
Partition	**Business as Usual**	**Improved State**	**Change**	**% Change**
Surface Runoff (mm)	462.11	628.23	166.12	35.95
Base Flow (mm)	64.5	98.49	33.99	52.70
Percolation (mm)	96.83	131.65	34.82	35.96
Aquifer Recharge (mm)	4.84	6.58	1.74	35.95
Water Yield (mm)	526.61	726.72	200.11	38.00
Streamflow (MCM)	11.69995768	16.1459016	4.445943925	38.00

Flow duration curves were derived for each of the catchments. The comparative differences between the scenarios showed that the Mudi catchment would experience a 4% reduction in the drought period. This translates to an increase of 14 days per year where water could still be abstracted, in contrast to no availability in the BaU scenario.

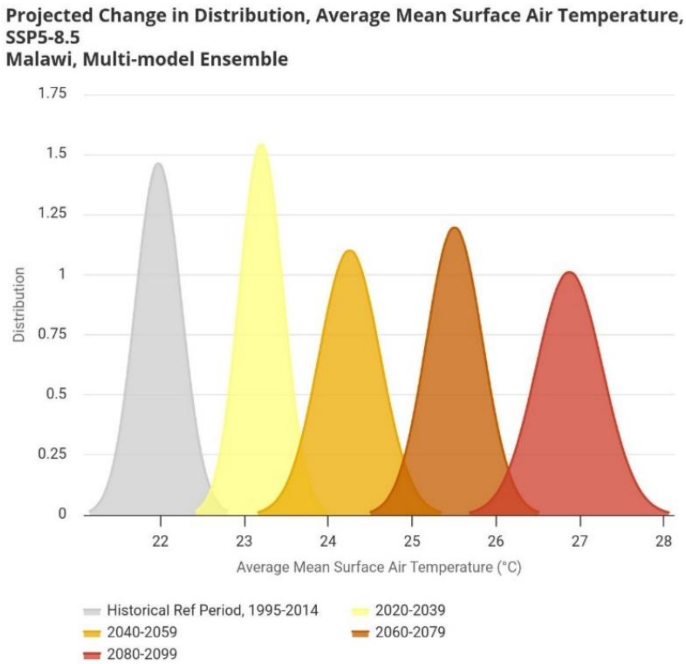
The Likhubula catchment would experience a 3.5% reduction in the drought period. This translates to an increase of 12 days per year where water could still be abstracted, in contrast to no availability in the BaU scenario.

An extreme value distribution using Log Pearson Type 3 distribution was calculated for the catchments. As the peak events are so extreme (tropical cyclone events), the reduction in peaks is small. A 2.3% reduction occurs between scenarios. Although small, this improvement is desirable to adapt to future extreme climate events.

8.1.2 Climate Adaptation

An increase in peak rainfall events, extended drought periods and an increase in temperature associated with a changing climate exacerbate the aforementioned landscape challenges in Malawi, according to the World Bank Group Climate Risk Profile for Malawi (2021). Using the Coupled Model Inter-Comparison Project Phase 6 (CMIP6) data ensemble, and considering the SSP5-8.5 high reference scenario, **mean surface air temperature changes are expected to increase by more than 2.0°C in the 2050s** and by 5°C by 2100 (Figure 24). Water resources are likely to be increasingly strained across the country as a result of warmer temperatures accelerating the rate of evapotranspiration for the country. This results in more frequent and severe droughts.

According to climate change projections, annual **precipitation levels are expected to decrease by up to 36mm by 2050**, while peak events increase. These shifts suggest a higher likelihood of extreme weather events, including more frequent and prolonged droughts and heat stress.



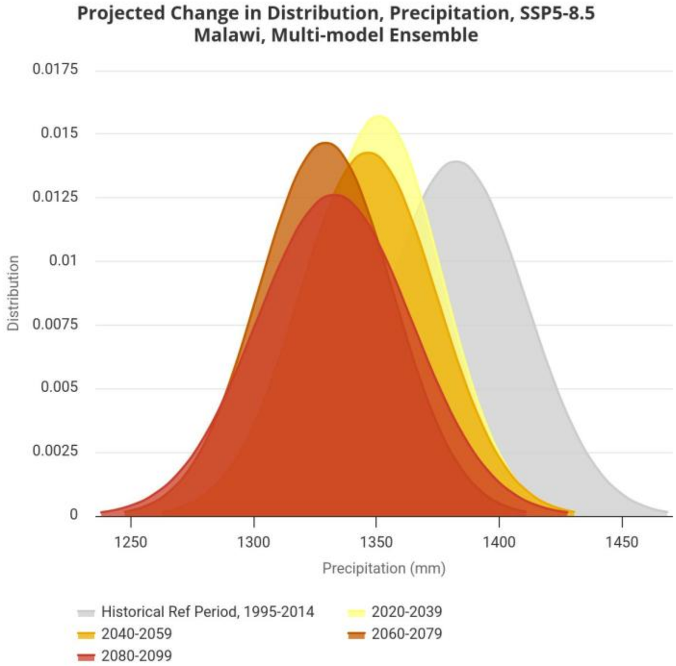


Figure 24: CMIP6 projected change in temperature (left) and precipitation (right) for Malawi.

The increasing frequency and severity of tropical cyclones and extended droughts are attributed to the broader impacts of climate change. The predominantly poor and rural population relies heavily on land production. These projected climate risks emphasise the need for NbS to provide long-term benefits that are effective in climate adaptation.

8.1.3 Water Supply Benefits

A reservoir analysis was undertaken considering the combined supply sources for Blantyre Water Board (BWB). This allowed for the relative difference between improved inflow to be captured, while also accounting for the avoided loss of storage in the dam due to sediment storage.

BWB currently supply the following (BWB, 2021):

- Maximum Supply (based on infrastructure)= 122 million ℓ/day.
- Blantyre City Demand = 140 million ℓ/day.
- Actual Supply = 80.5 million ℓ/day.

Through a Catchment Investment Programme (CIP), the following benefits could be achieved after full implementation (abstractable yield-not total flow increase):

- Mudi Dam could increase its yield by 4.6 million ℓ/day through increased inflow and avoided storage loss.
- Mudi Dam lifespan would be increased to beyond 2050.
- Likhubula Offtake could increase its yield by 6.01 million ℓ/day.

This would potentially allow the actual supply to be increased to 91.11 million ℓ/day or take reliance off the Walkers Ferry contribution (high treatment costs) to a split of:

- Walkers Ferry: 72%.
- Mudi Dam: 11%.
- Likhubula: 17%.

Using the simulation, it is estimated that Mudi Dam will no longer be able to store any water by 2044 (with a gradual but significant loss of yield up to this period). Figure 25 provides these results showing only the allocations of Mudi Dam and the Likhubula Offtake (excluding Walkers Ferry contributions).

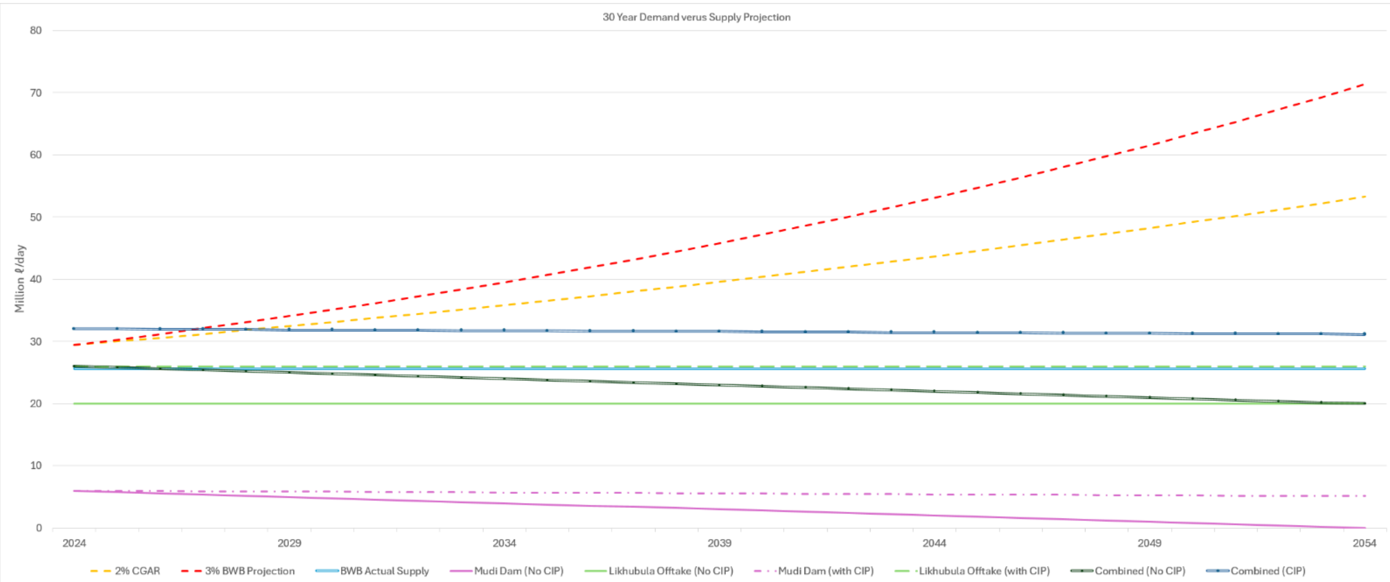


Figure 25: Projected demand versus supply for BWB with and without a CIP

8.1.4 Biodiversity Benefits

Miombo woodlands, dominated by *Brachystegia, Julbernardia,* and *Isoberlinia* species, are biodiversity hotspots, providing critical habitat for flora and fauna while delivering essential ecosystem services. Improving these irreplaceable hotspots not only improves flora and fauna but is also directly linked to livelihoods. Miombo woodlands store between 30 to 100 tons of carbon per hectare, vital for climate mitigation.

The habitat quality analysis undertaken using the InVEST model (Figure 26) shows that the vast majority of the catchment is under threat and is projected to be of low quality. Small pockets would remain as high quality. This finding supports the need for continued efforts in the catchment.

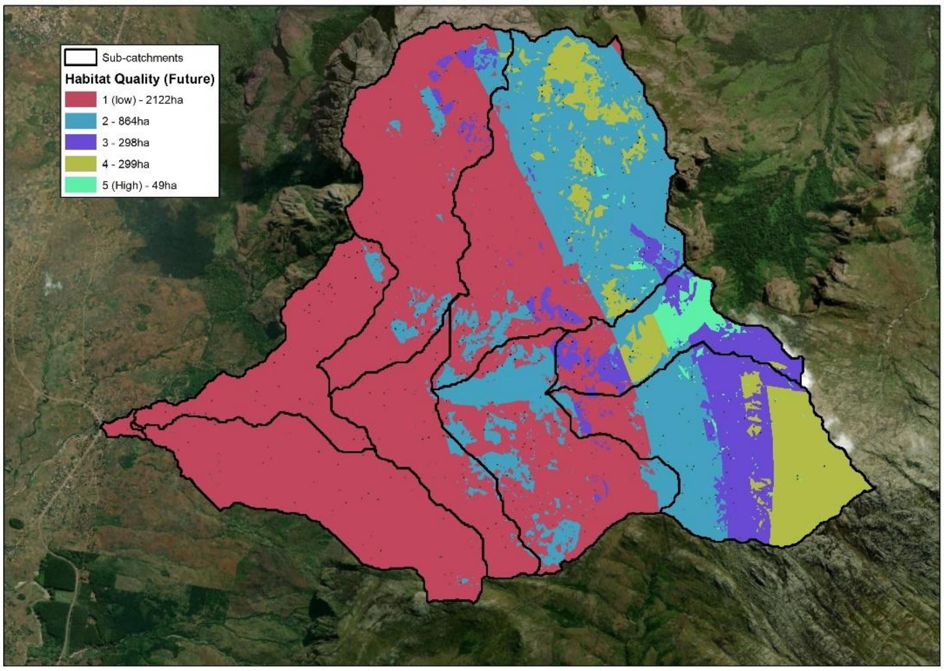


Figure 26: Projected habitat quality for the Likhubula catchment

8.2 Structured Implementation for Long-Term Success

For programmes at a catchment scale to be effective they need to integrate a structured approach that connects interventions to areas of highest return. In addition, local implementers, land owners and accessibility should be considered in guiding where interventions should occur first. This also assists the economic analysis in staggering the costs and benefits at a realistic rate.

As a point of departure, the annual average water yield and sediment reductions were mapped throughout the catchments. These benefits were reclassified into five classes (low to high). A spatial multiplication was then undertaken to combine these benefits. A second reclassification (natural breaks) was done to simplify the benefits into five management zones, ranging from the lowest benefit (Zone 1) to the highest benefit (Zone 5). Areas were adjusted according to land use type. By strategically aligning investments with ecosystem service benefits and financing opportunities, implementing NbS at scale can serve as a model for sustainable catchment management.

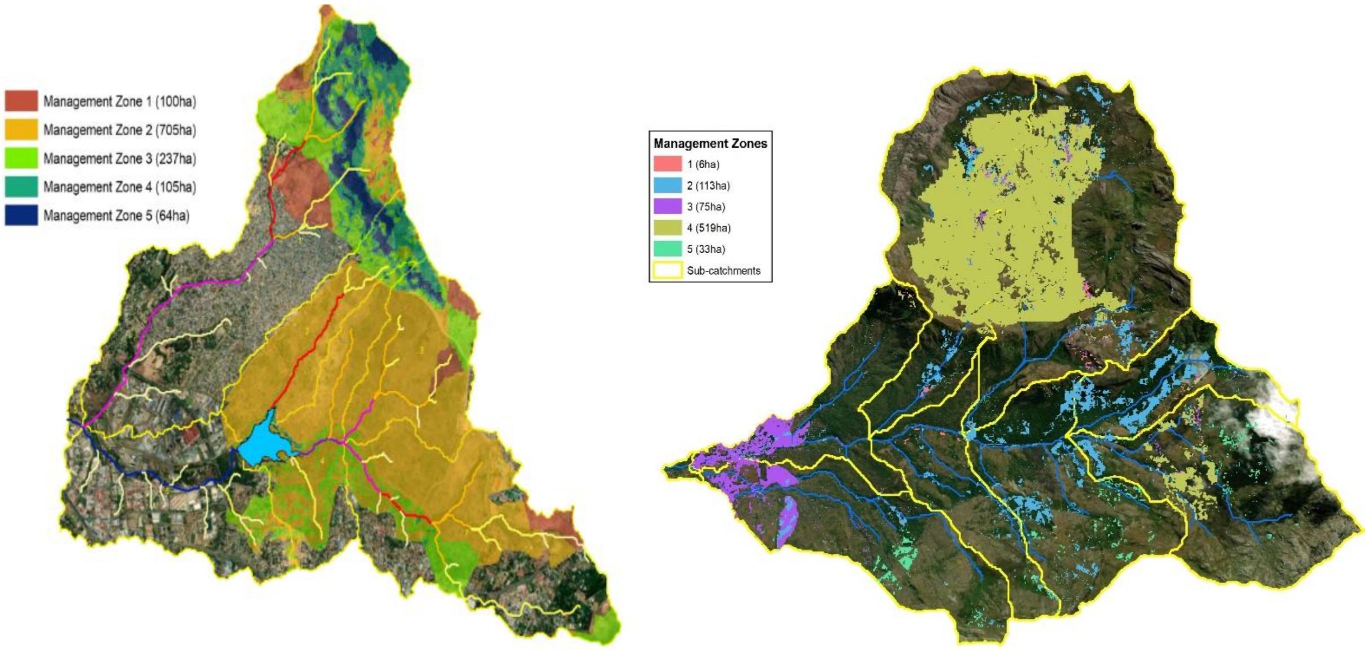


Figure 27: Management zones designed for each catchment

9 Financial and Economic Analysis

The economic analysis for the Blantyre-Mulanje Catchment/Catchment Investment Program Feasibility Study used a cost-benefit analysis approach to understand the socio-economic and financial feasibility of the program. The analysis presents the detailed costs and economic benefits associated with the programme in monetary terms. This includes the analysis of the costs and benefits of the program and developing financial decision metrics, including Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR), that help quantify the financial impact of the programme over a 30-year period.

The analysis is a useful tool to communicate the overall feasibility of implementation and to indicate the benefits of implementation in a form easily understood by a range of stakeholders and investors including government, the private sector, communities, philanthropies and other potential contributors. The analysis broadly followed four key steps:

Step 1
- Valuing the benefits of NbS (cost-benefit analysis)

Step 2
- Estimating the costs of NbS based on implementation scenario

Step 3
- Building a discounted timeline

Step 4
- Evaluating the net benefit of a WIP within the Mudi and Likhubula sub-catchments

Additionally, the economic analysis serves as a tool for prioritising implementation. This helps decision makers, implementation planners, and the CIP decide if and where certain NbS should be prioritised.

Further to the above, the analysis provides an estimate of the total cost of the program, and allows for a comparison on the approaches proposed to alternative or traditional approaches used elsewhere. The analysis also seeks to answer the questions of "Who benefits from the NbS programme?", "How much do they benefit?" and "What other or co-benefits can it generate?". In addition, a high-level analysis of potential funding and financing sources was conducted, to understand their value and likelihood.

9.1 Summary of analytical approach and presentation of outcomes

This section outlines the approach and results to determining the financial and economic costs and benefits of the proposed NbS for the Mudi and Likhubula catchments.

Each benefit is discussed in detail outlining a description of the benefit and calculation logic, core assumptions and data used in the benefit calculations followed by presentation of the result of the benefit calculation. All benefits quantified and monetised are then presented in summary format. A similar approach is taken to present the result of the cost estimation exercise.

The section is concluded by comparing the costs and benefits in a CBA approach. The concluding section presents charts comparing the costs and benefits as well as the key financial and economic decision-metrics for assessing the return on investment of the proposed NbS in the catchments.

9.2 Analytical Framework and Assumptions

The economic analysis of the CIP uses several inputs and assumptions to model the full life cycle costs and benefits attributed to the CIP for different beneficiaries over a 30-year period. Where possible, actual figures from implementation partners and stakeholders have been used, however in some instances appropriately justified assumptions were made.

The following key assumptions have been made in the model:

- The financial model relies on the outputs of the scientific modelling and assumes that the planned implementation will be successful. A phased implementation approach, whereby different management zones within each catchment were prioritised based on the scientific modelling, has been adopted to create an ROI output that aligns with scientific recommendations for NbS implementation in both catchments.
- A discount rate of 4.3% has been used to calculate the net present value of all costs and benefits. This was based on "Cost-Benefit Analysis of National Resource Management in Malawi - Technical Report" (National Plannning Commission, Copenhagen Consensus Center, 2021).
- The model does not incorporate inflation. This is an adopted economic modelling principle and allows consistency and a standardised approach for comparison.
- A Malawian Kwacha (MWK) to US dollar (USD) exchange rate of 1 735 was assumed for the model.[5] All outputs were calculated in USD and were presented in USD to mitigate against potential currency fluctuations that would affect local prices for imported goods.[6]
    - The model used a staggered mortality rate to calculate the expected replanting/maintenance needs of all reforestation efforts. This assumption used the national mortality rate for tree planting programmes from the 2022-2023 planting season of 40% to calculate an expected replanting/maintenance need of 40% of the initial implementation stock. This 1-year mortality rate was then used to create a staggered mortality rate of 16% for 2 years post implementation, 6% for 3 years post implementation and then 3% for 4 years to 30 years post implementation. The 3% was held constant from 4 years post-implementation to 30 years post-implementation so that the model accommodated for costs associated with the general maintenance and monitoring of the reforested area over the course of the potential CIP.

[5] 6-month average exchange rate for the period 24/08/24 to 18/02/25

[6] Malawi is highly dependent on imports for a large proportion of inputs that would be needed under a WIP/CIP (vehicles, fuel, equipment, technology, etc.).

9.3 Valuing the Benefits of Nature-based Solutions

The overarching benefits that arise from the priority NbS include water security, economic resilience, livelihoods, biodiversity and carbon sequestration. Other direct and indirect benefits may arise in the future when data becomes available which could further bolster the current cost-benefit profile. Figure 28 summarises the benefit framework for a potential CIP in Likhubula and Mudi-Ndirande catchments.

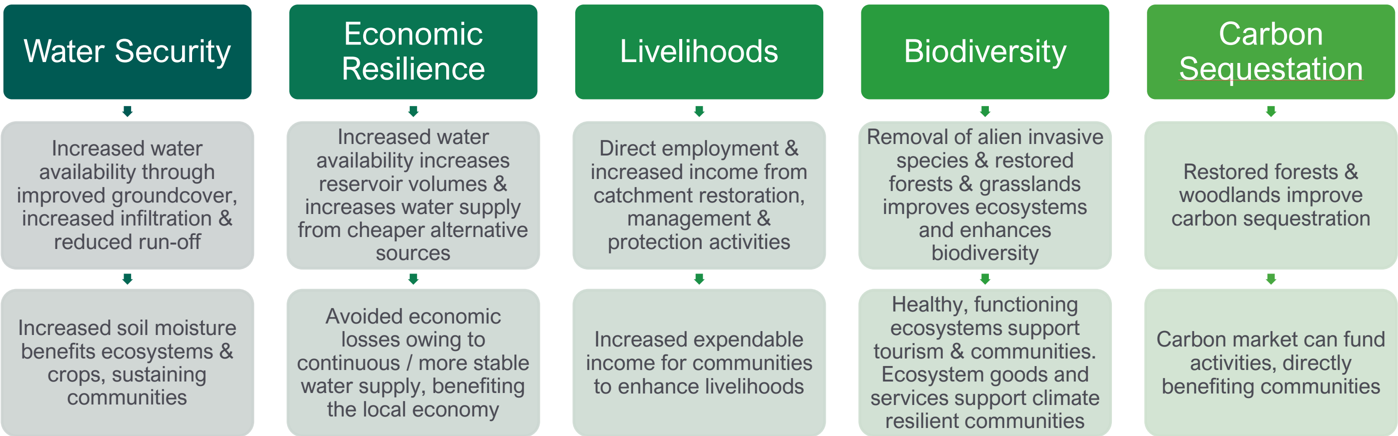


Figure 28: Benefit Framework for the Likhubula & Mudi-Ndirande catchments.

Various benefits will come about as a result of the implementation of NbS. However, not all are easily quantifiable. Some are difficult to measure, whilst others can be relatively accurately measured through the scientific and economic analysis.

For the purposes of this study six key benefits, that will be realised through the implementation of NbS in Likhubula and Mudi-Ndirande catchments, were quantified. The quantification took place using the outputs of the scientific modelling and applying data and assumptions from desktop research, stakeholder engagements and direct engagements with beneficiaries. Table 10 summarises the benefits that have been included and quantified in the economic analysis as well as the respective beneficiaries, linking these benefits to the overarching categories outlined as part of the benefit framework.

Table 10: Description of quantified benefits

Benefit Description	Rationale	Beneficiaries	Benefit Category
Alternative Water Supply	Reduced reliance on more expensive water source from Shire River through increased water supply from cheaper sources at Mudi-Ndirande and Likhubula	BWB	Water Security, Economic Resilience
Water Treatment Cost Savings	Reduced water treatment costs from increased supply of cleaner water at Likhubula and Mudi-Ndirande.	BWB	Water Security, Economic Resilience
Extension of Dam Lifespan	Reduced sedimentation in streamflow as a result of NbS leads to the extension of useful lifespan of Mudi dam	BWB	Economic Resilience
Employment	Cash for work for reforestation, tree nurseries, RBMPs, and AGBMPs through implementation and maintenance phases	communities	Livelihoods

Bee-keeping	Income generation from bee-keeping activities and products	Communities	Livelihoods
Carbon credit sales	Restoration of woodlands and grasslands provides increased carbon sequestration potential of the landscape	Potential CIP, communities, carbon investors	Carbon

The following sections describe the four targeted benefits, outlines the key model inputs and assumptions and indicates the benefit value for each beneficiary.

9.3.1 Alternative Water Supply

The proposed NbS interventions under a CIP would reduce sediment-heavy run-off in both Likhubula and Mudi-Ndirande, reduce sediment load in Mudi Dam and increase seasonal reliability of water supply in both catchments. Currently, Blantyre City abstracts approximately 79% of its water from the Walker's Ferry abstraction point on the Shire River, 16% from the Likhubula-Nguludi abstraction point and 5% from the Mudi dam. Whilst Blantyre abstracts most of its water from the Shire River, this has to be pumped 40km at 800 meters in elevation to Blantyre City. In comparison, water from Mudi-Ndirande catchment is abstracted from the Mudi dam within Blantyre City, and water from the Likhubula catchment is gravity fed 45km to the Nguludi Water Treatment Plant and pumped at horizontal elevation for 10 km to Blantyre City. Table 11 shows the abstraction, electricity and treatment costs for each water source and shows that Walker's Ferry is a significantly more expensive water abstraction source than Likhubula-Nguludi and Mudi. The model therefore calculated the potential benefits from increased water reliability from Likhubula-Nguludi and Mudi Dam.

Table 11: Abstraction, electricity and treatment costs per water source for Blantyre City

Year	Quarter	Walkers Ferry		Mudi Dam		Likhubula-Nguludi	
		Chemical (MK/M3)	Electricity (MK/M3)	Chemical (MK/M3)	Electricity (MK/M3)	Chemical (MK/M3)	Electricity (MK/M3)
2024	Q1	28,49	233,69	86,61	29,51	5,95	252,87
	Q2	15,79	231,09	35,21	41,63	4,54	196,01
	Q3	19,35	232,54	38,58	39,12	7,43	215,11
	Q4	21,69	220,16	61,94	39,46	9,81	258,55
Average		21,33	229,37	55,59	37,43	6,93	230,64

Model inputs and assumptions

In order to model this benefit, the model included the following assumptions:

- It is assumed that abstraction from the Mudi and Likhubula will be prioritised as cost-efficient sources of water.
- Cost of abstraction remains constant over the modelling period.
- The total amount of water abstracted does not exceed the total sum of the capacity of each source.
- The costs of supply numbers are those provided by BWB shown in Table 11 above.
- The model assumes that as NbS reduces the rate of loss capacity of Mudi dam and increases the availability of supply from the Likhubula, BWB will reduce their abstraction from Walker's Ferry proportionally.

- Critically, it should be noted that although NbS slow the loss of capacity at Mudi Dam, over time it would still lose its capacity entirely without a capital-intensive intervention like a refurbishment or upgrade.

Benefit value

Due to the increase in water supply from Mudi dam and Likhubula-Nguludi offtake, BWB would be able generate savings by offsetting abstraction from Walker's Ferry. Over a 30-year period this would lead to a cost savings benefit of USD 1.3 million when discounted at 4.3%.

9.3.2 Water Treatment Cost Savings

The proposed NbS interventions under a CIP would reduce sediment, nutrient and potential pollutant run-off in both Likhubula and Mudi-Ndirande and reduce the associated costs for water treatment.

Model inputs and assumptions

In order to value the water treatment cost savings, the following inputs and assumptions were made:

- Water treatment price elasticities exist due to turbidity in abstracted raw water and are significant. As per Price & Heberling (2018) empirical data indicated that on average, a 1% reduction in turbidity leads to a 0.12% reduction in treatment costs.
- The sediment load under BaU and CIP scenarios was modelled to identify a baseline and improvement scenario.
- The costs to treat the water sources are based on the values provided by BWB show in Table 11 above.

Benefit value

Using the assumptions stated, there is a total cost savings benefit of USD 370 thousand which equates to a present value of USD 206 thousand using the social discount rate of 4.3%.

9.3.3 Extension of Dam Lifespan and avoided replacement cost

The proposed NbS interventions under a CIP would reduce sediment-heavy run-off into the Mudi Dam. The reduction of sediment entering into the dam effectively increases the lifespan of the dam by offsetting the time by which, under the business-as-usual scenario, the dam would contain too much sediment for water abstraction to be possible. A feasibility study investigating the potential of raising the Mudi dam wall (funded by the World Bank on behalf on BWB) is currently underway with results expected this year. This is a critical opportunity for alignment. Although this study does not demonstrate the financial savings or benefit to the intervention itself, the **study does illustrate that NbS can extend the lifespan of the dam and therefore provide a better return on investment for the refurbishment.**

Model inputs and assumptions

In order to value the extension of the lifespans of the dam, the following inputs and assumptions were made:

- The model calculates the difference in sediment yield between the BaU and CIP scenarios. The difference in m^3 of sediment yield equates to saved storage capacity.
- An average cost per m^3 was calculated for based on the cost of several existing dam refurbishment projects that made use of dam wall raising as shown in Table 9 (SA News, 2024); (iha, 2022); (The Express Tribune, 2025).
- The avoided replacement cost is calculated as the saved storage capacity multiplied by the average cost per m^3 to refurbish the dam of USD 0,93/m^3.

Table 12: Sources of information used to quantify the per m3 replacement cost of dams

Project	Method	Additional Volume (million m^3)	Cost (USD million)	USD/m^3	Reference
Hazelmere Dam (SA)	Raising dam wall by 7m	19,7	43,6	$2,21	SA News

Clanwilliam Dam (SA)	Raising dam wall by 13m	221	206	$0,93	SA News
Roseires Dam (Sudan)	Raising dam wall 10m	4400	440	$0,10	World Bank
Mangla Dam (Pakistan)	Raising dam wall 9.1m	3,59	1,7	$0,47	Pakistan Water & Power Development Authority
Average				**$0,93**	

Benefit value
Using the assumptions stated, the total cost benefit of extending the dam's lifespan was modelled at USD 259 thousand which equates to a present value of USD 140 thousand over the 30-year period using the social discount rate of 4.3%. Importantly, under the business-as-usual scenario, the model projected a further 30 years in the dam's lifespan (replacement year 2055).

9.3.4 Employment

The employment benefits are calculated from cash for work for the following overarching intervention categories:

Reforestation:
- Cash for work associated with the planting of tree seedlings (implementation), the maintenance of tree seedlings and senior labour associated with monitoring and management of implementation and maintenance work).

Rangeland Best Management Practices (only present in Likhubula):
- Cash for work associated with the implementation and maintenance of firebreak areas.
- Cash for work associated with the clearing of invasive alien species (IAPs).
- Cash for work for senior labour associated with monitoring and management of firebreak implementation and maintenance as well as IAP clearing.

Agricultural Best Management Practices:
- Cash for work associated with the implementation and maintenance of terracing and cover cropping activities.
- Cash for work for senior labour associated with monitoring and management of terracing and cover cropping implementation and maintenance.

Tree Nurseries:
- Cash for work associated with operating tree nurseries.

Model inputs and assumptions
In order to value the employment benefit to communities, the following inputs and assumptions were used:

1. Wage rates:
   - Local casual labour wage rates applicable to Mudi-Ndirande and Likhubula were provided by WFP and MMCT, respectively. These amounted to:
     - Mudi-Ndirande: USD 2.88 per day (MWK 5,000 per day)
     - Likhubula: USD 2.31 per day (MWK 4,000 per day)
   - Local senior/officer cost rates (including daily allowances) applicable to Mudi-Ndirande and Likhubula were provided by WFP and MMCT, respectively. These amounted to:
     - Mudi-Ndirande: USD 10.95 per day (MWK 19,000 per day)
     - Likhubula: USD 10.37 per day (MWK 18,000 per day)

2. Person-days per hectare:

- Reforestation: A person-day per hectare rate of 10 was calculated using information provided by MMCT based on existing reforestation programmes in Likhubula. This was used to infer an assumed rate for Mudi-Ndirande, which was then discounted to 5 person days per hectare as Mudi is at lower altitude to Likhubula.
- RBMPs (only present in Likhubula): In line with the reforestation person-days per hectare rate for Likhubula, a rate of 10 person-days per hectare was assumed for firebreak implementation. A rate of 5 person-days per hectare was assumed for firebreak maintenance in Likhubula. A rate of 10 person-days per hectare was used for IAP clearing and maintenance that was based on model inputs from N4W's Feasibility Study of the Tugela catchment in South Africa.
- AGBMPs: A rate of 10 person-days per hectare was used for the implementation of cover cropping activities and a rate of five person-days per hectare was used for the maintenance of cover cropping in Mudi-Ndirande and Likhubula. This was based on model inputs from N4W's Business Case Study of the Yala Watershed Investment Programme in Kenya.

Benefit value
Using the assumptions stated, there is a total employment benefit of USD 419 thousand which equates to a present value of USD 248 thousand using the social discount rate of 4.3%.

9.3.5 Bee-keeping

The creation of nature-based enterprises is critical to creating alternative livelihood opportunities for communities living within the catchments. This study modelled the potential revenue generation for local communities through bee-keeping enterprises. The benefits included revenue from the sale of honey and beeswax.

Model inputs and assumptions
In order to value the benefit from bee-keeping enterprises, the following inputs and assumptions were used based on data received from the Yala River Water Fund[7] and Selina Wamucii, an agricultural cooperative, based in Malawi[8]:

1. Number of hives per community: An assumption of 10 hives per community (across 43 communites in Mudi-Ndirande and Likhubula) was.
2. Occupation rate: Bee occupation rate of hives was assumed at 80%.
3. Raw honey yield per hive: Honey yield per hive was assumed at 15 kg per annum.
4. Refined honey rate: The percentage of raw honey that is converted into refined honey was assumed at 70%.
5. Refined honey price: The retail price of refined honey ranges between MWK 13,800 and MWK 19,700 per kg[9]. The model assumed a fixed price of USD 9.6 per kg (the mean average of the MWK price range).
6. Beeswax yield proportion: The percentage yield of beeswax per hive was assumed at 30%.
7. Beeswax price: The retail price of beeswax ranges between MWK 12,000 and MWK 25,000 per kg[10]. The model assumed a fixed price of USD 10.7 per kg (the mean average of the MWK price range).

Benefit value
Using the assumptions stated, there is a total revenue creation benefit for local communities through bee-keeping enterprises of USD 935 thousand which equates to a present value of USD 517 thousand using the social discount rate of 4.3%.

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[7] Nashon, G. Wafula – Bee-kepping expert, Kenya
[8] Selina Wamucii: https://www.selinawamucii.com/
[9] Refined honey price was sourced from Selina Wamucii, a platform that provides data for food and agricultural produce: https://www.selinawamucii.com/insights/prices/malawi/natural-honey/
[10] Beeswax price was sourced from Selina Wamucii, a platform that provides price data for food and agricultural produce: https://www.selinawamucii.com/insights/prices/malawi/natural-honey/

9.3.6 Carbon credit sales

Increases in carbon sequestration potential of the forests and miombo woodlands in Likhubula and Mudi-Ndirande is anticipated as a result of reforestation. It was estimated, using the assumptions below, that the restored forest and miombo woodland will increase carbon sequestration **by an average of ~ 1 287 tC02e** per year after the first 10 years. The increase in sequestration potential of the forest and miombo woodland was used to model the potential benefit through the sale of carbon credits.

Model inputs and assumptions
In order to determine the value of the benefit accruing due to additional carbon sequestration of restored forests and miombo woodlands, the following assumptions were made:

- A carbon credit value of US$ 8.00 was used[11].
- A sequestration rate of 0.5 tC/ha/year was used (Z. J. Lupala, 2014).[12]
- A leakage factor, non-permanence factor and additionality discount of 15%, 20% and 10% were used respectively (Offsetguide, 2025); (Verra, 2014); (Verra, 2023).
- Several program costs were included in the calculation, including the mandatory transaction costs, costs of a verified carbon consultant, project validation costs, reporting and third-party verification, carbon development costs and monitoring and verification costs.
- Benefits accrue from year 3 increasing to an average of 1 287 tC02e per year after year 10. However, this will need to be reviewed and confirmed by a carbon expert.
- Carbon credits are only available to be sold after year 3 based on modelling assumptions above.

Value of benefit
The net benefit was modelled to include the costs of registering and ongoing verification of a carbon project. When the total costs, which are very high upfront, are considered, the total value of the carbon benefit equates to a benefit of USD -1.4 mill over the lifecycle of the potential CIP. This equates to a negative present value of USD -1 mill in today's terms using the social discount rate of 4.3% and including all carbon project costs. However, if the costs are not considered, the total carbon benefit equates to USD 276 thousand and a present value of USD 142 thousand. This demonstrates that there is benefit in investing in the catchments from a carbon perspective, however the scale does not warrant the development of a carbon project on its own. The carbon benefit calculated here, which is based on the sale of carbon credits, could, if deemed acceptable, be regarded as a proxy for the broader social and environmental benefit afforded by the restoration of these woodlands.

9.3.7 Benefits summary

The economic analysis quantifies the total benefits accruing to six benefit categories of the proposed NbS interventions in Likhubula and Mudi-Ndirande. These are detailed in the preceding sections and include:

- Alternative water supply
- Water treatment cost savings
- Extension of dam lifespan
- Employment benefits
- Bee-keeping
- Carbon (not included in CBA for reason above)

It should be noted that these are the benefits selected to be quantified. In reality, the benefits of the interventions will extend beyond these to other areas, which in most cases were difficult to quantify or assign a monetary value to.

[11] High-quality, verified nature-based credits deploy USD 8 per credit on the lower end based on Ecosystem Marketplace, 'State of Voluntary Carbon Market, 2025'; Sylvera: https://www.sylvera.com/blog/carbon-offset-price and MSCI: https://www.msci.com/research-and-insights/blog-post/investor-grade-tools-to-aid-the-global-carbon-market

[12] Africa Carbon Markets Pricing Map (2023), Removall (2024)

The results of the analysis are summarised in Table 13 below.

Table 13: Summary of present value of benefits

Benefit description	Present value (USD thousands)
Alternative Water Supply	1,282
Water treatment cost savings	206
Extension of dam lifespan	140
Employment	248
Bee-keeping	517
Carbon	142
Total Present Value of Benefits (incl. carbon)	**2, 535**
Total Present Value of Benefits (excl. carbon)	**2,392**

Figure 30 and Figure 30 provides an indication of the accrual of benefits over time. From the figure it can be observed that benefits accrue throughout the 30-year period with an uptake from year 6 onwards as the NbS mature and the phased implementation of different management zones is complete. By showing the two figures, the impact of the benefit provided by carbon is illustrated.

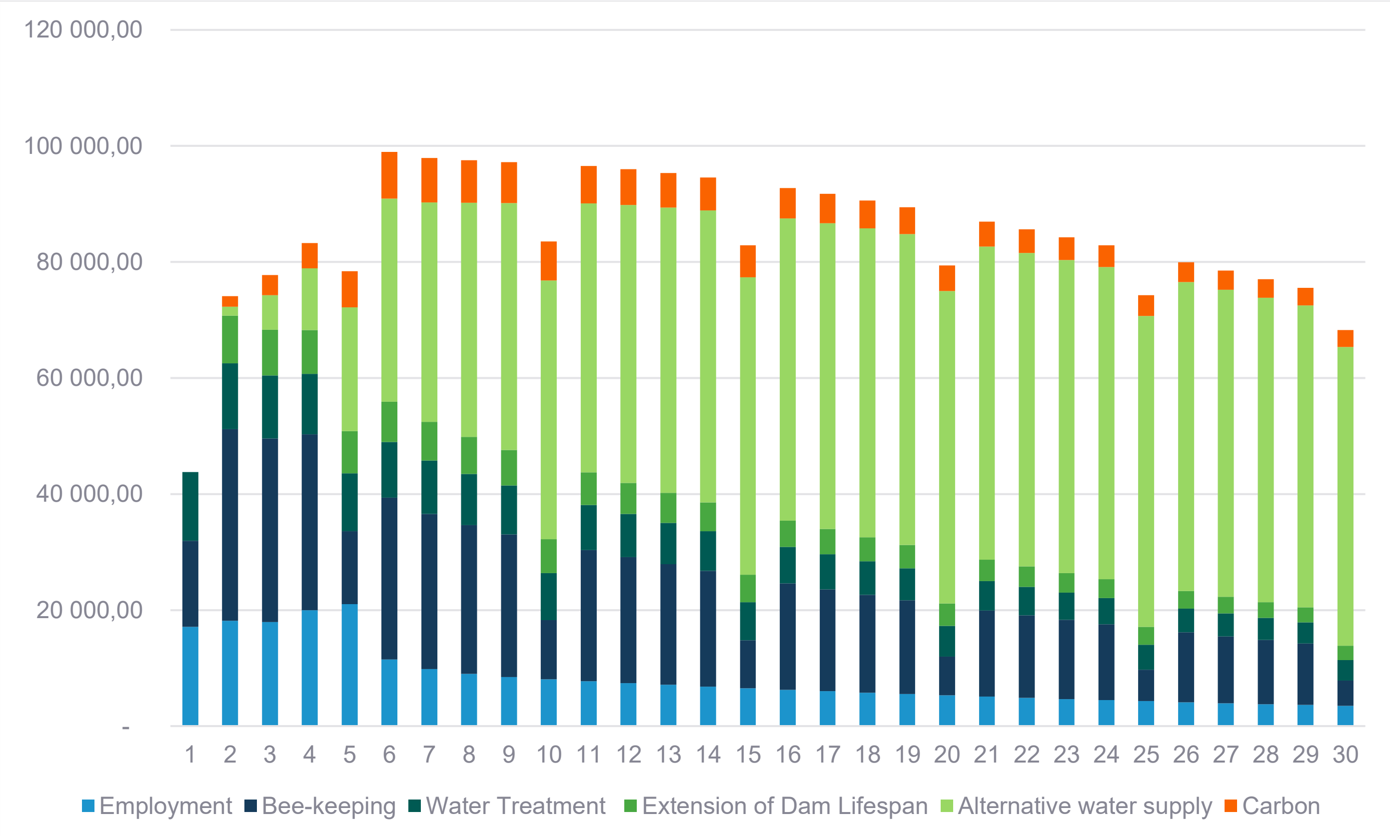

Figure 29: Timeline of discounted benefits over the CIP lifecycle including Carbon Benefit

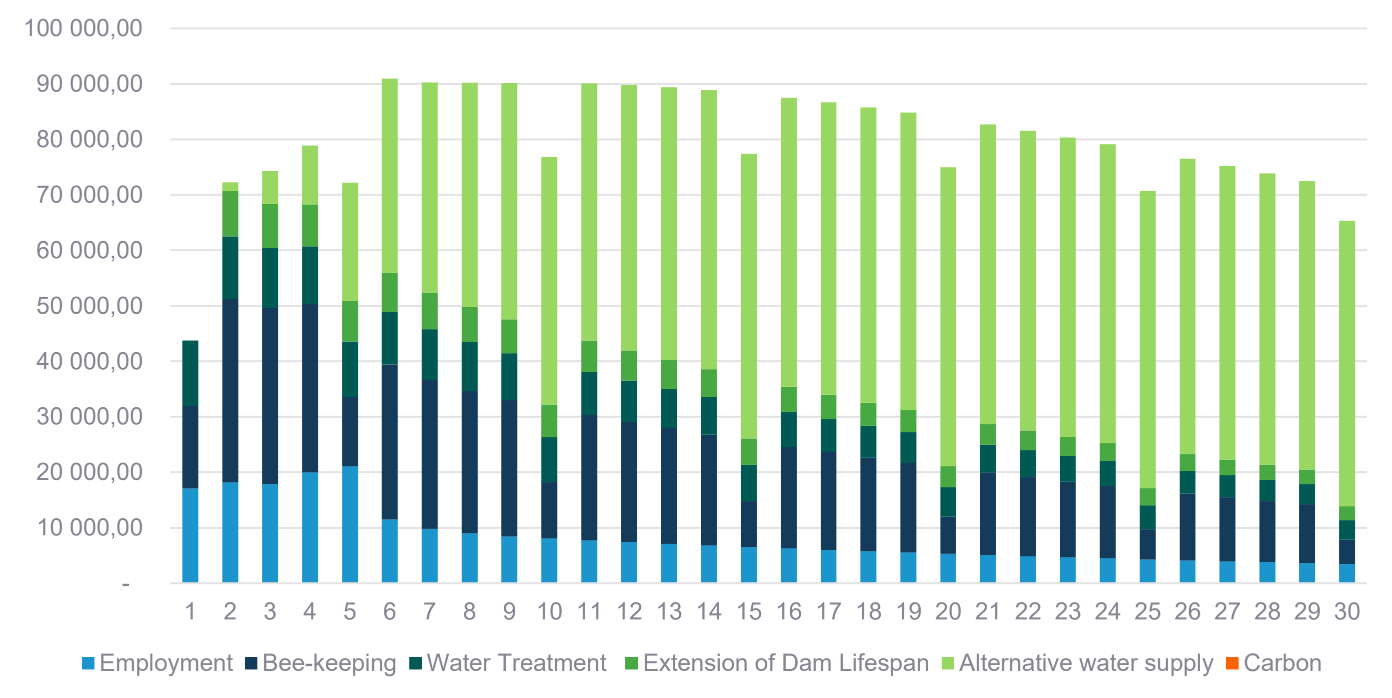

Figure 30: Timeline of discounted benefits over the CIP lifecycle excluding Carbon Benefit

9.4 Calculating the Costs of the CIP

The CIP's financial feasibility is determined by offsetting the benefits of implementation against the associated costs. Costs are split into programmatic and non-programmatic costs. Programmatic costs are those associated with the direct implementation of the NbS. Non-programmatic costs refer to those costs apportioned for the running of the CIP including monitoring and evaluation, CIP operations and management and back-office.

Programmatic costs have been calculated against several categories for each of the proposed NbS interventions (reforestation, RBMPs and AGBMPs) as well as for the costs associated with implementing the required number of tree nurseries to support the scale of reforestation needed. The cost categories associated with these interventions are listed below:

- Human Resources: The cost of labour, at various levels (management, oversight and implementation), as well as training and community and stakeholder engagement.
- Materials: Material inputs such as seedlings, fertiliser, etc.
- Equipment: Equipment required to implement and maintain NbS interventions which includes items such as shovels, measuring equipment and personal protective equipment.
- Transport: In the case of reforestation, a transport cost for specialised vehicle rental and fuel was factored in for transporting seedlings from nurseries (separate to logistics costs that might be incurred under non-programmatic costs).

Non-programmatic costs have been budgeted at 30%[13] of the total implementation and maintenance cost per annum and are assumed to cover costs for administration, logistics (vehicles and fuel), office supplies, staff support, etc.

The programmatic costs associated with each of the NbS interventions (reforestation, RBMPs and AGBMPs) for both Mudi-Ndirade and Likhubula catchments were informed by the management zone implementation strategy and hectarage information provided form the scientific analysis of this study. Table 14 and Table 15, below, provide a summary of the hectarage for each NbS intervention and the period of implementation for each management zone in both catchments.

[13] In line with comparative rates used across N4W WIP/CIP feasibility models.

Table 14: Mudi-Ndirande Catchment Reforestation Implementation per Management Zone

Management Zones (MZ)	NbS Intervention	Hectarage	Period of Implementation
Mudi-Ndirande MZ1	Reforestation	418	Year 1 & Year 2
	RBMPs	0	
	AGBMPs	0	
Mudi-Ndirande MZ2	Reforestation	0	Year 1 & Year 2
	RBMPs	0	
	AGBMPs	45	
Mudi-Ndirande MZ3	Reforestation	123	Year 3
	RBMPs	0	
	AGBMPs	0	
Mudi-Ndirande MZ4	Reforestation	16	Year 3
	RBMPs	0	
	AGBMPs	0	
Mudi-Ndirande MZ5	Reforestation	610	Year 4 & Year 5
	RBMPs	0	
	AGBMPs	0	

Table 15: Likhubula Catchment Reforestation Implementation per Management Zone

Management Zones (MZ)	NbS Intervention	Hectarage	Period of Implementation
Likhubula MZ1	Reforestation	5	Year 1
	RBMPs	27	
	AGBMPs	2	
Likhubula MZ2	Reforestation	36	Year 1
	RBMPs	3	
	AGBMPs	35	
Likhubula MZ3	Reforestation	61	Year 2
	RBMPs	35	
	AGBMPs	18	
Likhubula MZ4	Reforestation	4	Year 3, Year 4 & Year 5
	RBMPs	163	
	AGBMPs	353	
Likhubula MZ5	Reforestation	3	Year 5
	RBMPs	2	
	AGBMPs	1	

9.4.1 Reforestation – Tree Planting

Implementation Area:
Mudi-Ndirande sub-catchment total reforestation hectarage: 1,167 ha
Likhubula sub-catchment total reforestation hectarage: 108 ha

Cost Summary:
The costs associated with reforestation interventions in Mudi-Ndirande and Likhubula catchments involves the planting of tree seedlings (implementation) and the replanting and monitoring of seedlings over the duration of the CIP (maintenance) over the total reforestation hectareage (according to the management zone strategy in Table 14 and Table 15). Table 16 and Table 17 below provide a summary of the modelled costs over the 30 years and shows the total present value cost of reforestation interventions at USD 432,500 in Mudi-Ndirande and USD 215,700 in Likhubula.

Table 16: Mudi-Ndirande Reforestation Cost Breakdown

Cost category	Implementation (USD thousand)	Maintenance (USD thousand)	Total Cost (USD thousand)	Total Cost PV (USD thousand)
Human Resources	36.2	73	109.2	68.4
Materials	299.7	122.3	422	332.8
Equipment	9.6	6.8	16.4	11.9
Transport	5.8	29	34.8	19.3
Total	351.3	231.1	**582.4**	**432.5**

Table 17: Likhubula Reforestation Cost Breakdown

Cost category	Implementation (USD thousand)	Maintenance (USD thousand)	Total Cost (USD thousand)	Total Cost PV (USD thousand)
Human Resources	16.1	62.1	78.3	44.8
Materials	132.6	53.8	186.4	147.5
Equipment	3.2	2.3	5.5	4
Transport	5.8	29	34.8	19.3
Total	157.7	147.2	**304.9**	**215.7**

Inputs and Assumptions:
In order to model the costs associated with reforestation, the following inputs and assumptions were utilised:

- Number of seedlings per hectare: primary information from MMCT on ongoing reforestation programmes associated with effective spacing of tree seedlings for evergreen, broad leaf and conifer species was used as an input for the number of seedlings per hectare in Mudi-Ndirande and Likhubula. Based on this information the number of seedlings per hectare was assumed at 625 seedlings per hectare in Mudi-Ndirande and 1,320 seedlings per hectare in Likhubula.
- Cost per tree seedling: primary information from WFP and MMCT was used to derive an average cost per seedling for Mudi-Ndirande and Likhubula. The unit cost per tree seedling was assumed fixed at USD 0.29 (MWK 500) for Mudi-Ndirande and USD 0.58 (MWK 1,000) in Likhubula.
- Fertiliser: primary information from WFP and MMCT was used to derive an average cost per kilogram for fertiliser of USD 0.14 (MWK 250). WFP indicated the use of fertiliser for reforestation programmes in Mudi-Ndirande and the national average of fertiliser per hectare for arable land was used to calculate the total cost of fertiliser for Mudi-Ndirande. MMCT indicated that fertiliser is not currently used in Likhubula for reforestation programmes, therefore fertiliser was not costed for Likhubula.
- Person-days per hectare: primary information from MMCT on ongoing reforestation programmes was used to calculate an assumed person-days per hectare rate of five in Mudi-Ndirande and 10 in Likhubula (at higher altitude).
- Training: A five-day unit cost of USD 173 was derived from primary information from MMCT and WFP which factored in venue hire, refreshments and training materials. A total of 10 days of training per year was assumed over the 30-year period. This cost was included under human resources.
- Equipment costs: primary information from WFP and MMCT was used to inform unit costs for a basket of equipment goods. Assumptions on equipment unit quantities were based on the number of person-days per hectare and the number of days within Malawi's planting season to determine a likely number of labourers per planting season and a sufficient quantity of equipment units to cover the likely number of labourers.
- Maintenance: The national tree seedling mortality rate for the 2022-2023 tree planting season of 40% (Lunda, 2024)[14] was used to infer the number of tree seedlings that would need to be replanted for the first-year post-implementation.

[14] The Times quoted a 60% survival rate for the 2022-2023 tree planting season.

9.4.2 Agricultural Best Management Practices (AGBMPs)

Implementation Area:
Mudi-Ndirande sub-catchment total AGBMP hectarage: 45 ha
Likhubula sub-catchment total AGBMP hectarage: 408 ha

Cost Summary:
The costing of AGBMPs involves the implementation and maintenance of infiltration ditches for terracing and cover cropping over the total AGBMP hectarage according to the management zone implementation strategy in Table 14 and Table 15. The costs were categorised according to human resources, materials and equipment. Table 18 and Table 19 below provide a summary of the modelled costs over the 30 years and shows the total present value cost of AGBMP interventions at USD 82,200 in Mudi-Ndirande and USD 293,500 in Likhubula.

Table 18: Mudi-Ndirande AGBMP Cost Breakdown

Cost category	Implementation (USD thousand)	Maintenance (USD thousand)	Total Cost (USD thousand)	Total Cost PV (USD thousand)
Human Resources	24.6	74.5	99.1	58.8
Materials	18.2	3.6	21.7	18.4
Equipment	4	2.8	6.8	5
Total	46.8	80.9	**127.7**	**82.2**

Table 19: Likhubula AGBMP Cost Breakdown

Cost category	Implementation (USD thousand)	Maintenance (USD thousand)	Total Cost (USD thousand)	Total Cost PV (USD thousand)
Human Resources	42.7	158	200.7	114.2
Materials	137.3	54.7	192	151.4
Equipment	223	15.9	38.2	27.9
Total	202.3	228.6	**430.9**	**293.5**

Inputs and Assumptions:
In order to model the costs associated with AGBMPs, the following inputs and assumptions were utilised:

- Person-days per hectare: a rate of 10 person-days per hectare was used for the implementation of cover cropping activities and a rate of five person-days per hectare was used for the maintenance of cover cropping in Mudi-Ndirande and Likhubula. This was based on model inputs from N4W's Business Case Study of the Yala Watershed Investment Programme in Kenya
- Training: A five-day unit cost of USD 173 was derived from primary information from MMCT and WFP which factored in venue hire, refreshments and training materials. A total of 10 days of training per year was assumed over the 30-year period. This cost was included under human resources.
- Materials: material unit costs and quantities per hectare for cover cropping during implementation and maintenance were based on model inputs from N4W's Business Case Study of the Yala Watershed Investment Programme in Kenya.
- Equipment costs: primary information from WFP and MMCT was used to inform unit costs for a basket of equipment goods. Assumptions on equipment unit quantities were based on the number of person-days per hectare and the number of days within Malawi's planting season to determine a likely number of labourers per planting season and a sufficient quantity of equipment units to cover the likely number of labourers.

9.4.3 Rangeland Best Management Practices (RBMPs)

Implementation Area:

Mudi-Ndirande sub-catchment total RBMP hectarage: No RBMP interventions recommended.
Likhubula sub-catchment total RBMP hectarage: 230 ha

Cost Summary:
The costing of RBMPs involves the implementation and maintenance of firebreaks, the continued clearing of invasive alien plant species (IAPs) and training on regenerative practices for local communities in Likhubula (according to the management zone implementation strategy shown in Table 14 and Table 15). Table 20 below provides a summary of the modelled costs over the 30 years and shows the total present value cost of RBMP interventions in Likhubula at USD 123,800.

Table 20: Likhubula RBMP Cost Breakdown

Cost category	Implementation (USD thousand)	Maintenance (USD thousand)	Total Cost (USD thousand)	Total Cost PV (USD thousand)
Human Resources	35.9	181.6	217.6	120.8
Equipment	2.4	1.7	4.1	3
Total	38.3	183.3	**221.7**	**123.8**

Inputs and Assumptions:
In order to model the costs associated with RBMPs in Likhubula, the following inputs and assumptions were utilised:

- IAP clearing hectarage: the area for ongoing IAP maintenance was assumed to take place over the full RBMP implementation area.
- Firebreak hectarage: the area of live firebreaks in Likhubula was assumed based on primary information from MMCT. MMCT indicated a total length of double band firebreaks of 100 km in Likhubula. These were assumed to be six meters wide, giving an area of 60 ha.
- Training: A five-day unit cost of USD 173 was derived from primary information from MMCT and WFP which factored in venue hire, refreshments and training materials. A total of 15 days of training per year was assumed over the 30-year period. This cost was included under human resources.
- Person-days per hectare: IAP clearing person-days per hectare rate of 10 was based on model inputs from N4W's Feasibility Study of the Tugela catchment in South Africa. Firebreak implementation person-days per hectare rate of 10 was assumed to be consistent with reforestation person-day [er hectare rate informed by MMCT, while firebreak maintenance rate was assumed to half the implementation rate based on other N4W CIP models.
- Materials: IAP clearing and live firebreaks have already been implemented in Likhubula, thus only maintenance was factored in and there were no assumed material costs
- Equipment costs: primary information from WFP and MMCT was used to inform unit costs for a basket of equipment goods. Assumptions on equipment unit quantities were based on the number of person-days per hectare and the number of days within Malawi's planting season to determine a likely number of labourers per planting season and a sufficient quantity of equipment units to cover the likely number of labourers.

9.4.4 Tree Nurseries

Cost Summary:
The scale of tree nurseries required was quantified using input data from MMCT and WFP on tree density for the reforestation areas. Using inputs for tree density, based on indigenous tree species, and a maintenance replacement rate based on the annual tree seedling mortality rate for Malawi a total number of tree seedlings was calculated for each year over the CIP's 30-year period. Using unit quantities and unit costs for human resources, material and equipment provided by MMCT and WFP and annual tree seedling output estimations per nursery provided by MMCT it was possible to model the number of tree nurseries needed to satisfy the yearly demand for tree seedlings under the CIP.

A breakdown of costs for Mudi-Ndirande and Likhubula are provided in Table 21 and Table 22. The total present value costs of tree nurseries over the 30-year period in Mudi-Ndirande and Likhubula were USD 298 thousand and USD 82 thousand, respectively.

Table 21: Mudi-Ndirande Tree Nursery Cost Breakdown

Cost category	Implementation (USD thousand)	Maintenance (USD thousand)	Total Cost (USD thousand)	Total Cost PV (USD thousand)
Human Resources	155.6	12.5	168.1	143
Materials	127.4	-	127.4	111.3
Equipment	47.8	52.3	52.3	43.8
Total	330.8	16.9	**347.7**	**298**

Table 22: Likhubula Tree Nursery Cost Breakdown

Cost category	Implementation (USD thousand)	Maintenance (USD thousand)	Total Cost (USD thousand)	Total Cost PV (USD thousand)
Human Resources	28.8	4.3	33.2	28.6
Materials	45.9	-	45.9	42.4
Equipment	10.3	2.2	12.5	10.5
Total	85	6.6	**91.6**	**81.5**

Inputs and Assumptions:
In order to model the costs associated with tree nurseries, the following inputs and assumptions were utilised:

- Number of seedlings per nursery: primary information from MMCT on existing tree nurseries was used as an input for the number of seedlings per nursery for the CIP. The number of seedlings per nursery was therefore assumed at 7,000 seedlings per nursery.
- Costs for labour, material and equipment inputs were based on unit quantities and costs provided by MMCT and WFP for tree nurseries with an output capacity of 7,000 seedlings per year.
- Person-days per hectare: primary information from MMCT on ongoing reforestation programmes was used to calculate an assumed person-days per hectare rate of five in Mudi-Ndirande and 10 in Likhubula (at higher altitude).
- Training: A five-day unit cost of USD 173 was derived from primary information from MMCT and WFP which factored in venue hire, refreshments and training materials. A total of 5 days of training per year was assumed over the 30-year period for each tree nursery. This cost was included under human resources.

9.4.5 Non-programmatic costs

Additional costs will be required to cover overheads and administrative costs of the CIP. For each of the interventions above appropriate costs have been included for monitoring, reporting and verification (MRV), human resources and specialist equipment for the specific intervention. The remaining non-programmatic costs have been calculated as 30% of the annual costs of all CIP interventions. This amounts to a total value of USD 632 thousand over the lifecycle of the CIP, which equates to a present value of USD 458 thousand.

9.4.6 Cost Summary

The costs for the CIP are summarised in Table 23 below.

Table 23: Summary of discounted costs of the CIP

Intervention	Present value (USD thousands)
Reforestation	648

RBMPs	376
AGBMPs	380
Tree Nurseries	124
Non-programmatic Costs	458
Total Present Value of Costs	**1,985**

9.5 Cost Benefit Analysis

Following the analysis above, a cost-benefit analysis (CBA) was conducted. The cashflows of the costs of the interventions and the benefits accrued as a result in the two catchments were discounted to ascertain the present value of costs and benefits to the various beneficiaries. The CBA compares the value of benefits that deliver against the costs of implementation (assuming zero rated cost and wage inflation values and a social discount rate of 4.3%). To understand the value of the benefit, a comparison of future scenarios is done (between "Implementation" and "Do Nothing"). As described in preceding sections, these benefits are then valued, whilst the required costs to undertake the implementation are quantified. To account for the time variance in the value of money, the benefits and costs are presented using a "present value", which uses a discount rate (which reflects society's time preference and the opportunity cost of capital) to discount values annually into a present-day value, 2025 in this case.

Figure 31 shows the costs relative to the benefits as well as the discounted net cashflow over the lifecycle of the CIP including the carbon benefit. Figure 32 shows the same data but excluding the carbon benefit. The two graphs are shown in order to demonstrate the costs associated with monetising a carbon project at this scale. It is important, however, to show the potential carbon benefit as a result of interventions. The data in Figure 31 can be interpreted to show the benefit of the intervention from a carbon perspective, using the value of carbon credit sales as a proxy to monetise the benefit. In both cases, when including and excluding the costs associated with monetising carbon, the benefits only start to outweigh the costs from year 7. This is largely due to the high upfront costs of implementation. The fluctuations in the costs in the first 5 years is attributed to the differences in the areas of the management zones that are implemented in specific years, in accordance with the scientific recommendations for prioritised implementation of reforestation.

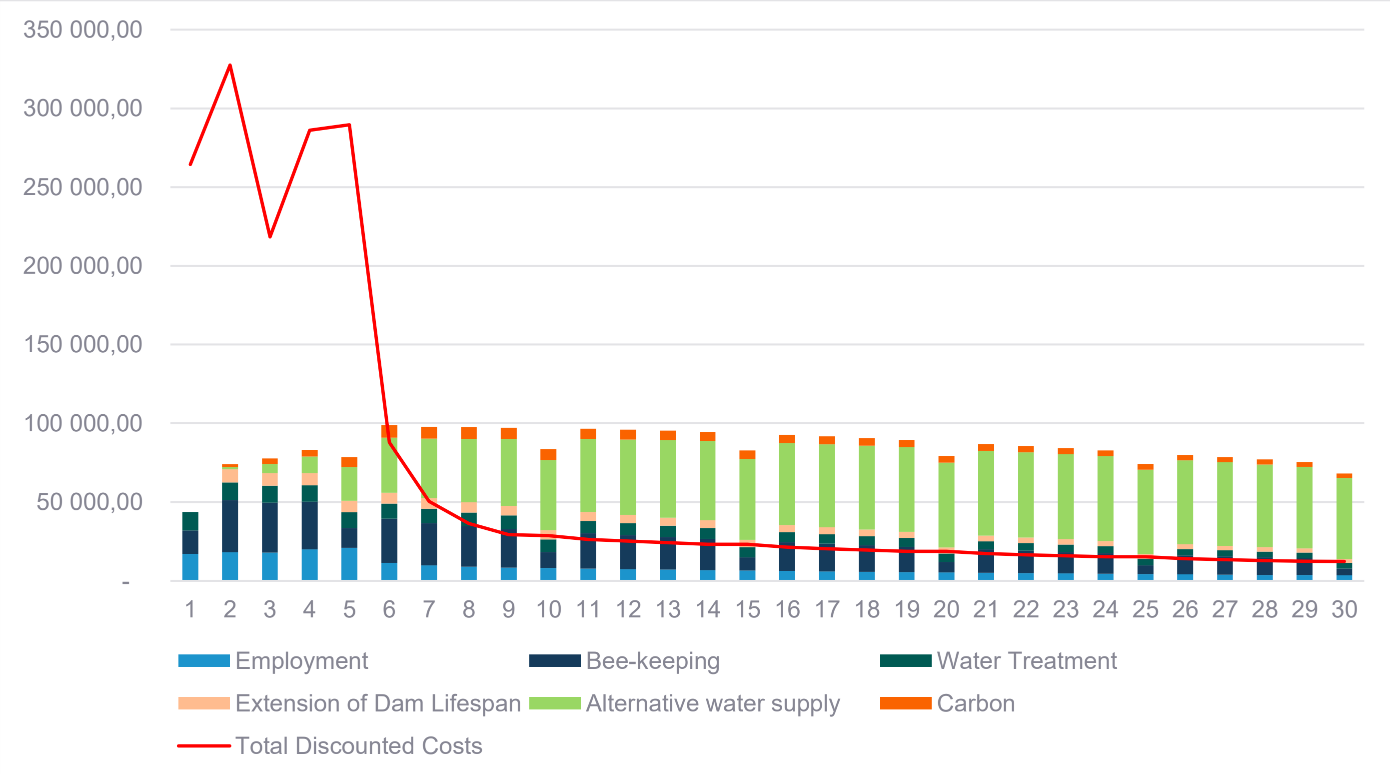

Figure 31: Timeline of discounted costs and benefits including net discounted cashflow (including carbon benefit)

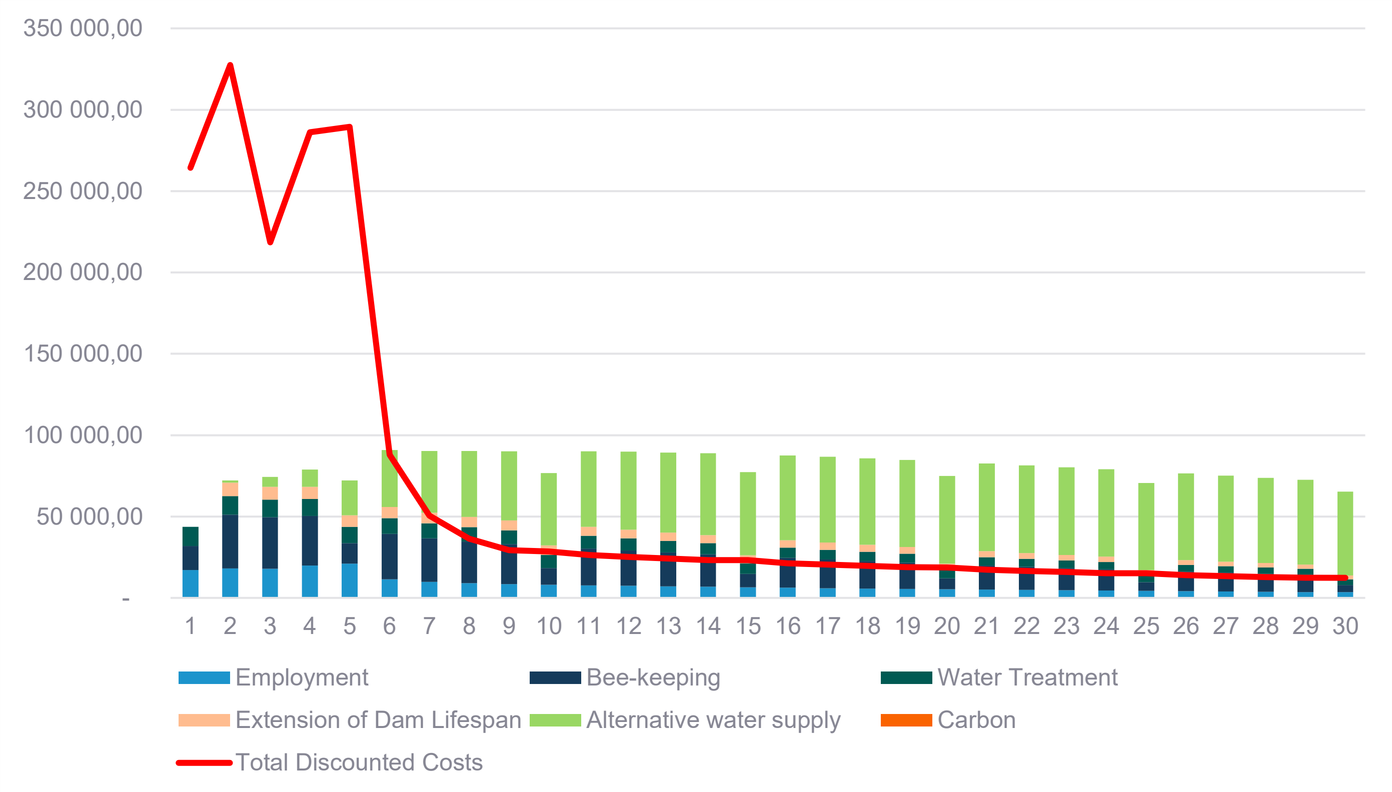

Figure 32: Timeline of discounted costs and benefits including net discounted cashflow (excluding carbon benefit)

The net present value (PV) (i.e. present value benefits less present value costs) of the CIP, when including carbon benefits and costs is USD 550 thousand as shown in Figure 33. The net present value when excluding the carbon benefits and costs associated with monetising carbon is USD 407 thousand as shown in Figure 34. The present values for each intervention and the benefits to each beneficiary across the entire implementation area of the CIP are also visible in Figure 33.

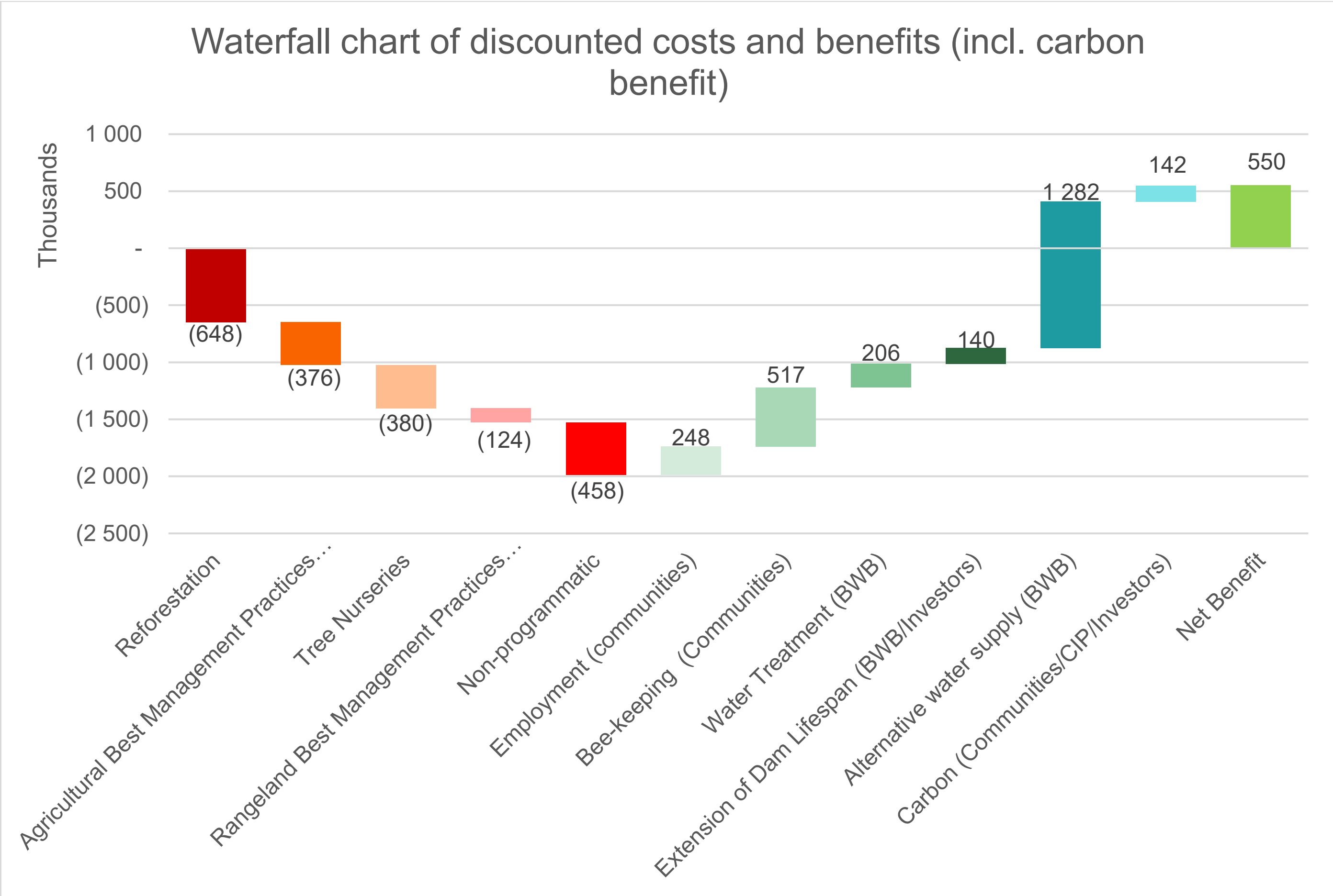

Figure 33: Waterfall chart showing discounted costs compared to benefits including the CIP NPV (incl. Carbon Benefit)

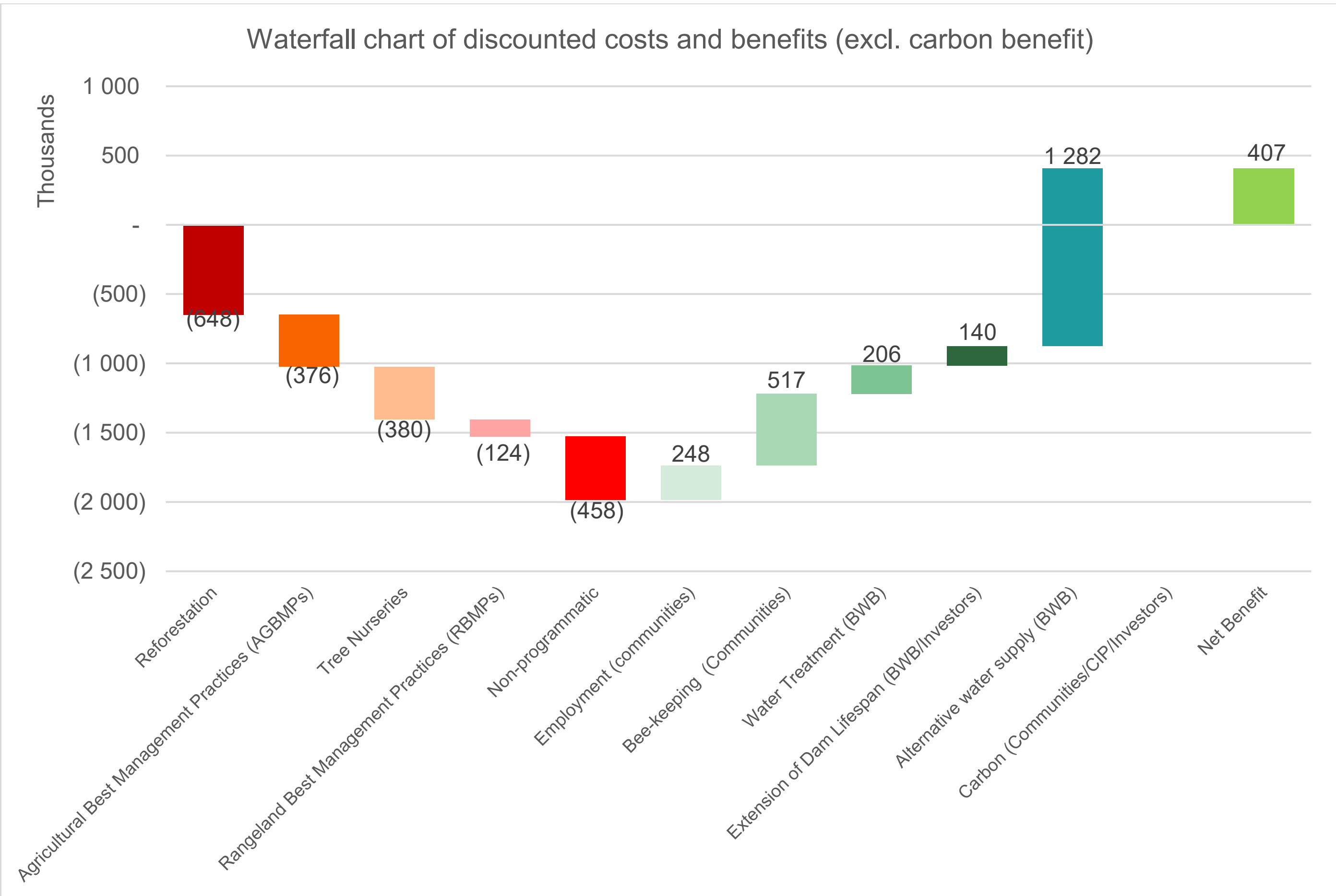

Figure 34: Waterfall chart showing discounted costs compared to benefits including the CIP NPV (excl. Carbon Benefit)

Net Present Value (NPV)
The NPV is a financial metric to estimate the total value of an investment opportunity, and is calculated using the following formula:

$$NPV = {}^{R_t}/_{(1+t)^t}$$

Where:

NPV = net present value
Rt = net cash flow at time t
i = discount rate
t = time of the cash flow

Utilising the above formula The NPVs are as follows:

- Incl. Carbon Benefit: **NPV of USD 550 million for the CIP**.
- Excl. carbon benefit: **NPV of USD 407 thousand for the CIP**.

Benefits-Cost Ratio (BCR)
The BCR is a cost-benefit analysis indicator which summarises the overall value for money of the proposed implementation. A BCR greater than 1 is an indication of a good investment and the higher the BCR, the more promising the returns. The formula is as follows:

$$BCR = {}^{PV\ of\ Expected\ Benefits}/_{PV\ of\ Expected\ Costs}$$

Utilising the above formula, the BCRs are as follows:

- Including carbon benefit: **BCR of 1.3**
- Excluding carbon benefit: **BCR of 1.2**

Internal Rate of Return (IRR)
The IRR is a financial analysis metric used to estimate profitability of a potential investment, it is the annual growth rate that an investment is expected to generate. It is calculated following the same concept of NPV, with the exception that it sets the NPV equal to zero.

The calculation returned:

An **IRR of 2.92% for the CIP including the carbon benefit**.
An **IRR of 2.18%% for the CIP excluding the carbon benefit**.

9.6 Summary of the Economic Analysis

In summary the economic analysis provided the following outcomes:

Table 24: Summary of present value of benefits, costs, and economic decision metrics

Metric	Value
Present Value of Benefits (USD thousands)	**4,025**
Alternative Water Supply	1,282
Water treatment cost savings	206
Extension of dam lifespan	140
Employment	248
Bee-keeping	517
Carbon	142

Metric	Value
Present Value of Costs (USD thousands)	**1,985**
Reforestation	648
AGBMPs	376
Tree Nurseries	380
RBMPs	124
Non-programmatic Costs	458
Net Present Value (incl. carbon benefit)	550
Net Present Value (excl. carbon benefit)	407
Benefit-Cost Ratio (BCR incl. carbon benefit)	**1.3**
Benefit-Cost Ratio (BCR excl. carbon benefit)	**1.2**
Internal Rate of Return (IRR incl. carbon benefit)	**2.92%**
Internal Rate of Return (IRR excl. carbon benefit)	**2.18%**

As can be seen in Table 24, the economic analysis indicates:

Where the carbon benefit is included there is a positive NPV of **USD 550 thousand**. The BCR indicates that **for every USD 1 invested there will be a return of USD 1.3**. The internal rate of return is **2.29%.**

Where the carbon benefit is excluded there is a positive NPV of **USD 407 thousand**. The BCR indicates that **for every USD 1 invested there will be a return of USD 1.2**. The internal rate of return is **2.18%.**

The economic analysis provides positive results for the CIP, the metrics indicate:

- Positive returns under both carbon benefit scenarios
- Multiple co-benefits that enhance resilience and sustainability
- Long-term value creation that exceeds initial investment costs
- Risk mitigation through diversified benefit streams

While the carbon benefit significantly enhances project economics, the analysis demonstrates that the core catchment interventions are economically sound even without carbon monetisation.

However, critically evaluating the results, although positive, the return is smaller than what is typically expected when compared to CIPs covering larger catchment areas. Increasing the scale of the intervention area could result in both an increase in the value of benefits and a decrease in costs through economies of scale. This would provide a stronger investment case and likely attract more opportunities for long-term sustainable funding and would make a stronger case for monetisation of carbon benefits.

9.7 Potential Funding Opportunities

As part of setting up a successful CIP, it is important to identify potential long-term funding and financing opportunities that may arise at various stages throughout the life of the programme. It is critical to recognise where money could come from and the likelihood of securing such funds, as this allows one to identify potential funding gaps early on. As part of this study, various engagements have been held with government entities, NGO's, Development Finance Institutions, large beneficiaries reliant on water, and stakeholders working in the landscape, to understand the potential willingness and appetite to support a CIP. Based on these engagements, a high-level flow of potential funds has been compiled, indicating the likelihood of funding, potential value as well as what next steps are required to realise this funding (see Table 25).

Table 25: Potential funding and financing sources in the short, medium and long-term.

Institution Type	Examples	Funding source	Likelihood Rationale	*Sustainable? (Which would we ideally pursue?)*	*Ease of access*	*What is needed to realise funding?*
MDB/DFIs/ Donor agencies and global funds	World Bank AfDB	Multilateral developing funding	**Likely** - Existing World Bank Projects in both supply and Water resource management.	**No**, unless endowment – good options for pilots	**Difficult** – stringent application process and requires internal capacity within government.	Engage with DFI's working within Malawi to attract funding that meets the CIP priority NbS.
Water Boards/NWRA	BWB SRWB NWRA	Tariff (or other contribution)	**Unlikely** - due to financial position of water boards	**Yes**	**Difficult** – Regulatory and political barriers.	Would require legislation changes at National level and political buy-in. Water abstraction tariff would likely apply across the country.
Private sector	Castel, Chikbuku, FDH Bank, Coca-cola	CSR commitments	**Potentially likely** – good understanding of the issue and good interest. Mechanism and sustainability not well understood.	**Uncertain**	**Medium** - If the correct mechanism is identified and business case is strong.	Ongoing discussions with key beneficiaries and large water users across Malawi.
MCF/MBFs	GCF GEF	Multilateral climate/environment funds	**Potentially likely** – Need better understanding of the results and impacts to identify alignment with applications requirements.	**No**, unless endowment – good options for pilots	**Difficult** – stringent application process and requires internal capacity within government	Consider where potential revenue could come from and if there is alignment with the planned activities and CIP approach.
Government/Public entity	Dept. Finance/Climate etc.	Landscape/Water Bond/National funding	**Potentially likely** – Need better understanding of the required capacities, preparation processes.	**Yes** – can be designed as such	**Medium** – limited precedent and capacity for funding NbS programs at scale.	Engage with various Ministries, to ascertain potential opportunities.
Carbon credits	National Carbon Project/initiatives	Revenue from slae of carbon credits	**Potentially Likely** – Scale is needed to warrant a carbon project feasible and for benefits/revenue to outweigh carbon project costs.	**Uncertain**	**Uncertain**	Would require a local partner / organisation to develop project, along with community buy-in in developing the proposal. Carbon sequestration benefit to likely only accrue after the first 10 years.

10 Leveraging National Level Initiatives to support Catchment Investment

10.1 Malawi's position on Carbon Trading

Malawi is actively positioning itself to tap into international carbon markets as a means of unlocking climate finance. Through the launch of a national framework supported by UNDP and the Climate Promise initiative, the government aims to establish transparent and robust systems for accessing voluntary and compliance carbon markets. The framework is part of broader efforts to finance Malawi's climate ambitions under its updated Nationally Determined Contributions (NDCs).

Key initiatives include the development of a national carbon registry and the establishment of clear guidelines for carbon project development. These tools are expected to increase investor confidence and attract private sector participation. Importantly, the framework prioritises integrity and environmental and social safeguards, ensuring that projects deliver real and lasting benefits.

This evolving carbon market infrastructure offers a significant opportunity to fund large-scale catchment restoration efforts in Malawi and in turn create further carbon projects that can draw in foreign investment. By generating carbon credits through nature-based solutions such as reforestation, afforestation, and avoided deforestation, Malawi can create sustainable revenue streams to finance long-term ecosystem recovery and potentially improve its national balance of payments. Catchment restoration aligns well with carbon market eligibility criteria, offering co-benefits such as climate adaptation, biodiversity conservation, and improved water security.

As such, integrating carbon finance into catchment restoration strategies could provide both the capital and long-term incentives needed to scale and sustain these interventions as well as creating broader economic opportunities for Malawi.

10.2 World Bank Projects

The World Bank has a strong presence in Malawi. Historically it has funded and developed several projects within the water and adjacent sectors, spanning catchment restoration, agriculture, irrigation and infrastructure in the country. During the feasibility study, the World Bank was consulted on multiple occasions to better understand ongoing projects and opportunities for alignment and collaboration. It was encouraging to learn of several projects to which the establishment of a CIP and/or implementation of NbS could offer significant benefit or opportunity for collaboration. A short list of projects is shown in Table 26 (for full project list, please refer to Annex F).

Table 26: Existing and upcoming World Bank projects aligned to the CIP model and/or NbS

Project Name	Project Development Objective	Implementing Agency	Project Closing Date	Alignment to NbS/CIP model
Mpatamanga Hydropower Storage Project	The objectives are to increase peak power generation capacity, secure green electricity for domestic users and industries in Malawi, and expand renewable energy trade between Malawi and the SAPP	Ministry of Energy, Republic of Malawi,Mpatamanga Hydro Power Limited (MHPL)	June 30, 2031	NbS have been proven to have significant benefits for reliability of supply to hydropower reservoirs and improve water quality
Water and Sanitation Project - I	To increase access to improved water supply and sanitation services in Blantyre Metropolitan Area, and to enhance the operational and financial	Blantyre Water Board	March 31, 2029	As part of the project, the World Bank is conducting a feasibility study to identify the most suitable option to refurbish Mudi dam. This study demonstrates that NbS can increase

	efficiency of the Blantyre Water Board.			the lifespan of the dam thereby improving return on investment and ensuring security of the supply infrastructure in the future.
Malawi Watershed Services Improvement Project	Increase adoption of sustainable landscape management practices and improve watershed services in targeted watersheds	Ministry of Water and Sanitation	July 31, 2026	This project is fully aligned to a CIP model where sustainable funding for NbS in source water catchments is identified. A future CIP model could support ongoing efforts to ensure sustainability of the interventions and reliability of supply and long-term water quality benefits in the target catchments.
Unapproved/In discussion				
Payment for ecosystem service and public works project	From discussions with the World Bank, it is understood that the World Bank is investigating developing a project to develop a framework for payment for ecosystem services incorporating public works programmes to implement interventions to support the preservation of ecosystem services	Unknown	Unknown	A CIP model mirrors payment for ecosystem services (PES) models in a lot of ways. Source water catchments are useful areas to pilot PES models where there is a clear benefit to a set of downstream beneficiaries who may be willing to pay for interventions. Additionally, the idea of incorporating public works programmes aligns to our findings that cash for work or formal employment are necessary for the success of such a project in Malawi.

11 Summary and Recommendation

The findings of the analysis point towards a positive case for NbS implementation under a CIP in Mudi-Ndirande and Likhubula. However, the limited scale of these catchments limits access to sustainable long-term funding. Findings from this study suggest that the success of a CIP is hugely reliant on its scalability in order to draw in foreign funding and broad stakeholder buy-in (from national-level stakeholders to local-level stakeholders). Furthermore, the findings suggest:

- Existing catchment management-related efforts should continue to leverage on-the-ground activity (e.g., MMCT, WFP, local corporate CSR tree planting initiatives, etc.) as well as the momentum created by various stakeholders as part of this study (e.g., Steering Committees, Technical Working Groups, etc.) to continue to coordinate local and national stakeholders around shared objectives for landscape restoration and water security.
- Investigation of the use of NbS for water security benefits continues, focusing on critical catchments and watersheds throughout Malawi to unlock economies of scale both in terms of reducing costs and, importantly, unlocking funding mechanisms that could sustain long-term restoration and protection of critical landscapes that support fresh water availability and quality - the key focus should be on the scalability of a CIP model.
- The findings of this study are used to develop a case for National Government stakeholders to leverage national initiatives and pursue international funding opportunities to ensure the safeguarding of water security through landscape restoration/protection in priority source water catchments where there is strong local leadership and coordinated stakeholders (such as Likhubula and Mudi-Ndirande).
- Leveraging the opportunities for collaboration with the World Bank on the development of a Payment for Ecosystem Services Framework for watershed management and the refurbishment of the Mudi dam – these are critical opportunities for collective action across several stakeholders and beneficiaries towards NbS for water security.

11.1 Feasibility study findings

Table 27 summarises the key outcomes of the Feasibility Study in terms of the various components and workstreams completed, addressing the key questions that need to be answered as part of this phase. It also provides overarching conclusions about the study and viability of a Catchment Investment Programme in the Mudi-Ndirande and Likhubula catchments.

Table 27: Feasibility conclusions

Feasibility Component	Conclusions and justification
Stakeholder Analysis	1. The **water security challenges, specifically water quality, can be clearly linked to and prioritised by stakeholder experiences** (and is clearly evident by the extreme drought unfolding in the 2023/2024 agricultural season). 2. There is a strong willingness by stakeholders to work collaboratively through a **multistakeholder model**, however, further work is required to refine what this would look like, who would drive the CIP and what the key roles and responsibilities would be for stakeholders. 3. A number of stakeholders are already implementing NbS activities within both catchments. In Likhubula NbS activities are well-established, led by MMCT and coordinated with a range of stakeholders. In Mudi-Ndirande NbS activities are relatively less established, but BWB and the Mudi Catchment Management Committee could play a strong role in

	coordinating implementation of NbS alongside several committed stakeholder groups. 4. Stakeholders have confirmed the benefits that NbS can offer to both the biophysical and socio-economic environments, exhibiting a strong acceptance of such solutions.
Science Workstream	1. Nature-based Solutions **can contribute meaningfully to impoving water quality and reliability of supply through the dry season**, supporting important ecosystems, livelihoods and economic activity for communities. 2. **Reforestation, AGBMPs and RBMPs can significantly reduce surface water run off reducing sediment loads and water treatment costs** in both catchments. In the case of Mudi Dam this can also lead to a significant extension in the lifespan of the dam. 3. NbS activities in Likhubula can help to **protect biodiversity on Mulanje Mountain, a critical biosphere,** benefiting wildlife, communities and tourism. NbS activities can also restore some of the biodiversity benefits in Mudi-Ndirande, which is almost completely degraded.
Return on Investment	1. The RoI analysis **demonstrated that a positive NPV is achieved both when the costs of developing a carbon project are excluded and when the carbon benefit is excluded.** 2. **Without carbon project costs, a NPV of USD 2 million** is achieved. **Excluding the carbon benefit, a NPV of USD 407 thousand** is achieved. **The feasibility study confirms that NbS result in benefits for stakeholders, however the case at this scale is not convincingly strong.** 3. The **economic benefits to selected beneficiaries can be clearly articulated** as a result of increased water availability over the 30-year lifecycle: • Alternative Water Supply 1,230 • Water treatment cost savings 202 • Extension of dam lifespan 138 • Employment 244 • Bee-keeping 15 4. In addition, restored grasslands will **increase carbon sequestration by an average of 1 287 tC02e per year after year 10**, with the potential to generate **~$1.6 million**, after 10 years, through the sale of carbon credits (costs not included). 5. **NbS are critical in extending the lifespan of the Mudi dam** and therefore have the potential to improve the return on investment of the proposed refurbishment of the dam. The refurbishment project feasibility study is currently being conducted and there is an opportunity for alignment.
Funding Potential	1. Potential funding sources were identified in the Feasibility Study, where the likelihood of each potential funding source was ranked, as well as

	indicating short, medium and long-term funding opportunities, highlighting a broad range of target areas. 2. The certainty of unlocking any of these funding sources is unclear and further work would be required to understand whether these funding sources are realistically available and appropriate for NbS for water security outcomes. 3. A number of other potential funding sources were identified, each requiring further effort to establish firm commitments or to improve the likelihood of the funding source, such as: - World Bank projects, both existing and potentially upcoming - Private sector funding through corporate stewardship - Donor agencies and global funds - Carbon credits through forest restoration - Water or energy tariffs for catchment management activities 4. Both the direct and co-benefits that would arise cover a range of key areas, such as biodiversity, community resilience and livelihoods, wildlife and tourism meaning that water security does not need to be the only funding focus to achieve the desired end results of long-term water security.
Implementation Modality / Delivery Model	1. Given the socio-economic status quo and the reliance of communities on the natural resources in the sub-catchments for livelihoods, communities would need to be both consulted as a critical stakeholder and employed during implementation of NbS. This is very likely the case across Malawi. 2. **The delivery model would need to be such that the water fund employs community members to implement the interventions with oversight from experienced organisations and individuals.** This would likely take a **Contract-management type model** where individuals are employed for a period to undertake activities. The Water Fund would cover all associated costs (salaries, equipment, etc.). The Water Fund will also support with all costs associated with community engagement, training, materials and equipment. 3. The **community based delivery model** relies on community support, buy-in and uptake, driven through support of Traditional Leaders and Group Village Heads, in addition to support from key local partners. Community engagement is crucial to the success of this model. 4. The **contract-management type model** relies on effective local partners to oversee the implementation of activities, manage and train staff, etc. 5. Work would be needed to assess the capacity of organisations and institutions to manage the implementation of interventions. Organisations like MMCT have a strong track-record of implementing NbS at scale and therefore should be considered a good example. The experience and lessons from MMCT should be leveraged for conservation and NbS-focused work going forward.

11.1.1 Clear interest in action and continuing collective action efforts

Stakeholder engagement and investigation of existing initiatives in both the Mudi-Ndirande and Likhubula sub-catchments show that there is a clear understanding of the challenges faced in both catchments and a willingness and interest in ensuring future catchment health. Stakeholders are taking action and this should be continued and strengthened through the work done by local stakeholders through the feasibility project phase. This is a very positive finding and critical for the success of a CIP model. Collective action across stakeholders should be leveraged and the momentum gained through this study should be maintained to enable both local action in the Mudi and Likhubula sub-catchments but also bringing critical local, national and international stakeholders together to create the necessary conditions for sustainable long-term funding for NbS at scale.

11.1.2 Leveraging existing institutions and initiatives

Although progress towards implementing the institutional framework provided for in the Water Resources Act is still underway, the framework supports integrated water resources management and the mechanisms to fund and govern the implementation of NbS at scale to address water security challenges through a Catchment Investment Programme. The NWRA should consider a scalable CIP model as a means of achieving its mandate of protecting and managing source water catchments in Malawi and implementing catchment management plans at a local level.

A CIP at the catchment scale should be designed in congruence to the provisions of the Water Resources Act. A combination of top-down and bottom-up interventions is needed. A CIP offers the opportunity for a bottom-up approach to meeting top-down objectives. This can accelerate impact and outcomes at the community and local level, whilst ensuring government mandates are met.

11.1.3 Final conclusion

This Feasibility Study has demonstrated that NbS provide a host of direct and co-benefits to various stakeholder groups. Importantly, this study shows that appropriate NbS interventions could have a significant impact in addressing water security challenges in the Mudi and Likhubula catchments. However, due to the scale of these two sub-catchments, the findings suggest that long-term financial sustainability of a CIP model depends on a strategy that could scale to priority water catchments throughout the country. This would allow for greater economies of scale both in terms of reducing costs and, importantly, unlocking funding mechanisms that could sustain long-term restoration and protection of critical landscapes that support fresh water security. The adoption of a CIP model that is replicable and scalable to broader source water catchment areas or source water catchments in other regions of Malawi could allow for greater coordination of local funding that goes toward reforestation, catchment management and livelihood programmes whilst creating sufficient project portfolios that could access international carbon funding markets and other international climate-related funding mechanisms.

While this study shows positive water security and livelihood outcomes from the implementation of NbS in Mudi-Ndirande and Likhubula, it is recommended that **further study to assess the feasibility and/or design of a CIP (or CIPs in other areas of Malawi) to critically assess the potential opportunities for scaling interventions and benefits is needed. This should form part of an overarching strategy that can coordinate international and national funding sources and intermediaries**. Moreover, it is rather recommended that:

1. Existing catchment management-related activities leverage the momentum gathered through this project to continue to coordinate local and national stakeholders around shared objectives for landscape restoration and water security.
2. The findings of this study are used to develop a case for National Government stakeholders to leverage national initiatives and pursue international funding opportunities to ensure the safeguarding of water security through landscape restoration/protection in priority source water catchments where there is strong local leadership and coordinated stakeholders (such as Likhubula and Mudi-Ndirande).

3. Collaboration with the World Bank on the development of a Payment for Ecosystem Services Framework for watershed management and the refurbishment of the Mudi dam is critical and offers an opportunity for further collective action for the use of NbS for catchment restoration.

11.2 Towards a future CIP in Malawi

This feasibility study shows that NbS would yield positive net benefits in Likhubula and Mudi-Ndirande catchments. However, sourcing long-term sustainable funding for the implementation of NbS remains a challenge due to local funding limitations and resource constraints. This challenge, however, is not unique in Malawi, and many landscape-scale restoration/conservation activities require foreign funding and at the very least, coordinated national support structures that might contribute to funding and facilitate foreign funding flows. There are limited local funding avenues, some of the downstream corporate stakeholders such as Castel, Chibuku, Capital Oil Refineries and FDH Bank have expressed interest funding NbS and as such should not be discouraged from contributing to catchment restoration efforts. However, greater long-term funding is needed in order to overcome systemic challenges (e.g., energy insecurity drives demand for charcoal and deforestation) that can not only be addressed at the sub-catchment and catchment-level.

A key finding of this study is that securing a sustainable long-term source of funding requires a scalable strategy for linking priority source water catchments – as “links-in-a-chain” – through a coordinated national-level programme that could unlock foreign funding mechanisms (e.g., development grant funding, multilateral development bank funding, climate funding, carbon credit monetisation, etc.) that could then capacitate and sustain local-level Catchment Investment Programmes and the implementation of Nature-based Solutions. Therefore, this feasibility study shows that Mudi-Ndirande and Likhubula catchments are critical links in the chain, demonstrating the positive net benefits of NbS, that can foster greater national coordination and broad stakeholder engagement to address water security challenges in Malawi.

The study shows strong signs of collective action for NbS implementation in Likhubula and Mudi-Ndirande. This is demonstrated most notably in Mulanje Mountain and the Likhubula sub-catchment where MMCT has successfully led several multi-stakeholder initiatives to protect and conserve Mulanje’s natural ecosystem while creating livelihood opportunities for local communities. In Mudi-Ndirande several stakeholders such as BWB, WFP and various other corporate entities, local government bodies and NGOs show a clear interest and commitment to working with local communities to rehabilitate the catchment. In both catchments, there are clear signs of local coordination which is a critical factor for the long-term success of CIPs. Through continued engagement and strong local leadership, these stakeholders provide a national example for integrated water resources management in Malawi. Stakeholders within the Malawian water sector should continue to leverage the institutional knowledge, ways of working and vision of these kinds of organisations to spark greater uptake for landscape restoration activities and integrated water resources management to realise the National Water Resources Act and create the impetus for implementing Nature-based Solutions to ensure long-term water security, not just in Likhubula and Mudi-Ndirande, but in other source water catchments across Malawi.

Figure 35 provides a conceptual framework of this “links-in-a-chain” strategy, whereby a larger fund of funds approach is able to leverage the portfolios of multiple CIPs in order to attract larger investment for NbS in Malawi. Importantly this fund of funds approach would need the leadership of key national-level institutions such as NWRA to ensure that various CIPs have sufficient local leadership and appropriate catchment management plans. A fund of funds approach would then be critical to ensuring the flow of funding for NbS implementation to various CIPs in Malawi.

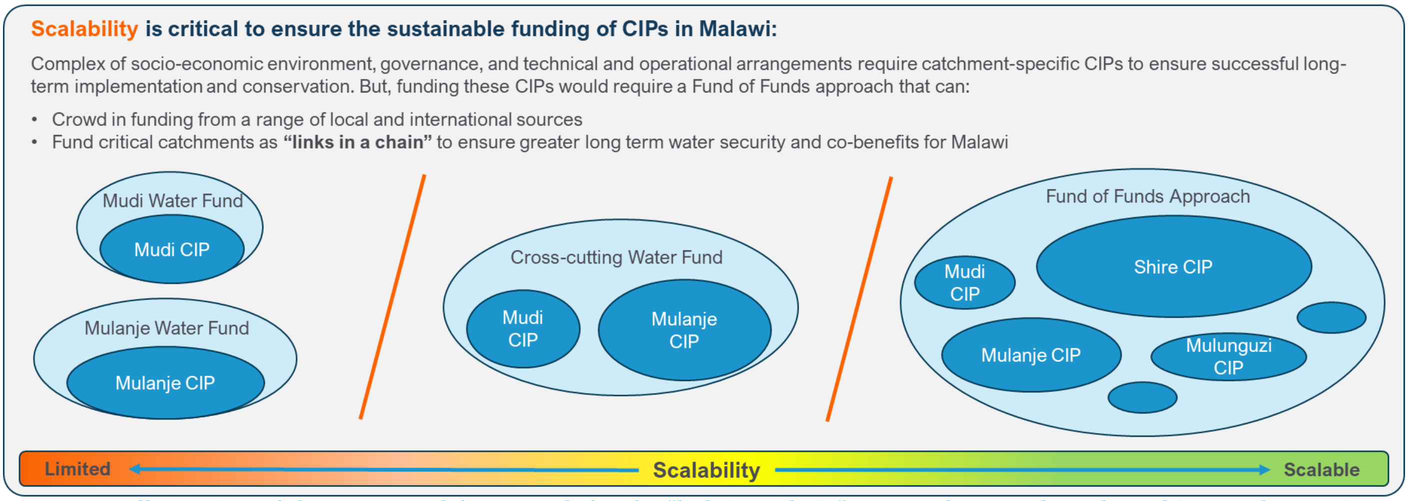

Figure 35: Illustration of the conceptual framework for the "link in a chain" approach towards scale and impact leveraging a national coordinated effort (N4W)

Considering the studies recommendation for a a scalable strategy for linking priority source water catchments – as "links-in-a-chain" – through a coordinated national-level programme, there are some risks that should be considered and analysed going forward that include:

1. Fiscal Risk: It is a reality, given the current fiscal situation in Malawi that securing short- and medium-term funding may be difficult and may require specific and dedicated donor support
2. Political risks: Congnisance must be take of potential high churn within critical institutions and the need for concerted efforts to gather buy-in from senior government stakeholders and decision-makers
3. Implementation: It is unclear whether there is existing implementation capacity across other catchments in Malawi, there is evidence that points towards capacity that can be leveraged with the right amount of support in Blantyre and Mulanje.
4. Energy Insecurity: Energy insecurity is a major issue in Malawi and a key driver for deforestation and resulting water security issues in source water catchments. The energy security issue can not be considered in isolation to catchment challenges and should be taken into consideration in any further work around developing solutions for catchment management.

12 Next steps

Following on from the positive Feasibility Study findings, a set of next step activities has been developed to outline and guide the next steps towards establishing a CIP. This section outlines key follow-on activities across three strategic areas, namely 1) Local implementation, 2) Scaling and replication and 3)Governance development.

Strategic Area 1: Local Implementation

Activity	Continued efforts in the local sub-catchments (Mudi and Likhubula).
Steps	Continued stakeholder engagement and coordination of NbS activities leveraging the momentum gained through the project and noting the benefits that are demonstrated through this study to encourage collective action across stakeholders.

Activity	Ongoing engagements across the multiple workstreams to ensure that stakeholders are consulted, are able to provide valuable input and that the Steering Committee plays a central role in moving the CIP forward.
Steps	• Detailed engagements with communities to test delivery models, implementation partners, key governments (local, district and national levels) as the CIP is developed. • Support and guide the Steering Committee as the vehicle that will drive the creation of the CIP. • Continue to build and foster relationships within the catchment.

Strategic Area 2: Scaling and Replication

Activity	Ensure that other pre-feasibility and/or feasibility studies for CIPs in other source water catchments of Malawi assess the scalability and potential linkages with other catchments in Malawi in order to strengthen national-level strategy for carbon and other foreign funding mechanisms.
Steps	• N4W and SRWB are undertaking a pre-feasibility study in Mulunguzi catchment, Zomba. As part of this study, the team will seek to build upon the key recommendations of this study and further assess opportunities for scalable benefits and funding sources. • Support national stakeholders in maintaining ongoing dialogue around the importance of scale as a means to secure funding opportunities to address landscape challenges that are driven by systemic challenges.

Activity	Confirm funding and financing opportunities where alignment has already been identified.
Steps	• Continue to engage with the project teams developing World Bank projects (Water resources and Payment for Ecosystem Services) • Engage other funders using supportive materials • Leverage national level initiatives (national carbon trading framework supported by UNDP and the Climate Promise initiative)

Strategic Area 3: Governance development

Activity	Ensure continued Steering Committee Meetings.
Steps	• Coordinate key stakeholders and decision-makers to identify opportunities for catchment restoration and the use of NbS

	• Guide the focus on critical matters and areas where NbS can have significant impact and support with scaling of activities.

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Annex A. Field Trips – Agenda and Notes

A 1.1. June 2024 Field Trip

Stakeholders we need to meet include:

- **One group meeting: SteerCo/Core consortium:** NWRA, BWB, SRWB
- **Meeting at different NGO offices where appropriate: NGOs/CSOs:** WESA, CEPA, CURE – unsure if these should be individual engagements or in one meeting
- **One meeting, need venue: National Ministries:** Representation from Water Resources, Forestry, Water supply and sanitation, Land Resources, Environmental Affairs, Irrigation, Finance – unsure what level of representation exists in Blantyre. This meeting would likely work best as a workshop style engagement within everyone at the same time in a venue. Refreshments may be required.
- **At government offices?: Local Gov:** Blantyre City and District Council, Mulanje District Council
- **At beneficiary offices: Commercial beneficiaries:** FDH Bank, Castel Limited, Coca-Cola, maybe others
- **At utility offices/facilities: Utilities (in capacity as utilities to observe operations, dams, abstraction points:** BWB, SRWB etc.
- **At community areas: Water User Associations or similar + Local communities/traditional authorities:** Blantyre?, Mulanje

As part of our time in Blantyre and Mulanje, it is important that we visit key areas in each catchment where work is being done or where significant catchment degradation has taken place.

Some ideas for Blantyre include:

- Mudi Catchment
- Mudi Dam
- Reforestation project
- Encroachment areas

Mulanje:

- BWB offtake
- SWRB offtake
- Reforestation projects
- Forest rehab/protection
- Local communities – Land stewardship, Agriculture, MEGA
- Tour of the Mountain area to see the landscape

Wednesday 12 June: Morning in Blantyre, then travel to Zomba and then to Mulanje.

Sunday 9 June	Time slots	Monday 10 June	Tuesday 11 June	Wednesday 12 June	Thursday 13 June	Friday 14 June (Potentially holiday in Malawi)	Saturday 15 June
Arrive Blantyre	**09:00 – 10:00**	N4W/LL Check-in	N4W/LL Check-in	N4W/LL Check-in	Check-in	Mulanje Field Visit/community/Mulanje city	**Leave Blantyre**
	10:00 – 11:00	BWB operations and Mudi	1-1 Coca-cola	1-1 FDH Bank	Meet with MMCT		

		Catchment (Must check how much time we will need to visit abstraction /treatment facilities and do tour of the dam and catchment ?)				council/We Forest/SW RB	
	11:00 – 12:00		1-1 Castel limited	Travel to Zomba	Mulanje Field Visit/community/Mulanje city council/We Forest/SW RB	Drive to Blantyre leave by 10am	
	12:00 – 13:00		1-1 CEPA/WESM/CURE/Water witness/LEAD	Meet with SWRB and VEI		Any additional meetings required	
	13:00 – 14:00	Lunch	Lunch	Travel to Mulanje/Lunch	Lunch	Lunch/	
	14:00 – 15:00	Blantyre City Council?	1-1 CEPA/WESM/CURE/Water witness/LEAD	Mulanje Field Visit/community/Mulanje city council/We Forest/SW RB	Mulanje Field Visit/community/Mulanje city council/We Forest/SW RB	Debrief – catch up meetings	
	15:00 – 16:00	NWRA/Shire Best?	1-1 CEPA/WESM/CURE/Water witness/LEAD				
	16:00 – 17:00	Lilongwe University?	Suggestions				
Stay in Blantyre		**Stay in Blantyre**	**Stay in Blantyre**	**Stay in Mulanje**	**Stay in Mulanje**	**Stay in Blantyre**	

A 1.2. March 2025 Field Trip

The field trip focussed on engaging stakeholders based in Lilongwe and presenting the work of N4W/WFP on a panel at the Just Transitions for Water Security Leadership Forum. Importantly in-person meetings with NWRA and the World Bank were scheduled to ensure alignment, buy-in and support for the work N4W and WFP are doing.

Time slots	**Mon 3 March**	**Tues11 March**	**Wed 12 March**	**Thurs13 March**	**Fri14 March**
09:00 – 10:00	**Travel World Bank**	World Bank - Water supply and Resources	JTWS – Leadership Forum	JTWS – Leadership Forum	World Bank – Samantha Braid and Public Works team – PES and public Works
10:00 – 11:00					
11:00 – 12:00		Ministry of Water Reosources			Engagement at Ministry of Natural Resources on NIRAS/Agreer project on Land-use
12:00 – 13:00					

					planning, Forestry, Restoration and sustainable finance
13:00 – 14:00		Lunch			Liz Venable – Palladium Growth Poles
14:00 – 15:00	Work and prep	NWRA			Meeting – Malawi Environment Endowment Trust
15:00 – 16:00					
16:00 – 17:00					
	Stay in Lilongwe				

Annex B. Land Degradation assessment.

Annex C. SWAT Model Modifications to Simulate NbS

Intervention	Purpose	Landscape	SWAT Parameter		Value when NbS simulated	Reference
			Parameter	Default/calibration value		
			Rangeland/Grassland Best Management Practices			
Invasive pine clearing and Miombo re-establishment	Increase basal cover, vegetation interception	Degraded Areas	Landuse input	Rnge_Deg	Mod First_SUHF	N4W User Modification
Fire management – Facilitate biennial (every two year) spring burn to improve yield and biodiversity	Increase biomass, remove sediment and nutrient build up on impervious areas in the HRU	Grassland/Rangeland	BLAI ALAI_MIN USLE_C OV_N.hru	5 1.8 0.005 0.8	0.5 0 0.008 0.1	Carvalho-Santos et al. (2019)
			Wetland/Riparian Restoration			
Revegetated waterways	Reduce peak flow rate Reduce channel erodibility Increase sediment trapping Reduce gully erosion	Channel (1st stream class)	CH_COV CH_EROD CH_N2	0.02–0.25 0.01–0.45 0.01–0.031	0.001(completely protected) 0.001(completely protected) 0.24	Arabi et al. (2008) Tesfahunegn et al. (2012)
Streambank stabilization	Reduce sediment load Maintain channel capacity	Channel (2nd and 3rd stream class)	CH_COV CH_EROD CH_N2	0.02–0.25 0.01–0.45 0.01–0.031	0.001(completely protected) 0.001(completely protected) 0.05	Chow (1959) Narasimhan et al. (2007) Arabi et al. (2008) Tuppad et al. (2010b)
Wetland/riparian buffers	Facilitate sediment setting. Reduce velocity of flow Reduce erosion	Channel & Grassland	Landuse input	20m buffer on drainage lines	Rnge_Sums	N4W User Modification
			Agricultural Best Management Practices			
Conservation tillage	Facilitate sediment setting. Reduce velocity of flow Reduce erosion	Cropland	OV_N CH_N1 EFFMIX DEPTIL, mm CN2	0.14–0.15 0.079 0.50–0.95 125–150 35–98	0.20 0.14 0.25 100 CN2 reduced by 2	Chow (1959) Neitsch et al. (2004) Neitsch et al. (2005)
Vegetative filter strips	Reduce sediment, dissolved contaminants, and sediment adsorbed organics in runoff	Cropland	FILTERW	0.0 m	14 m 20 m	Cho et al. (2010) Melbourne Water (2010) Mbonimpa et al. (2012)
Contour farming	Reduce surface runoff Reduce sheet and rill erosion	Cropland	CN2 P-factor	Varies 0.27–0.70	CN2 reduced by 3 0.5, if slope ≤ 10% 0.6, if slope > 10%	Wischmeier and Smith (1978a, b) Arabi et al. (2008) Tuppad et al. (2010b)

Annex D. NbS Opportunity Mapping

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Annex E. Steering Committee and Technical Working Groups

Table 28: Steering Committee Members

	Name		Organisation	Email	Phone
1	Dr Dwight Kambuku	CEO- Chair	National Water Resource Authority	dwightkambuku@engineer.com dwight.kambuku@nwra.mw ceo@nwra.mw	881472781
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5	Verson Kafodya	Director of distribution and commerce	Blantyre Water Board	bkafodya@bwb.mw	0884623790/0994170890
6	Bright Mziliwanda	Engineer	Blantyre Water Board	bright-mziliwanda@srwb.mw	
7	Ulemu Chiluzi	Country Director	Water for people	uchiluzi@waterforpeople.org	
8	Levie Nkunika	Head of Marketing	FDH	LNkunika@fdh.co.mw	887099666
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10	Linda Kolomba	Corporate Social Responsibility Manager	Castel	linda.kolomba@castel-afrique.com	995588678
11	Prince Mleta	Deputy Director	Ministry of irrigation and water development, department of water resources	princemleta@gmail.com	991873498
12	Jipate Munyenyembe	Deputy Director, Environment and Forestry	Ministry of Natural Resources and Climate Change	jipatekk@yahoo.co.uk	999792427/0888895825
13	Gertrude Kambauwa	Director of land resources conservation	Ministry of Agriculture-Department of Land Resources conservation	gkambauwa@gmail.com	
14	Lucy Ng'ombe Mtilatila	Director	Department of Climate Change and Meteriological services	lmtilatila@gmail.com or lmtilatila@metmalawi.gov.mw	
15	GVH Nankhonyo	Group Village Head	Mulanje		882054683

Biodiversity and watershed management Technical Working Group

	Name	Organisation
1	Lameck Mtali	Malawi Environment and Endowment Trust (MEET)
2	Edger Nkoka	The Wildlife and Environmental Society of Malawi (WESM)
3	Dennis Phwandaphwanda	Blantyre District Council
4	Chrispin Kambani	Lilongwe University of Agriculture and Natural Resources (LUANAR)
5	MacPherson Nkhata	Ministry of Water and Sanitation
6	Gift Wanangwa	Ministry of Water and Sanitation
7	Feston Chitseko	Forestry zone office
8	Sphiwe Nyalugwe	Leadership for Environment and Development (LEAD)
9	Eunice Shame Kafwamba	Leadership for Environment and Development (LEAD)
10	Weenly Genesis	Coordination Union for the Rehabilitation of the Environment (CURE)
11	Richard Swirah	We Forest
12	Steven James Minora	Southern Region Water Board
13	Dean Kampanje-Phiri	Lilongwe University of Agriculture and Natural Resources (LUANAR)
14	Charles Nkoka	Coordination Union for the Rehabilitation of the Environment (CURE)
15	Doreen Chanje	Shire Best
16	Ausward Bonongwe	The Wildlife and Environmental Society of Malawi (WESM)
17	Moffat Kayembe	Mulanje Mountain Conservation Trust (MMCT)
18	Chikumbutso Kaonga	Malawi University of Business and Applied Sciences (MUBAS)
19	Baxton Chirombo	Catholic Relief Services (CRS)
20	Herbert Mwalukomo	Centre for Environmental Policy and Advocacy (CEPA)
21	Juma Masumba	Catholic Relief Services (CRS)

Community engagement and stakeholder relations Technical Working Group

	Name	Organisation
1	Manota Mphande	Art Mal
2	Edger Nkoka	The Wildlife and Environmental Society of Malawi (WESM)
3	Violet Kapolo	Capital Oil Refining Industries (CORI)
4	Lawrence Muhamba	Capital Oil Refining Industries (CORI)
5	Edwin Mchilikizo	Mulanje District Council
6	Harlod Chirwa	Ministry of Water and Sanitation
7	Chimwemwe Kadongo Kwanjana	Southern Region Water Board (SRWB)
8	Weenly Genesis	Coordination Union for the Rehabilitation of the Environment (CURE)
9	Charles Nkoka	Coordination Union for the Rehabilitation of the Environment (CURE)
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11	Richard Swirah	We Forest
12	Moffat Kayembe	Mulanje Mountain Conservation Trust (MMCT)
13	Christabel Yollanda Kambala	Malawi University of Business and Applied Sciences (MUBAS)
14	Macpherson Nkhata	Ministry of Water and Sanitation
15	Caeser Kachale	Catholic Relief Services
16	Harold Mapoma	Malawi University of Business and Applied Sciences (MUBAS)

Environmental engineering and water & wastewater treatment Technical Working Group

	Name	Organisation
1	Manota Mphande	Art Mal
2	Ina Makocha	Mulanje District Council
3	Dennis Phwandaphwanda	Blantyre District Council
4	MacPherson Nkhata	Ministry of Water and Sanitation
5	Gift Wanangwa	Ministry of Water and Sanitation
6	Gertrude Botomani	Ministry of Water and Sanitation
7	Modesta Kanjaye	Ministry of Water and Sanitation
8	Harlod Chirwa	Ministry of Water and Sanitation
9	Weenly Genesis	Coordination Union for the Rehabilitation of the Environment (CURE)
10	Matthews Kalaya	Ministry of Water and Sanitation
11	Alexander Mwangonde	Ministry of Water and Sanitation
12	Professor Chavula	Malawi University of Business and Applied Sciences (MUBAS)
13	Dan Van der Velden	VEI
14	Emma Lesterhuis	VEI
15	Vida Tembo	Southern Region Water Board (SRWB)
16	Madalitso Jere	Catholic Relief Services
17	Ivaylo Hristov Kolev	World Bank
18	Tesfaye Bekalu	World Bank
19	Bright Mziliwanda	Blantyre Water Board (BWB)
20	Joe Chimeta	Blantyre Water Board (BWB)

Water Resources Management & Development Technical Working Group

	Name	Organisation
1	Dennis Phwandaphwanda	Blantyre District Council
2	Edger Nkoka	The Wildlife and Environmental Society of Malawi (WESM)
3	Manota Mphande	Art Mal
4	Baleke Banda	Water Witness
5	Gloria Kanyumba	Water Witness
6	Edwin Mchilikizo	Mulanje District Council
7	MacPherson Nkhata	Ministry of Water and Sanitation
8	Gift Wanangwa	Ministry of Water and Sanitation
9	Wonderful Yonamu	Southern Region Water Board
10	Frank Chunga	Catholic Relief Services
11	Khumbo Kalulu	Malawi University of Business and Applied Sciences (MUBAS)
12	Harold Mapoma	Malawi University of Business and Applied Sciences (MUBAS)
13	James Chimtengo	Chibuku
14	Dana Van der Velden	VEI
15	Emma Lesterhuis	VEI
16	Herbert Mwalukomo	Centre for Environmental Policy and Advocacy (CEPA)
17	Vincent Msadala	Malawi University of Science and Technology (MUST)
18	Dr. Kaonga	Malawi University of Business and Applied Sciences (MUBAS)
19	Ackley Kananji	Blantyre City Council
20	Yamikani Mtimuni	National Water Resources Authority (NWRA)

Annex F. Existing World Bank Project List

Project Name	Project Development Objective	Implementing Agency	Effective Date	Project Closing Date
Mpatamanga Hydropower Storage Project	The objectives are to increase peak power generation capacity, secure green electricity for domestic users and industries in Malawi, and expand renewable energy trade between Malawi and the SAPP	Ministry of Energy, Republic of Malawi,Mpatamanga Hydro Power Limited (MHPL)		June 30, 2031
Regional Climate Resilience Program for Eastern and Southern Africa 2 Project (RCRP2)	To improve resilience to water-related climate shocks in Malawi and in the Eastern and Southern Africa region, and in case of an Eligible Crisis or Emergency, to respond promptly and effectively to it.	MW-Ministry of Finance and Economic Affairs,African Union Commission (AUC)	March 21, 2024	December 29, 2028
Malawi: Piloting Fecal and Solid Waste Integrated Management Services for Peri-Urban Lilongwe City	To increase access to fecal sludge management for 20,000 people and solid waste management services for 50,000 people in Mtandire and surrounding peri-urban areas in Lilongwe City and enhance access to income-generating activities for 100 women.	Lilongwe City Council		Septembe r 30, 2025
Water and Sanitation Project - I	To increase access to improved water supply and sanitation services in Blantyre Metropolitan Area, and to enhance the operational and financial efficiency of the Blantyre Water Board.	Blantyre Water Board	June 6, 2023	March 31, 2029
Shire Valley Transformation Program - Phase 2	To develop irrigated commercial agriculture and strengthen the management of natural resources in the Program area.	Ministry of Agriculture	Septembe r 12, 2022	Septembe r 30, 2028
Additional Financing For Lilongwe Water and Sanitation Project	To increase access to improved water services and safely managed sanitation services in Lilongwe City	Lilongwe Water Board		June 30, 2025
Malawi Watershed Services Improvement Project	Increase adoption of sustainable landscape management practices and improve watershed services in targeted watersheds	Ministry of Water and Sanitation	December 21, 2020	July 31, 2026
Additional Financing to the Malawi Resilience and Disaster Risk Management Project	Support the recovery of livelihoods and infrastructure in flood and drought affected areas and strengthen capacity for flood and drought risk management	Ministry of Finance, Economic Planning and Development,Ministr y of Agriculture,Irrigation and Water Development		January 31, 2025
Lilongwe Water and Sanitation Project	To increase access to improved water services and safely managed sanitation services in Lilongwe City	Lilongwe Water Board	March 26, 2018	June 30, 2025
Malawi Strategic Program for Climate Resilience	The Project Development Objective (PDO) is to assist the Government of Malawi to prepare a national investment plan for climate resilience, strengthen institutional capacity and improve the analytical base for mainstreaming climate risks in policy and planning.	Ministry of Natural Resources, Energy and Mines	November 23, 2017	June 30, 2020
Shire Valley Transformation Program - Phase 1	The program development objective of the Shire Valley Transformation Program is to increase agricultural productivity and commercialization for targeted households in the Shire Valley and to improve the sustainable management and utilization of natural	Ministry of Agriculture, Irrigation and Water Development	December 19, 2014	December 31, 2024

	resources. The project development objectives (PDO) of SVTP-I are to provide access to reliable gravity fed irrigation and drainage services, secure land tenure for smallholder farmers, and strengthen management of wetlands and protected areas in the Shire Valley of the Recipient.			
Shire Valley Irrigation Project	To sustainably increase agricultural productivity and incomes for targeted households in the districts of Chikwawa and Nsanje in the Shire Valley by establishing market-linked smallholder farming ventures and professionally operated irrigation services.	Ministry of Agriculture and Food Security (MoAFS),Ministry of Water Development and Irrigation (MoWDI)		
Malawi Resilience and Disaster Risk Management Project	Support the recovery of livelihoods and infrastructure in flood and drought affected areas and strengthen capacity for flood and drought risk management	Ministry of Irrigation and Water Development	January 18, 2017	January 31, 2025
Malawi Floods Emergency Recovery	The Project Development Objective is to "sustainably restore agricultural livelihoods, reconstruct critical public infrastructure to improved standards in the flood-affected districts, and improve the Government of Malawi's disaster response and recovery capacities".	Government of Malawi	August 20, 2015	January 31, 2021
Irrigation Rural Livelihoods and Agricultural Development Project AF II	To: (i) increase agricultural productivity of poor rural households in all districts; and (ii) strengthen institutional capacity for long-term irrigation development.			June 30, 2015
Shire River Basin Management Program (GEF)	The Global Environmental Objective (GEO) of the SRBMP is to develop a Shire River Basin planning framework and improve land and water management for ecosystem and livelihood benefits in target areas. (same as PDO)		Septembe r 7, 2012	January 31, 2019
Malawi: Shire River Basin Management Program (Phase-I) Project	The overall Program Development Objective of the Shire River Basin Management Program is to generate sustainable social, economic and environmental benefits by effectively and collaboratively planning, developing and managing the Shire River Basin's natural resources. The program would support the Government's Shire basin Policy Letter , and would have a duration of 12-15 years. The first phase project – the Shire River Basin Management Program (Phase-I) Project (SRBMP) – would establish coordinated inter-sectoral development planning and coordination mechanisms, undertake the most urgent water related infrastructure investments, prepare additional infrastructure investments, and develop up-scalable systems and methods to rehabilitate sub-catchments and protect existing natural forests, wetlands and biodiversity. Future phases would consolidate Basin planning and development mechanisms and institutions, undertake further infrastructure investments, and up-scale catchment rehabilitation for sustainable natural resource management and livelihoods. The Project Development Objective (PDO) of the SRBMP is to develop a Shire River Basin planning framework and improve land and water management for ecosystem and livelihood benefits in target areas. The project would:(a) strengthen the institutionalcapacities and mechanisms for Shire Basin monitoring, planning, management and decision support systems; (b) invest in water related infrastructure that sustainably improves water resources management and development; (c) reduce erosion in priority catchments andsedimentation and flooding downstream, while enhancing environmental services, agricultural productivity and improving livelihoods;(d) improve flood management in the Lower	Ministry of Agriculture, Irrigation and Water Development	Septembe r 7, 2012	January 31, 2019

	Shire and provide community level adaptatin and mitigation support; and (e) protect and enhance ecological services in the Basin.			
Second National Water Development Project - Additional Financing (IDA)	Increase access to sustainable water supply and sanitation services in target areas and improve water resources management at the national level.			October 31, 2015
Irrigation, Rural Livelihoods and Agricultural Development Project	To: (i) increase agricultural productivity of poor rural households in all districts; and (ii) strengthen institutional capacity for long-term irrigation development.			June 30, 2015
Second National Water Development Project	Increase access to sustainable water supply and sanitation services in target areas and improve water resources management at the national level.	Ministry of Agriculture, Irrigation, and Water Development	November 14, 2007	October 31, 2015
Irrigation, Rural Livelihoods and Agricultural Development Project	To: (i) increase agricultural productivity of poor rural households in all districts; and (ii) strengthen institutional capacity for long-term irrigation development.	Ministry of Agriculture, Irrigation and Water Development, Government of Malawi	May 24, 2006	June 30, 2015
Mulanje Mt. Biodiversity Conservation Project	1) Maintain Mulanje Mountain ecosystem, includin g globally significant biodivers ity and vital ecological services. 2) Increase awareness, understanding and appr eciation of the value of the Mulanje Mountain ecosystem, at local and national l evels. 3) Improve sustainability of biological resource use and enhance the value of the MM ecosystem to local communities. 4) Establish long-term income stream a nd institutional capacity to ensure continuation of 1-3; MMCT appreciated and respected by stakeholders at local, national an d international levels. Demonstrate the appropriateness of Conservation Trust Fund as financing mechanism for biodiv. Conservation.		August 15, 2001	June 30, 2008