The Malawi Priorities Project

A Cost-Benefit Analysis of National Resource Management in Malawi - Technical Report

National Planning Commission Report with technical assistance from the Copenhagen Consensus Center and the African Institute for Development Policy

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This work has been produced as a part of the Malawi Priorities project.

Malawi Priorities: Background

Malawi Priorities is a research-based collaborative project implemented by the National Planning Commission (NPC) with technical assistance from the African Institute for Development Policy (AFIDEP), and the Copenhagen Consensus Center (CCC) to identify and promote the most effective interventions that address Malawi's development challenges and support the attainment of its development aspirations. The project seeks to provide the government with a systematic process to help prioritize the most effective policy solutions so as to maximize social, environmental and economic benefits on every kwacha invested. Cost-benefit analysis is the primary analytical tool adopted by the project. Cost-benefit analysis will be applied to 20-30 research questions of national importance. Research will take place over the course of 2020 and 2021.

Research questions were drawn from the NPC's existing research agenda, developed in September 2019 after extensive consultation with academics, think tanks, the private sector and government. This sub-set was then augmented, based on input from NPC, an Academic Advisory Group (AAG) of leading scholars within Malawi, and existing literature, particularly previous cost-benefit analyses conducted by the Copenhagen Consensus Center. The research agenda was validated and prioritized by a Reference Group of 25 prominent, senior stakeholders. The selection of interventions was informed by numerous consultations across the Malawian policy space, and one academic and two sector experts provide peer review on all analyses.

Cost-benefit analyses in Malawi Priorities consider the social, economic and environmental impacts that accrue to all of Malawian society. This represents a wider scope than financial cost-benefit analysis, which considers only the flow of money, or private cost-benefit analysis, which considers the perspective of only one party. All benefit-cost ratios (BCRs) reported within the Malawi Priorities project are comparable.

The cost-benefit analysis considered in the project is premised on an injection of new money available to decision makers, that can be spent on expanding existing programs (e.g. new beneficiaries, additional program features) or implementing new programs. Results should not be interpreted as reflections on past efforts or the benefits of reallocating existing funds.

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Limestone is a Canada-based consulting firm specializing in the evaluation of international development projects and social programs. The firm is recognized for combining academic rigor, state of the art methods, and international development experience to provide customized evaluation and economic analysis services and to help their clients incorporate evidence to improve the design, financing, and implementation of their projects. Information about our current and past projects can be found at: limestone-analytics.com.

Contents

Acronyms

AfDB	African Development Bank
AMV	Africa Mining Vision
ASM	Artisanal and Small-scale Mining
BCR	Benefit-Cost Ratio
BDS	Business Development Services
CAPEX	Capital Expenditures
CASA	Commercial Agriculture for Smallholders and Agribusiness
CBA	Cost-Benefit Analysis
CBNRM	Community Based Natural Resources Management
CCC	Copenhagen Consensus Center
CORS	Continuously Operating Referencing Station
CSA	Climate Smart Agriculture
CSO	Civil Society Organizations
EITI	Extractive Industries Transparency Initiative
ELD	Economics of Land Degradation
FAO	Food and Agriculture Organization
FLR	Forest Landscape Restoration
MALCMV	Malawi Country Mining Vision
MGDS	Malawi Growth and Development Strategies
MPRS	Malawi Poverty Reduction Strategy
MPRSP	Malawi Poverty Reduction Strategy Paper
MSME	Micro, Small and Medium Scale Enterprise
MWK	Malawian Kwacha
NPC	National Planning Commission
NPV	Net Present Value
OEC	Observatory of Economic Complexity
OPEX	Operating Expenses
PSA	Productivity Sustainability Analysis
SHF	Smallholder Farmers
SLM	Sustainable Land Management
SME	Small and Medium Enterprises
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
WWF	World Wide Fund for Nature

Executive Summary

As part of the Malawi Priorities project, this paper focuses on the following research questions:

- *How can national resources best contribute to wealth creation?*
- *What institutional structures best deliver the returns on investment in national resource management?*

This paper examines a subset of intervention options to address these questions based on a review of academic and grey literature, past and current projects, and consultations with sector experts. Considering Malawi's prosperity in mineral and water resources and their significant potential in replacing agriculture and tobacco as the primary industry and source of foreign exchange, the research team concentrates on the mining and fisheries/aquaculture sectors. Furthermore, the study conducts a cost-benefit analysis (CBA) to quantify the impacts of a subset of the identified interventions that will improve, among others, formalization, regulation, job creation, value-addition, marketing, and exports in both sectors, a combination of which presents a significant potential of wealth creation in Malawi.

Malawi's arable land, forests, woodlands, and water and mineral resources are vital for livelihoods, food and nutritional security, economic development, and wealth creation. Malawi is endowed with a variety of mineral resources, including gemstones and ornamental stones, industrial minerals, construction mineral materials, and coal. Moreover, diverse mineral resources include gold, uranium, bauxite, heavy mineral sands, rare earths, niobium, tantalite, copper, nickel, iron ore. Malawi is also home to plentiful water resources contributing to the country's wealth creation via capture fisheries, aquaculture, irrigation, electricity generation, and tourism. Lake Malawi is one of the world's most important freshwater bodies, with some 700 to 1,000 fish species in a single lake (FAO, 2020).

Artisanal and small-scale operations in the extractive and fisheries/aquaculture sectors play a crucial role in poverty reduction and the livelihood of poor communities in rural areas. Aquaculture, both pond-based and cage farming, has great economic potential to be the main driver of sustained fish supply to the nation to match the increasing protein needs of the population to compensate for the dwindling fish catches under capture fisheries.

Challenges in both sectors include informality, illegal trade, weak institutional capacity, limited and ineffective monitoring. These barriers limit the sectors' potential to contribute significantly to Malawi's wealth creation. Some of the key sectoral constraints include the following technical, administrative, financial, and legal factors, directly and indirectly, affecting investment and development:

Mining;

- Informal and scattered production practices,
- Lack of knowledge and practices of value-addition,
- Deficiency of critical human capital and expertise, e.g., gemologist,
- Lack of capital to mechanize the exploration and extraction processes,
- Limited or no access to international markets,
- Export of minerals in rough form, generating meager foreign exchange earnings,
- Adverse health, safety, child labor, and environmental externalities.

Fisheries and aquaculture;

- Overharvesting due to illegal fishing technologies and open access,
- Habitat degradation,
- Climate change,
- Poor post-harvest handling of the fish, leading to poor quality,
- Aquaculture sector still being in its nascent stage,
- Lack of port and infrastructure facilities,
- Low-quality input production and, therefore, dependence on imports.

Working closely with the Department of Fisheries, Department of Mines, and Gemstone Association of Malawi, the research team prioritized the following interventions to address these barriers:

1. Formalization and Modernization of the ASM Sub-sector by District Landing Centers[1]
2. Chipoka Port Fisheries and Aquaculture Infrastructure and Land Development Program[2]

[1] ASM district landing centers hereafter.
[2] Chipoka fisheries and aquaculture project hereafter.

Intervention 1: ASM district landing centers

The intervention targets Malawi's ASM subsector's critical deficiencies of unorganized and generally informal operations and miners lacking the means and knowledge of exploration, extraction, value addition, and marketing. It contains the construction and operation of zonal landing centers that accumulate the unorganized and inefficient mining operations and provide formalization, licensing, semi-mechanization, exploration, value addition, capacity building, and marketing support to the subsector. In addition to its financial and technical supports, the intervention aims to ensure the subsector's compliance with laws and regulations, particularly concerning health, safety, child labor, mercury emission, and environmental protection.

In detail, the intervention consists of the following components;

- Building 12 landing centers in the districts listed below,
- Building 3 regional headquarters for the control and administration of the landing centers,
- Building mineral libraries and laboratories in each regional headquarter,
- Building an international marketing center,
- Providing ASM operators with exploration, digging, and value-addition equipment and machinery,
- Providing capacity building to local miners on each operation step,
- Sending representatives to international exhibitions for promoting Malawi's processed minerals.[3]

Furthermore, the intervention considers sending small groups of miners to international educational tours and exhibitions, from which they would obtain knowledge and experience on the latest marketing trends and value-addition techniques in the global mining sector. With the vision of turning Malawi into a minerals hub, the intervention also includes the construction and operation of an international marketing center.

The intervention's minerals focus covers gemstones, gold, and rocks operated in the ASM subsector. Namely, ruby, sapphire, rhodolite, aquamarine, tourmaline, opal, zircon, sodalite, amazonite, sugilite, corundum, malachite, agate, manganite, azurite, garnet, quartz, galena, granite are among the gemstones and rocks the intervention targets.

The research team worked closely with the Gemstone Association of Malawi to determine locations and to estimate investment and operating costs of 12 landing centers to be built in the following districts from three regions of Malawi. The intervention contains 3 headquarters to be located in each region.

1. Northern region
    - Mzuzu, Mzimba, Rumphi, Karonga
2. Central region
    - Lilongwe, Kasungu, Salima, Dedza
3. Southern region
    - Blantyre, Mangochi, Balaka, Chikwa

The research team considers the close collaboration among the Ministry of Mining, associations, mining companies, and mining cooperatives in mineral-rich zones of Malawi for the successful and efficient implementation of the intervention. The partnership would play a crucial role in land ownership, benefit-sharing, and the distribution of responsibilities in operating the landing centers, organizing and structuring the artisanal and small-scale miners, providing technical support and capacity building.

Considering the semi-mechanization aspect of the intervention, the centers will equip the miners with, among others, stone testing equipment, lapidaries, heat treating, tumbling and testing machines, pump engines, drilling machines, dredgers (gold panning machines), excavators, and other earth-moving machines. The landing centers will also provide occupational health and safety instructions, training, and equipment.

The intervention contains training the miners in handling and operating the machinery and equipment. In addition, the intervention will provide an on-site field supervisor in every center, helping miners understand the geological and gemological aspects from prospecting to value addition.

It is essential to note that the intervention's impact on the transition from artisanal mining to small- and medium-scale mining through semi-mechanization of the operations brings the risk of adverse environmental externalities to forests. In this context, the research team followed the National Forest Landscape Restoration Strategy of GoM and included the cost of rehabilitating all mining sites of the intervention. In addition, the team considers the proper application of the integrated "forest-smart mining procedures" approach described in World Bank (2019c) crucial for preventing the land degradation and deforestation externalities of the transition. The method categorizes the general forest-smart principles for mining into four aspects: (i) good governance, (ii) improved understanding and approaches, (iii) capacity building, and (iv) widening the participants in the pursuit of forest-smart mining. World Bank (2019c) lists the required priority action points for, among others, the governments, mining entities, downstream companies, civil societies and NGOs, and standard-setting organizations for successful implementation of the procedures.

We believe that the successful implementation of the intervention will transform the ASM subsector into a modern medium-scale one.

[3] The appendix to the CBA model of the intervention contains the complete list of the capital and operating expenses of the components.

The formalized and modernized subsector would generate more revenues for the operators, create employment opportunities for the youth, and increase Malawi's foreign exchange earnings from value-added mining exports. It is also reasonable for the intervention to improve Malawi's mining sector's attractiveness for foreign direct investments, generating economic growth and wealth.

As President Chakwera frankly stated, "if [the GoM does] the right things and [does] things right, [Malawi's] mining sector can transform every other sector ... and facilitate the creation of a New Malawi as envisioned in Malawi 2063." We believe that formalization and modernization of the ASM sub-sector through district landing centers and providing financial and technical support to thousands of miners, mainly from rural areas, are among the right things the sub-sector has lacked for decades.

Intervention 2: Chipoka fisheries and aquaculture project

The Ministry of Forestry and Natural Resources has developed the Chipoka Port Fisheries and Aquaculture Infrastructure and Land Development Project as part of the Blue Economic Working Group's ongoing activity, led by the National Planning Commission (NPC). The project focuses on developing a sector-wide national hub for industrial, commercial, and logistical activities, linking to related vital sectors such as tourism, transportation, agriculture, and urban development. Chipoka fisheries and aquaculture project targets the infrastructure and functional port area to provide the sector with boat docking and repair, fish storage, processing, packaging facilities, and models for smaller fish farms. Figures A1.1 and A1.2 in Annex A1 present the project's render and scenarios for positioning its components.

This proposed project concept is a component within the more extensive Chipoka Port Infrastructure Development Program, a compendium of projects across several related sectors that will transform Salima district's economic and urbanization status, catalyzing more significant expected regional and national impacts and benefits. The project is also in line with Malawi 2063 Vision, developed by NPC, as it strives to achieve urbanization, industrialization, economic infrastructure, agriculture productivity, and commercialization.

The project contains the potential to transform the current highly informal fisheries and aquaculture sector towards a formalized industry linked to industrial, urban, and service industries upon completion of this program. It would advance the fisheries and aquaculture sector by developing an industrial and logistical national center for commercial and small-scale fisheries linked to transport, water, and energy infrastructure at the port of Chipoka. Therefore, the project would significantly contribute to creating wealth, employment opportunities, and food and nutritional security for the Malawian population.

To analyze the economic benefits of the Chipoka fisheries and aquaculture project, the research team first consulted local officials and made conservative assumptions on the number of vessels, farms (pond and cage farming), farmgate price per kg, factory price of industrially processed fish per kg. The research team then estimated the incremental annual fisheries and aquaculture revenues due to the Chipoka project.

The investment and implementation costs of the intervention cover the development of lakefront hubs and peripheral and localized farms and markets (spokes) containing the following items:

Hubs

- Fishing Boat docking and repair shops
- Industrial processing + packaging + cold storage
- Cage farms + facilities
- Wholesale fish market
- Lakefront training and research facilities
- Aquarium
- Small aquaculture farming communities

Spokes

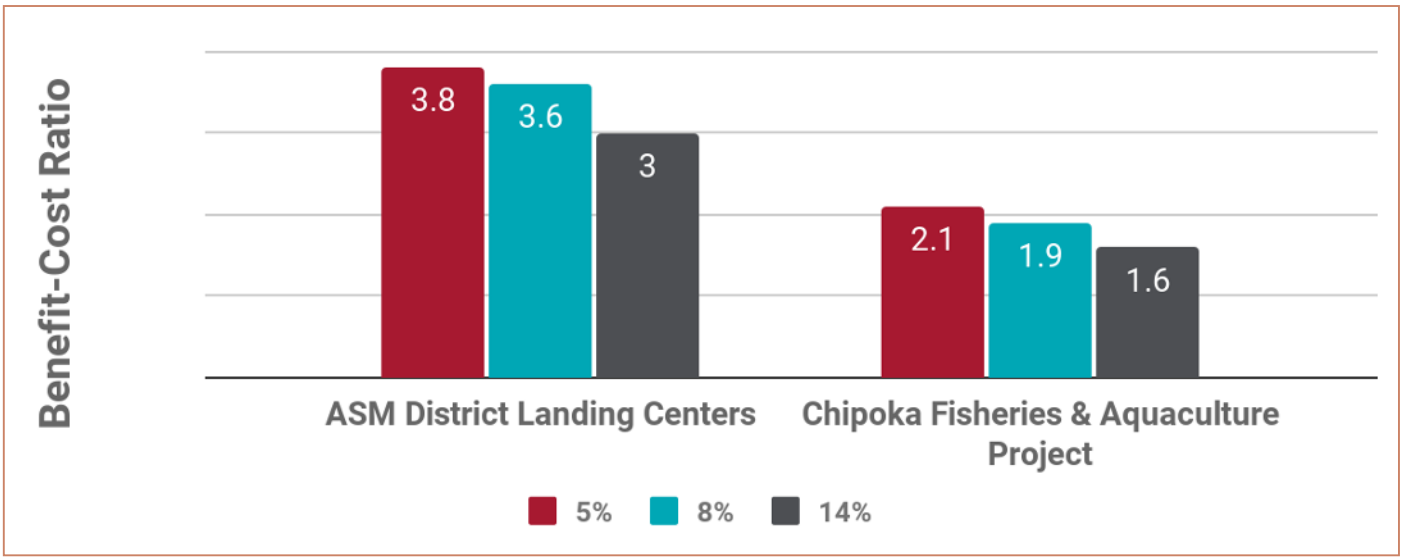
- Fish feed milling
- Fingerlings hatchery
- Commercial Aquaculture farming
- Small aquaculture farming communities
- Marine wildlife reserves including Lake Malawi National Park

CBA Results

The CBA results show that both interventions have benefit-cost ratios (BCRs) in the range of 1-5, meaning that the net benefits outweigh the net costs of each intervention. The findings suggest that the interventions are likely to generate positive results while remaining cost-effective. The following figure presents interventions' BCRs with alternative discount rates.

The team has conducted the analyses with a conservative view of the impact of interventions on the sectors. It is reasonable to assume that the successful implementation of both interventions could generate significant benefits not only to the particular sectors of interest but also to other industries. The multiplier effects of the expansions in the mining and fisheries sectors on other industries could substantially improve the results.

Figure 1: Interventions' Benefit-Cost Ratios at Alternative Discount Rates



ASM landing stations and the international marketing center present an outstanding potential for Malawi's mining sector. It is likely for the intervention to lead to the discovery, extraction, and marketing of a considerable amount of gold, gemstones, and other minerals. The Chipoka fisheries and aquaculture investment project, on the other hand, could turn into a national hub for industrial, commercial, and logistical activities and generate a significant multiplier effect on the key related sectors of agriculture, tourism, and transportation.

There is no doubt that the realization of these scenarios could present higher net revenues in the sectors than what the team has assumed in the analyses. It is also reasonable to consider the potential of the interventions in generating additional employment both in the industries of interest and the subsidiary businesses. Moreover, occupational health and safety, positive environmental externalities are among the interventions' possible benefits that the team could not account for in the analyses due to the unavailability of reliable data.

1. Introduction and Context

The National Planning Commission (NPC), with technical support from AFIDEP, and the Copenhagen Consensus Center (CCC) are implementing the Malawi Priorities project across 2020 and 2021. The Project is a research and advocacy exercise to identify the most effective ways to address the nation's challenges using the framework of CBA. The aim is to inform both short and long term development priorities for the country, acknowledging that there are insufficient resources to address all of Malawi's challenges and that maximizing outcomes requires careful, evidence-based consideration of the costs and benefits of all policies.

The starting point of all research questions is the NPC's existing research agenda, structured around the six thematic areas of Sustainable Agriculture, Sustainable Economic Development, Human Capital and Social Development, Sustainable Environment, Demography, Governance, Peace, and Security, and Human Capital and Social Development.

The NPC's research agenda was developed by the Commission in September 2019 after extensive consultation with academics, think tanks, the private sector and government. Consequently, the Commission's research agenda, prima facie, contains questions of national importance. As a first step, Malawi Priorities drew questions from the NPC research agenda that could be answered using a cost-benefit methodology. Then, additional research questions were added based on input from NPC, an Academic Advisory Group of leading scholars within Malawi, and existing literature, particularly previous cost-benefit analyses conducted by the Copenhagen Consensus Center. This process of identifying research questions for investigation generated a total of 38 potential research questions across all 6 thematic areas.

The research agenda was validated and prioritized by a Reference Group of 25 prominent, senior stakeholders from government, civil society and the private sector. The outcomes of the Reference Group exercise were used to inform which research questions to prioritize and which interventions to focus on within those 38 potential research questions. The validation process finished in July 2020.

Research process

In December 2020, the research team began the investigation on the research questions, "how can national resources best contribute to wealth creation?" and "what institutional structures best deliver the returns on investment in national resource management?" combination of which ranked 4.6 out of 5, according to the national priority.

The research team conducted a comprehensive literature review to understand the sector and identify key barriers and performance gaps to national resource management in Malawi. As part of the initial research process, the team participated in a series of consultations with local government officials, experts, and sector representatives including:

- Dr. Clement Chilima - Director, Department of Forestry
- Mr. Max Wenga-wenga - Deputy Director, Department of Water Development
- Mr. Burnett Msika - Chief Engineer, Department of Mines
- Mr. Maxwell Maida - Senior Development Planning, NPC
- Mr. Geoffrey Kanyerere - Expert, Department of Fisheries
- Ms. Emma Adams - President, Malawi's Women in Mining Association
- Dr. Paul Kamlongera - Academic, Lilongwe University of Agriculture and Natural Resources
- Mr. Chikomeni Manda - Managing Partner, Perekezi ASM[4] Consultants and Events
- Mr. Kobi Ruthenberg - Associate Director in Urbanism, Org Permanent Modernity

Once the key performance gaps were outlined, the research team explored interventions that have been implemented in Malawi that address such issues. The sector experts provided valuable insight into what interventions have had the most significant reach, impact, and data availability and helped identify what subset interventions should be included in the feasibility study. The research team collaborated closely with the Department of Fisheries, Department of Mines, and Gemstone Association of Malawi in choosing the interventions and validation of costs and benefits.

Sector background

Select structural reform programs

The Malawi Poverty Reduction Strategy (MPRS) outlined in the Malawi Poverty Reduction Strategy Paper (MPRSP) had the goal of achieving "sustainable poverty reduction through empowerment of the poor" (GoM, 2002, p.xi). GoM based the Strategy on the following pillars:

- Promote rapid sustainable pro-poor economic growth and structural transformation,

[4] Artisanal and Small-scale Mining

- Enhance human capital development,
- Improve the quality of life of the most vulnerable,
- Promote good governance.

The Strategy highlighted the need to diversify the specific sectoral source of sustainable pro-poor growth from agriculture into natural resources, manufacturing, tourism, and small-scale mining, primarily through Micro, Small and Medium Scale Enterprises (MSMEs). Therefore, natural resources and small-scale mining were among the six sub-goals of Pillar 1's "Sources of growth" goal. Natural resource management activities were focused on three critical sub-sectors of forestry, fisheries, and wildlife. GoM aimed to promote Community Based Natural Resources Management (CBNRM) by encouraging natural resources-based enterprises (including value-adding activities) to generate more income in the rural areas.

On the one side, the Strategy listed the main objectives in promoting small-scale mining as:

- Disseminate information on mineral availability,
- Identify mineral resources suitable for small scale mining,
- Encourage the development of small-scale mineral based industries,
- Provide technical and financial support,
- Ensure appropriate mining legislation,
- Improve understanding of value adding methods,
- Promote marketing.

On the other side, the establishment of better markets and marketing practices for fish through training in handling, processing, and packaging fish products was among the targeted efforts to improve the sustainable utilization of fishery resources. In addition, fisheries extension services aimed to strengthen and focus on promoting technology to increase off-shore fishery, fisheries enhancement technology, and fish farming (aquaculture) in local communities, mainly targeting women.

The mining and fisheries sectors continued to be among the targets in other structural reform programs, such as the Malawi Growth and Development Strategies (MGDS) I-III.[5] Malawi 2063 emphasized the significance of the industrialization and structural transformation of the economy to maintain the rapid long-term national economic growth. In this regard, the Strategy emphasized "mining exploration, extraction and regulation to unleash the sector's potential and empower the rural masses who live around mining sites" (GoM, 2017a, p. 54). It showed poor infrastructure behind ineffective efforts to diversify the economy to other sectors such as industry, mining, and tourism, targeted in MPRS. Moreover, the Strategy followed MPRS in setting the promotion and encouragement of sustainable fisheries management and commercial aquaculture development among the goals of the 'increased agricultural diversification' outcome.

Mining

Although Malawi is endowed with mineral resources and the GoM has ambitious development objectives, the mining sector remains relatively underdeveloped. "The mining sector currently contributes only about one percent to national income, and it is characterized by very little value addition (beneficiation)" (GoM, 2020b, p. 17). Predominant mineral resources are various types of gemstones and ornamental stones, industrial minerals, construction mineral materials, and coal. Moreover, diverse mineral resources include gold, uranium, bauxite, heavy mineral sands, rare earths, niobium, tantalite, copper, nickel, iron ore. According to Extractive Industries Transparency Initiative (EITI, 2020), Malawi's recognized mineral deposits are as below.

Table 1.1: Mining Deposits

Commodity	Reserves	Unit
Uranium	11,337	metric tons
Coal, bituminous	21.4	million metric tons
Limestone	25	million metric tons
Bauxite	28.8	million metric tons
Beach dune sand	700	million metric tons
Rare earths	2.5	million metric tons

Source: *EITI, 2020*

According to Government of Malawi (GoM, 2020a), the Department of Mines projects the mineral production and monetary figures for 2021 as below. Mr. Burnett Msika, a chief engineer at the Malawi Department of Mines, confirms the ASM and medium-scale operations' shares as listed in the table 1.2.

As cited in GoM (2020a), the Malawi Department of Mines predicts that the mining sector will generate employment for 19,555 individuals in 2021. Various references[8] state that there are 40,000 ASM operators in Malawi. According to our consultations with Mr. Burnett Msika, a chief engineer at the Malawi Department of Mines;

[5] However, it is essential to highlight that while MGDS II (2011-2016) identified the mining sector as among the priority sectors, MGDS III (2017-2022) downgraded it.

Table 1.2: Mining Sector Projections for 2021

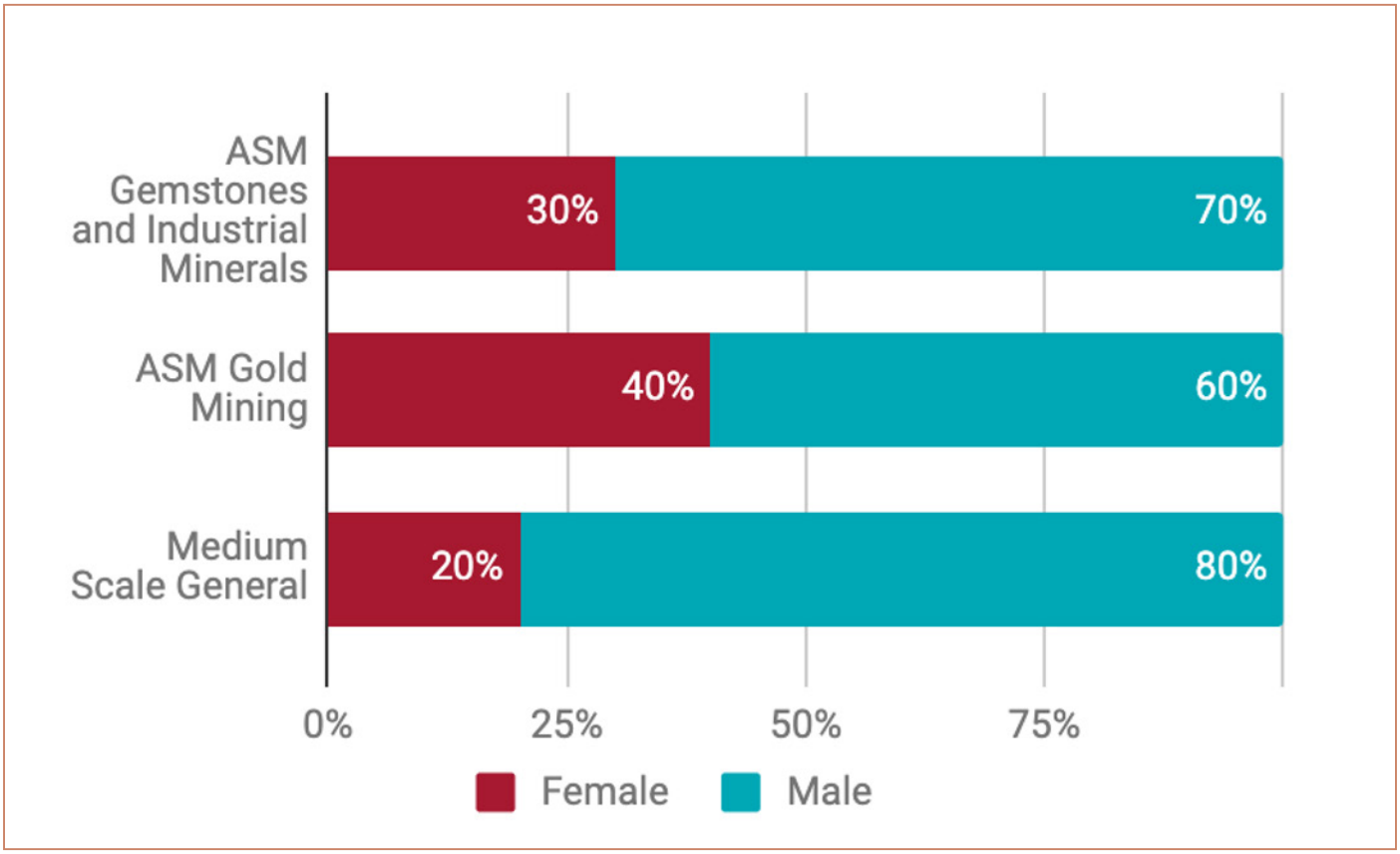
	ASM Scale	Medium Scale	2021 (Projection)	
	%	%	Quantity (tonnes)	Value (MWK[6] million)
Coal	0	100	40,052	590
Cement	0	100	262,521	162
Agricultural and Hydrated Lime	70	30	96,770	1,264
Rock Phosphate	0	100	1,628	29
Rock Aggregate	10	90	19,032,340	31,647
Gemstones	100	0	790	326
Iron ore	70	30	1,220	3
Total ASM[7]			*1,972,617*	*4,378*
Total MSM[7]			*17,462,704*	*29,644*
Grand Total			**19,435,321**	**34,022**

Source: *GoM (2020a)*

- It is reasonable to consider 20-40,000 ASM operators directly employed in Malawi's informal mining sector,
- Those involved indirectly and seasonally may range from 80,000 to 120,000, and they work on average 3-5 months in a year,
- 90% of the official employment figures belong to the medium-scale subsector.

There are no official statistics on the gender ratios of the total mining employment in Malawi. Hence, the research team obtained the following estimates from the interviews with Mr. Msika.

Figure 1.1: ASM and Medium Scale Subsectors' Gender Ratios



[6] Malawian Kwacha.
[7] Authors' calculation as the weighted average of the total figures.
[8] E.g., World Bank (2011), African Minerals Development Centre (AMDC, 2017), Barreto et al. (2018), Tychsen et al. (2018), and references therein.

GoM official reports do not contain any gold mining figures. This is due to the fact that the majority of the operations are artisanal and small-scale and conducted illegally. Haundi et al. (2021, p. 21) claims that the government of Malawi "was unable to stop the illegal artisanal gold mining in various districts, such as Mangochi, Balaka, and Lilongwe, despite several attempts to curb the practice." According to EITI (2019), on the one hand, Malawi's gold resources remain unexplored. The Observatory of Economic Complexity (OEC) data shows, on the other hand, that gold accounts for almost all of Malawi's precious metals, gems, and jewelry exports in 2019 (99.2%, $21,992,690). These observations highlight Malawi's significant potential to utilize its mineral prosperity and generate wealth for its nation. GoM (2020b) emphasizes this "tremendous potential" and considers mining as the vital component of the industrialization pillar in Malawi 2063.

It is essential to mention that Malawi 2063 vision determines the transformation the country needs in two aspects. Firstly, the development narrative and mindset focus must change from poverty reduction to wealth creation. Secondly, the Malawian economy must be transformed from being predominantly importing to an industrialized exporting one.

Similar to MPRS, Malawi 2063 vision considers the mining sector as crucial as agriculture. Accordingly, the Vision sets "[a] vibrant knowledge-based economy with a strong and competitive manufacturing industry that is driven by a productive and commercially vibrant agriculture and mining sector" among ten ultimate goals of the Vision by 2063 (GoM, 2020b).

The "development philosophy" of the Vision also targets creating a favorable business environment for the private sector and public-private partnerships (PPPs) to be rated amongst the top three in Africa by 2063. In addition, the Vision emphasizes the mining sector as the critical component of industrialization that would increase the local production and export of value-added products, thus moving away from exporting raw products generating low revenues.

The GoM aims through the Vision's implementation to formalize and regulate the ASM sector while linking them to appropriate technologies. Furthermore, enforcing the requisite health, environmental, and safety standards and undertaking geophysical surveys for mineral exploration are also among the government's plans for the industry. Figure 1.2 shows the locations of awarded and applied mining claims and licenses in Malawi. Kamlongera (2020) states that while the computer-based cadastre, in operation since 2017, has improved access to geological data, the lack of infrastructure to support the exploration and exploitation of mineral resources such as energy remains a crucial challenge. Another critical deficiency of the online system is that it is yet to cover the ASM subsector.

In line with Malawi 2063, Mr. Lazarus Chakwera, the President of Malawi, has recently emphasized his administration's action plans and accomplishments towards using the mining sector as "a catalyst for restructuring the economy." The President stated that "if we do the right things and do things right, our mining sector can transform every other sector we have and facilitate the creation of a New Malawi as envisioned in Malawi 2063, where mining is linked to industry under Pillar 2 of our national agenda."[9]

President Chakwera also emphasized the mining sector's potential to be;

1. a long-term game-changer for the economy,
2. a foreign exchange generator and a critical factor in administration's job and wealth creation strategies,
3. a launchpad for the industrialization agenda.

The President listed his administration's four major outcomes as follow:

1. Creation of the Mining Regulatory Authority with a mandate to regulate the development, management, and utilization of Malawi's mineral resources in line with sustainable development principles and practices.
2. Establishment of the National Mining Company, a state-owned enterprise, promoting the development of the sector, catalyzing private sector investment into the mining industry, promoting in-country beneficiation and downstream processing of minerals, collaborating with cooperatives on formalization of the sector.
3. Authorization of the Reserve Bank of Malawi's function as a structural market for minerals, buying gold from ASM operators, operating trading centers for gold in different parts of Malawi, as the sole institution to purchase, sell or hold gold in Malawi
4. Funding in the 2021-22 financial year the development of infrastructure and deployment of mining experts, inspectors, geologists, and engineers to respond to technical issues arising from mining activities in "mineral heart districts."

Fisheries/Aquaculture

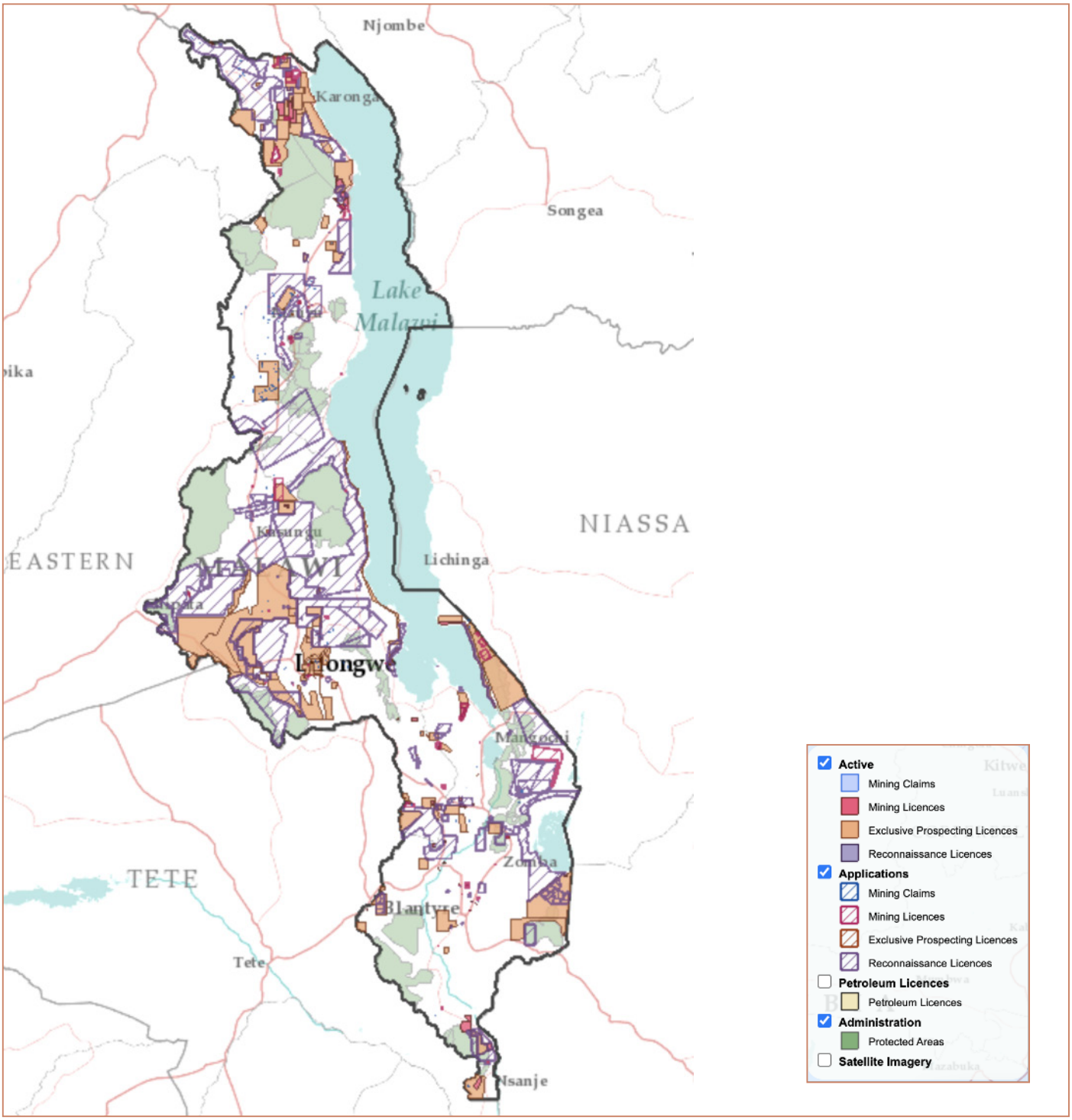
Malawi is considered to have plentiful water resources, which contribute to the country's wealth creation via fisheries, aquaculture, irrigation, electricity generation and tourism. The country is endowed with numerous water bodies that include Lakes Malawi, Malombe, Chilwa and Chiuta, and the Shire River System.

Malawi has a large network of surface water bodies covering about 21 percent of the country's total area; about 20 percent of this area is Lake Malawi, which is the third largest lake in Africa. Over one-third of Malawians depend on Lake Malawi for their food and livelihoods. Lake Malawi is a Class I[11] due to having low total concentrations of ions/alkalinity and conductivity.[12] Lake Malawi is one of the world's most important fresh water bodies, with some 700 to 1 000 fish species in a single lake (Food and Agriculture Organization, FAO, 2020). The Shire River is the largest river in Malawi, which is the only outlet of Lake Malawi.

Similar to MPRS, Malawi 2063 emphasizes the significance of water resources by considering them in the pillars of 1. Agricultural productivity and commercialization, and 3. Urbanization. "Beyond focusing on crops that guarantee food security, emphasis shall be on strategic crops, livestock and fisheries that will yield high-income in the local, regional and international markets" (GoM, 2020b, p. 14). Malawi 2063 also appreciates the critical role of Lake Malawi, which shall have ports in strategic positions to handle goods and

[10] http://portals.flexicadastre.com/Malawi
[11] In the terminology of Talling and Talling (1965).
[12] Class I includes Lakes Malawi, Malombe, Victoria, Tana, and George, among others.

Figure 1.2: Map of Mineral Concessions in Malawi



Source: *Adapted from the Mining Cadastre Portal*[10]

passengers and connect with the road, railway, and airports.

GoM (2020a) presents that Lake Malawi alone generated 94% of the total fish production in 2019. As we display in Figure 1.3, the report also shows that artisanal fisheries are the primary type of fish production in Malawi.

Table 1.3 shows the Department of Fisheries' projections for the production volumes and monetary values in 2021.

"Fishing is an important sector that contributes to livelihoods of the rural population and economic growth of the country. Fish contributes substantially to the food security and livelihoods of millions of people in Malawi" (FAO, 2020). Table 1.4 below summarizes the Department of Fisheries 2020 Annual Frame Survey for the registered fishers and fishing crafts. The counted number of small-scale fishers who directly benefited from fishing was 68,819. In aquaculture, over 7,000 small-scale farmers and two commercial operators are engaged in aquaculture production. These numbers increase with the inclusion of fish processors, wholesale and retail traders, boat builders, input suppliers like boats, nets, and aquaculture feed suppliers along the fish value chain.

"While harvesting is dominated by men, fish processing and trading is largely done by women" (Anderson, 2018, p. 10). Manyungwa-Pasani et al. (2017) highlights the significant participation of women in the fish export market, with 60% of the participants being women. "This is in line with findings that over 70% of the informal cross border trade in the SADC region is undertaken by women" (cited in Manyungwa-Pasani et al., 2017, p. 15).

Figure 1.3: Fisheries Production by Lakes and Types

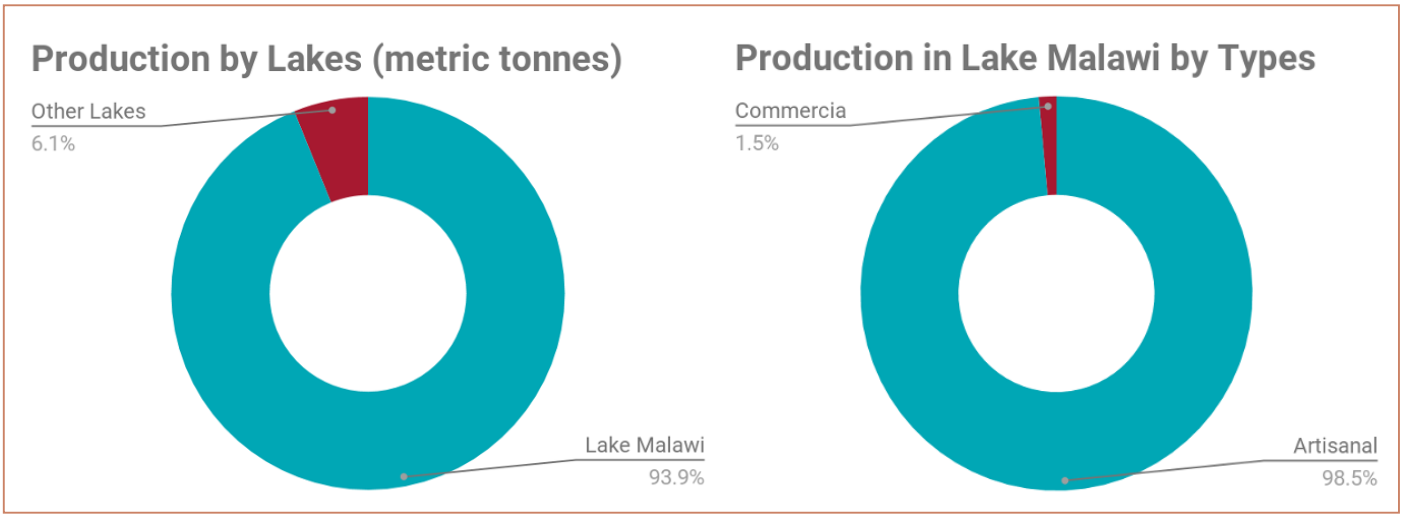


Table 1.3: Fisheries Sector Projections for 2021

	Quantity (tonnes)	Value (MWK billion)
Total Production	163,766	179.90

Table 1.3: Fisheries Sector Projections for 2021

	Gear Owners		Fishing Crew Members		Total Number of Fishers
	Total	% of Female	Total	% of Female	
Lake Chilva	1,818	0.6%	3,048	-	**4,866**
Lake Chiuta	325	-	334	-	**659**
Lake Malawi	8,797	1.6%	47,012	0.4%	**55,809**
Lake Malombe	256	-	2,335	-	**2,591**
Upper Shire	152	-	1,083	-	**1,235**
Lower Shire	1,554	3%	2,105	-	**3,659**
TOTAL	**12,902**	**5.2%**	**55,917**	**0.4%**	**68,819**

2. Literature Review and Intervention Selection

The research team has included around twenty different interventions in this review, which can be broadly categorized as supporting land, water or forest management or a combination of the above. Each of these interventions is effective at mitigating the relevant barriers discussed above in either Malawi specifically, or in similar contexts. These interventions were identified through a review of the literature on national resource management as well as government plans and policies.

As presented in Annex A2, the team extensively reviewed the literature and intervention options on land and forest resources in addition to extractives and water. Given the study's CBA modeling focus, we present the latter's literature review and intervention options in this section.

Intervention options

Extractive resources

GoM (2020b, p. 17) records that "there is rampant illegal mining with export of raw minerals" in Malawi. "Informal ASM operations bring about several socioeconomic, health and environmental challenges, which exacerbate the existence of poverty among miners and rural communities" (Tychsen et al., 2018, p. 120). Tychsen et al. (2018) also underlines that over 90% of the various gemstones extracted in Malawi are exported to the overseas markets in their raw form, thereby attracting very low values. EITI (2020) emphasizes this considerable opportunity cost by stating that much of actual economic potential is lost due to the lack of a legal or fiscal framework for small-scale mining and due to rudimentary production, processing, and marketing techniques. These references present that the Malawian mining sector suffers from being mainly informal, fails to process rough minerals to generate significant foreign exchange earnings, and generates critical negative externalities.

Kamlongera and Hilson (2011, p. 61) emphasizes the significance of a formalized and supported ASM subsector as "one of few viable options available for tackling poverty in rural Malawi." The authors point out the critical role of 'radical change in mindset' from a largely agriculturally focused economic pathway to more cost-effective and dynamic solutions.

Kamlongera (2013) investigates the impact of the "mining boom" in Malawi on community development. The analysis suggests a set of checks and balances to guide the processes so that the sector's expansion gets translated into benefits for affected communities:

1. Environmental legislation and regulatory frameworks must be updated and implemented without any irregular exemptions. As the author states frankly, "[t]he government must also avoid cutting corners and disregarding its own regulations" (p. 387).
2. Decision-making processes must include all stakeholders, including communities and their representatives, e.g., civil society organizations (CSOs), whose livelihoods would be affected by mining operations.
3. Consultations with communities are also helpful to increase the transparency of mining companies and operations.
4. Stakeholders, i.e., government, mining companies, and CSOs, must perform deliberate attempts to build trust among them and value all partners' input. "Overall, greater participation from CSOs and affected communities in decisions concerning mine development is a key to ensuring effective local-level development in emerging mineral economies such as Malawi, where legislation is still inadequate" (Kamlongera, 2013, p. 388)

Kamlongera (2020)[13] examines Malawi's progress in the implementation of the Malawi Country Mining Vision (MALCMV), i.e., a localized version of the Africa Mining Vision (AMV). The paper's findings suggest a lag and little progress made in the domestication process of the AMV. Kamlongera (2020, p. 467) claims that "[w]hile there is great potential for mining to catalyze inclusive development in Malawi, for this to come to fruition, the government would need to take a far more proactive approach to fully and systematically implementing the MALCMV."

Malawi's mining sector has been included in several initiatives and donor programs. Table 2.1 presents a select list of them.

> *"While the MALCMV process has benefited from other initiatives and donor funds, the government must still set aside the resources needed to ensure that a full domestication of the AMV and its implementation is possible. Dependence on donor money alone will not be enough to ensure the sustainability of efforts needed to make mining the pinnacle of Malawi's development strategy. Overall, a consistent financial commitment and prioritisation of the mining sector could help to ensure that Malawi maximises the potential the AMV holds for development". (Kamlongera, 2020, p. 482)*

Malawi is not alone in experiencing these challenges. African Development Bank (AfDB, 2020) provides financial and technical support to Guinea Bissau, Sierra Leone, and Liberia, which could not adequately translate their extractive resources into better economic and social outcomes. AfDB (2020) emphasizes the impact of illegal mining activities in Sierra Leone on deforestation and

[13] It is necessary to highlight that Kamlongera (2020) reviewed a draft version of MALCMV waiting for cabinet approval. The Vision is yet to be finalized and approved by the cabinet.

Table 2.1: Initiatives implemented to strengthen mining sector governance in Malawi

Intervention	Funding Organisation	Year Launched
Malawi Mineral Sector Review	World Bank	2009
Mining Governance Growth and Support Project (MGGSP)	World Bank and European Union	2013
Malawi Mining Sector Political Economy Analysis	Tilitonse Fund	2013
Malawi Extractive Industry Transparency Initiative (MWEITI)	Gesellschaftfur Internationale Zusammenarbeit (GIZ); DFID and World Bank	2014
Publish What You Pay (PWYP)	GIZ; Natural Resource Justice Network (NRJN)	2014

Source: *Kamlongera (2020)*

land degradation, which pollute or degrade the quality of soils and land, negatively affecting food production, livelihoods, and the production and provision of other ecosystem goods and services.

> Some of the output and outcomes will include; enhanced capacity of ASMs for efficient mining; integration of ASMs into the formal economy in targeted areas; adoption of sustainable mining practices, improved safety, health and security issues, reduction in environmental impacts of ASM activities and reduction in deforestation as a means of increasing the carbon sink hence slowing climate change. (AfDB, 2020, p. xi)

World Bank (2011) analyzes the Mining Governance and Growth Support Project in Malawi, which targets the improvement of the efficiency, transparency, and sustainability of mining sector management. The project's scope includes activities to support the government of Malawi in;

- Building an efficient, transparent and environmentally and socially sustainable framework for managing mineral rights and operations,
- Developing transparent arrangements for optimal generation and use of mineral revenues,
- Improving the enabling environment for mining sector development by acquiring and disseminating geo-data, fostering more sustainable ASM, increasing the supply of Malawians trained at tertiary level in minerals, and improving the policy environment for mining-related infrastructure development.

World Bank (2015) describes Chile and Ghana's success stories in developing modern small- and medium-scale mining sectors. The report suggests crucial lessons for Tanzania from the structural reforms which led Chile to evolve "from artisanal mining to the status of world mining superpower" (World Bank, 2015, p. 38). The financial and technical support to Chilean "miners stimulated a rapid growth of modern small- and medium-scale mining enterprises and the phasing out of artisanal mining" (World Bank, 2015, p. 39). The district landing centers responsible for registration, supervision, monitoring, and technical support to artisanal miners played a vital role in the Chilean and Ghanaian achievements.

World Bank (2017) documents the appraisal of the "Nigeria: Mineral Sector Support for Economic Diversification Project". The project's objective is to enhance the Nigerian mining sector's contribution to the country's economy by (i) strengthening key government institutions, i.e., the Ministry of Mines and the Solid Mineral Development Fund, (ii) improving information infrastructure and knowledge, and (iii) fostering domestic investment in the sector. The targeted main results of the project include;

- Development of the mining information management systems (including geological database, Decision Support System - DSS, Environmental Information Management System - EIMS),
- Enhancement of geological knowledge through a publically accessible integrated geological database,
- Increased economic linkages from industrial minerals to the services and manufacturing sectors (manufacturers sourcing mining materials locally),
- Increasing the percentage of ASM operators in target areas inventoried, formalized, and supported through technical assistance,
- Increasing the percentage of mining exportation and production projects subject to formal environmental and safety inspections following good international practices set under the project,
- Increasing the production data collected from artisanal, small-, and medium-size mining operations.

Fisheries and aquaculture

Severe land degradation and loss of forest cover also threaten Malawi's fisheries resources. Additional significant threat on the water sector of Malawi emerges from unsustainable and over-fishing practices. Overharvesting and illegal trade, exacerbated by weak governance, also lead fish stocks and biodiversity to decline (World Bank, 2019a). As World Wide Fund For Nature (WWF, 2018) alarmingly emphasizes:

> While conservation action has brought renewed hope for some species, today's update of the IUCN[14] Red List of Threatened Species reveals that overfishing is causing fish species in parts of the developing world to decline.

[14] International Union for Conservation of Nature.

According to the updated list, 9 per cent of the 458 fish species assessed in Lake Malawi are at high risk of extinction, causing concern for regional food security. Three out of the four species of Chambo (Oreochromis karongae, Oreochromis squamipinnis, Oreochromis lidole) – Malawi's most economically valuable fish – are Critically Endangered. Chambo fisheries are now on the brink of collapse.

As emphasized by FAO (2020), the fisheries sector in Malawi has a key role to play in poverty reduction through the provision of rural employment and, more importantly, through its contribution to household food security.

Aquaculture is an important sector in Malawi. Commercial Agriculture for Smallholders and Agribusiness (CASA, 2020) emphasizes the sector's potential of being the main driver of sustained fish supply to the nation to match the increasing protein needs of the population to compensate for the dwindling fish catches under capture fisheries. However, smallholder farmers (SHF) lack access to quality inputs such as fingerlings and floating feeds, which comprises their productivity and makes Malawi dependent on imports from Zambia. Weak market information signals about the commercial viability of the sector makes most actors in the value chain face serious challenges to access commercial finance and investment to expand their enterprises (CASA, 2020).

The cage farming and bio-flow recirculation production systems used by the two commercial operators in the sector require significant investment. Therefore, SHF, lacking required finance, can only perform pond-based production in upland locations. Productivity for most SHF is low, averaging about 1 metric tonne per hectare compared to a potential of 6 tonnes per hectare (CASA, 2020). Non-existence of aggregation arrangements among SHF make them not having access to urban markets and sell fish locally at a lower price.[15]

Fish supply of the combination of capture fisheries and aquaculture is not enough to meet the domestic demand. The estimated excess demand is about 20,000 tonnes a year, and Malawi is importing fish from neighbouring countries, with fish imports from Zambia alone estimated to average 800 tonnes a year (CASA, 2020).

Critical watersheds which are becoming degraded also create serious risks on water resources of Malawi. This leads to reduced water availability, deteriorating water quality, increased vulnerability to droughts and floods, reduced energy security and reduced agricultural productivity (World Bank, 2019b). According to World Bank (2019a), Malawi is not only experiencing rapid decrease in water availability, the country has the lowest availability per capita relative to its neighboring countries.

Narayan (2017) conducts the CBA of mangrove restoration for coastal protection and an earthen dike alternative[16] in Quelimane, Mozambique. On the one hand, the earthen dike alternative is not financially or economically viable[17] due to high capital costs of building and maintaining the earthen dike combined with the low benefits from storm protection. Mangrove restoration, on the other hand, presents positive NPVs as it provides substantial additional benefits relative to the earthen dike, such as fish production, aquaculture, beekeeping, storm protection, and carbon sequestration. The primary benefits of mangrove restoration are found to be carbon sequestration and fish production.

In addition to the aforementioned land restoration interventions suggested by the CBA of the national FLR assessment in Malawi, the following ones are those related to water resources management issues:

- Soil and water conservation generates additional benefits of approximately 1.5 mil- lion MWK per hectare over a 20-year period compared to degraded conventional maize agriculture.
- River- and stream-bank restoration is most beneficial when it is done on landscapes with low agricultural and forestry opportunity costs or in areas where the public benefits of reducing erosion and increasing water quality are high.

CASA (2020) presents the CASA Program's strategy for the aquaculture sector in Malawi which targets increasing commercial participation of key value-chain actors in input and output markets in Malawi. CASA plans to continue supporting the sector by improving the capacity of identified promising emerging small and medium enterprises (SMEs) to access working capital finance and by leveraging investments in SMEs to provide key business support services. CASA also targets making the sector more attractive for investment by contributing to the required regulatory and policy improvements. CASA's intervention areas and their links to growth and investment are summarised in Table 2.2.

Table 2.2: CASA Intervention Areas

Intervention Area	Link with Drivers for Growth	Prioritised Projects	Link to Investment Readiness
Strengthening SHF access to commercial markets	Access to commercial input markets Organise production arrangements Strengthen emerging commercial producers	Strengthening the technical and management capacity of SHF organisations for bulk input purchasing and aggregation Facilitating access to finance for SHF to improve productivity	Support SHF to register as cooperatives; Business Development Services (BDS) support; matchmaking and linkages between producers & Financial Service Providers/SMEs
Support SMEs to attract investment through strengthened vertical and horizontal business linkages	Strengthening SME involvement in the sector Strengthening access to commercial input markets	Preparing SME input suppliers to receive investment Strengthen operational capacity of upcoming SMEs to become investment-ready so they can expand	BDS support to develop and strengthen business models Facilitating linkages for acceleration and incubation support Matchmaking with investors

[15] The price in these localities is around $2.70 compared to $4.0 in urban markets (CASA, 2020).
[16] Two strategies to combat flooding and coastal erosion that arise from climate change.
[17] Both analyses suggest negative NPVs.

Improved Business Enabling Environment	Improving regulatory and policy environment	Strengthening capacity of business organisations Innovative Fish Farmers Network Trust to lobby for reforms	Introduction of fast-growing species

Source: *CASA (2020, p. 25)*

As summarized by FAO (2020), in order to make agriculture and fisheries more productive and sustainable, the National Fisheries and Aquaculture Policy (2016-2021) of Malawi directs interventions to promote:

- sustainable control measures for the recovery of the over-exploited stocks,
- proper monitoring and control of exploitation of the fisheries resources in all lakes and river systems,
- appropriate fishing technologies for the various fisheries with focus on the offshore fish resources,
- regulatory measures for sustainable aquaculture development, and
- development of an information system for sustainable exploitation, management, and conservation of biodiversity.

Msukwa et al. (2021) applies a Productivity Sustainability Analysis (PSA) to assess the vulnerability of Lake Malawi's 103 most targeted ornamental fish species to fishing for the export trade. According to the PSA approach to ornamental fish species export records from Malawi between 1998 and 2019, most species (71) are in the category of low vulnerability. The conclusion highlights Malawi's fisheries and aquaculture sector's significant potential for the promotion of exports. "This is line with the Malawi Fisheries Policy which advocates promotion of ornamental fish export trade as an alternative option for boosting the public private partnerships and investment in capture fisheries" (Msukwa et al., 2021, p.7)

Summary of impact evaluation evidence

We here summarize the evidence from impact evaluations across the intervention options cited above.

Extractive resources

Table 2.3 summarizes the interventions to the extractive resources we cited above.

Table 2.3: Summary of Impact Evaluation Evidence - Extractive Resources

Intervention	Location	Impact
Improving the efficiency, transparency, and sustainability of mining sector management World Bank (2011)	Malawi	• Building an efficient, transparent and environmentally and socially sustainable framework for managing mineral rights and operations, • Developing transparent arrangements for optimal generation and use of mineral revenues, • Improving the enabling environment for mining sector development by acquiring and disseminating geo-data, fostering more sustainable ASM, increasing the supply of Malawians trained at tertiary level in minerals, and improving the policy environment for mining-related infrastructure development
District landing centers responsible for registration, supervision, monitoring, and technical support to artisanal miners World Bank (2015)	Chile, Ghana, and Tanzania	• A rapid growth of modern small- and medium-scale mining enterprises and the phasing out of artisanal mining • ASM administration and extension services, including financial assistance, training on mining techniques and logistics support • Establishment of the Precious Minerals Marketing Corporation with a mission to purchase gold from registered small-scale miners • Establishment of ASM hot spots to serve as catalysts for the technical, financial, environmental and social transformation of ASM
Mineral sector support for economic diversification World Bank (2017)	Nigeria	• Development of the mining information management systems • Enhancement of geological knowledge through a publically accessible integrated geological database • Increased economic linkages from industrial minerals to the services and manufacturing sectors • Increasing the percentage of ASM operators in target areas inventoried, formalized, and supported through technical assistance • Increasing the production data collected from artisanal, small-, and medium-size mining operations

Enhancing efficiency and sustainability of ASM through climate smart actions AfDB (2020)	Guinea Bissau, Sierra Leone, and Liberia	• Enhanced capacity of ASMs for efficient mining • Integration of ASMs into the formal economy in targeted areas • Adoption of sustainable mining practices • Improved safety, health and security issues • Reduction in environmental impacts of ASM activities • Reduction in deforestation as a means of increasing the carbon sink • Slowing climate change
Establishment of mining cooperatives Akpalu and Wong (2020a)	Ghana	• Increased revenue from improved production practices • Reduced environmental damages • Reduced deaths and injuries from accidents • Reduced in-utero exposure to mercury from harmful production practices

Fisheries and aquaculture

The above-cited interventions on water resource management and their economic impacts are listed in the following table.

Table 2.4: Summary of Impact Evaluation Evidence - Fisheries Resources

Intervention	Location	Impact
Increasing commercial participation of key value-chain actors in input and output markets of the aquaculture sector CASA (2020)	Malawi	• Strengthening SHF access to commercial markets • Support SMEs to attract investment through strengthened vertical and horizontal business linkages • Improved Business Enabling Environment
Replacement of illegal/destructive fishing nets Training and subsidizing feed for aquaculture Installation of video devices on trawl vessels Akpalu and Wong (2020b)	Ghana	• Increased revenue from selling mature and valuable fish • Stock build up and the corresponding increase in rents in the captured fisheries sector • Rise in artisanal profits by almost three-quarters

Key barriers and interventions

As outlined in the sector background, there are a number of challenges/barriers negatively affecting the natural resources of Malawi. In light of the intervention options reviewed from the literature, the following tables present the possible alternatives applicable to the land and water management challenges in Malawi.

Table 2.5: Barriers and Possible Intervention Options - Land and Forests

Key Barriers	Possible interventions
Land and forest degradation	• Land and forest degradation
Weak land tenure security	• Weak land tenure security
Loss of soil fertility	• Loss of soil fertility

Table 2.6: Barriers and Possible Intervention Options - Extractive Resources

Key Barriers	Possible interventions
Lack of cooking fuels alternative to wood	• Promote legalized and green charcoal value chains • Promote affordable and efficient cook stoves
Illegal mining operations and trade	• Formalization of the sector by cooperatives
Rudimentary production, processing, and marketing techniques	• District landing centers responsible for registration, supervision, monitoring, and technical support to ASM operators

Table 2.7: Barriers and Possible Intervention Options - Fisheries Resources

Key Barriers	Possible interventions
Illegal mining operations and trade	• Utilize technological methods, e.g. Remote Electronic Monitoring • Strengthen decentralized fisheries management arrangements
Aquaculture sector still being in its nascent stage	• Improve accessibility to commercial input and service markets · Generate incentives for the production of quality inputs (fingerlings, floating feeds) • Strengthen and formalise organised production arrangements among SHF • Provide SHF with access to finance • Microfinance + financial literacy training • Reconsider tax regime on cost of feed and duty-free imports

In addition to the possible interventions listed above, there are other alternatives which might be applied to the common barriers present in land and water sectors of Malawi. The table below lists these alternatives.

Table 2.8: Barriers and Possible Intervention Options - Common

Key Barriers	Possible interventions
Climate change	• Strengthen climate information services
Weak institutional capacity & Limited and ineffective monitoring	• Strengthen Village Natural Resources Management Committees • Utilize technological methods, e.g. Remote Electronic Monitoring

Selection criteria

The research team used a number of criteria to screen and select a subset of interventions to include in the feasibility analysis. These criteria have been applied to other CCC pre-feasibility research projects as well.

Sector expert priority – The intervention is identified by sector experts as important and relevant to local context. Experts can provide input through several channels: the Reference Group questionnaire, inferences from the NPC research agenda, the academic advisory group, and during individual interviews.

High benefit-cost ratio or cost-effectiveness in similar previous research – The purpose of the Malawi Priorities project is ultimately to identify interventions of outsized benefits relative to costs. Input into this factor is determined from the economics literature, particularly previous research conducted by the Copenhagen Consensus Center. In the Center's experience BCRs above 15 are among the highest across all interventions. Due consideration is given to contextual differences between previous research and the current situation in Malawi in determining the effect of this criterion.

Addresses a problem of sufficient size – some interventions could be considered highly effective but only address a small percentage of a given problem, limiting the overall net benefits of the approach. To avoid focusing on solutions that are too small, each intervention must have the potential to address a problem that is significant.

Significant gap in current levels of intervention coverage – all analysis conducted in Malawi Priorities focuses on marginal benefits and costs. Therefore if an intervention already has high coverage rates, then additional resources provided towards that intervention are unlikely to be effective, or will suffer from the 'small-size' problem.

Availability of crucial data or credible knowledge of impact – due to time and resource constraints, all analyzes conducted by Malawi Priorities are based on secondary data. No primary research is conducted, such as field experiments or trials. Therefore, each intervention is constrained by the availability of data. In many cases, one key constraint is knowledge concerning the impact of a given intervention. It is typical to formally deal with uncertainty via sensitivity analyzes. However, in some cases the uncertainty is so great that it precludes even researching the intervention at all.

Final selection

In order to identify the final subset of interventions to include in the feasibility analysis, we apply the selection criteria to each of the intervention options that were outlined in the previous section. This is summarized below, in Table 2.9.

Table 2.9: Selection of final interventions for inclusion in CBA

Intervention	Sector Expert Priority	High BCR or cost-effectiveness	Sufficient size	Gap in current coverage	Availability of data	Overall
Land and Forests						
Rehabilitation of land	Medium	High	Yes	Yes	Yes	No
Digitized land information and management systems	High	High	Yes	Yes	Yes	Yes
Climate Smart Agriculture technologies	Medium	Medium	Yes	Yes	Yes	No
Extractive Resources						
Promote legalized green charcoal value chains	MediumHigh	Medium	Yes	Yes	Yes	No
Formalization of the sector by cooperatives	High	Medium	Yes	Yes	Yes	Yes[18]
District landing centers	High	Medium	Yes	Yes	Yes	
Fisheries Resources						
Remote Electronic Monitoring	Medium	High	Yes	Yes	Yes	No
Promote quality fisheries and input production	High	Medium	Yes	Yes	Yes	Yes[19]

The interventions that were chosen for inclusion in the pre-feasibility study include:

- ASM district landing centers
- Chipoka fisheries and aquaculture project

Additionally, digitizing land information systems arose as another key intervention. This intervention was carved out in a separate paper within the Malawi Priorities series that examines implementing the Land Reform Act. This includes digitization of land information systems along with a wider range of activities including surveying urban and customary lands in Malawi. Interested readers should consult that paper for results of that particular cost-benefit analysis.

[18] We considered that the cooperatives would play a crucial role in landing centers' administration and combine two intervention options.
[19] We viewed the Chipoka Port Fisheries and Aquaculture Infrastructure and Land Development Program in this context.

3. Cost-benefit Analysis Methodology

CBA provides a way to assess which intervention options will result in the greatest impact at the most efficient cost, allowing policy makers and program managers to make informed decisions regarding their program models.

This section summarizes the methodology for the cost benefit analysis of two interventions; first, mining landing centers for ASM operations, and second, Chipoka Port Fisheries and Aquaculture Infrastructure and Land Development Program.

Intervention 1: ASM district landing centers

Mining - General summary

Malawi is endowed with a variety of mineral resources. However, the sector is largely unregulated, and the production, processing, and marketing procedures of the value chain performed by the ASM operators are rudimentary. This leads to significant economic and social losses for the country. Our intervention targets the ASM district landing centers to accumulate these unorganized and inefficient operations and provide formalization, licensing, mechanization, exploration, value addition, training, and marketing support to the Malawian ASM subsector. We, therefore, expect the intervention to significantly increase the production and revenues from the formalized, consolidated, and value-added operations.

The primary beneficiaries of the intervention are the ASM operators and the GoM.

The direct benefits include:

- Benefit 1: Increased ASM Revenues

The main costs include:

- Cost 1: Investment and Infrastructure Costs
- Cost 2: Operational and Administrative Costs
- Cost 3: Mining Sites Rehabilitation Costs

The methodology for calculating the benefit stream of the intervention follows World Bank (2015) appraisal for the zonal mining offices and extension services in Tanzania and assumes a 35% increase in incremental revenues in real terms during the project's lifetime. Considering the efficiency and productivity gains through mechanization, value-addition support, and marketing aspects of the intervention, the research team finds the 35% increase in incremental revenues reasonable for the ASM sector in Malawi. This critical assumption in the analysis is validated with the Gemstone Association of Malawi.

However, the research team takes a conservative view and considers that the revenues will increase by 5% annually before reaching a 35% annual increase rate in 7 years. The team also tests the responsiveness of the CBA model to this critical parameter in a sensitivity analysis.

It is essential to note that the intervention's impact on the transition from artisanal mining to small- and medium-scale mining through semi-mechanization of the operations brings the risk of adverse environmental externalities to forests. In this context, the research team followed the National Forest Landscape Restoration Strategy of GoM and included the cost of rehabilitating all mining sites of the intervention.

Mining - Benefits, costs, and stakeholders

Table 3.1:

		Stakeholders	
Intervention	**Impact**	**ASM Operators**	**GoM**
1. ASM District Landing Centers	B1 - Increased Production and Revenues	X	
	C1 - Investment and Infrastructure Costs		X
	C2 - Operational and Administrative Costs		X
	C3 – Mining Sites Rehabilitation Costs		X
	T1 - Increased Royalties, Licence Processing and Annual Ground Rent Fees	X	X

Mining - Model specification

B1 - Increased production and revenues

World Bank (2015) describes Chile and Ghana's success stories in developing modern small and medium scale mining sectors. The report suggests crucial lessons for Tanzania from the structural reforms which led Chile to evolve "from artisanal mining to the status of world mining superpower" (World Bank, 2015, p. 38). The financial and technical support to Chilean "miners stimulated a rapid growth of modern small- and medium scale mining enterprises and the phasing out of artisanal mining" (World Bank, 2015, p. 39). The district landing centers responsible for registration, supervision, monitoring, and technical support to artisanal miners played a vital role in the Chilean and Ghanian achievements.

World Bank (2015) Tanzania project contains zonal mining offices to provide extension services, conduct knowledge exchange, disseminate information on best practices and appropriate technologies, and ensure compliance with laws and regulations, particularly concerning health, safety, child labor, mercury emission, and environmental protection. World Bank (2015, p. 18) assumes for the first ten months of operation that the "extension services and the model mines for artisanal and small-scale miners are expected to increase production and income of miners by an average of 35 percent (real increase)."

Tychsen et al. (2018) emphasizes that most of the ASM operators in Malawi are scattered across the country in very remote areas.

Extractive Industries Transparency Initiative (EITI, 2019) highlights that ASM in Malawi

> is largely unregulated and typically practised in the most remote rural areas of Malawi by a population with little other employment alternatives. Meanwhile, much of actual economic potential is lost due to the lack of legal or fiscal framework for small-scale mining and due to rudimentary production, processing and marketing techniques. (p. 25)

Our intervention closely follows the reforms mentioned above and targets the ASM district landing centers to accumulate these unorganized and inefficient operations and provide formalization, licensing, mechanization, exploration, value addition, training, and marketing support to the Malawian ASM subsector. We, therefore, expect the intervention to significantly increase the production and revenues from the formalized, consolidated, and value-added operations. Similar to World Bank (2017),

> Successful implementation of the roadmap is expected to result in, among others, (a) new exploration activity and discoveries; (b) increased mine production emerging from both new discoveries and the unblocking of assets impeded by current regulatory, institutional, and infrastructure deficiencies; (c) expanded processing and refining capacity; (d) improved economic, social, and environmental performance of the artisanal sector; and (e) higher value addition in exports. (p. 96)

We present in Annex 3, the Department of Mines projections for Malawi's mineral production and monetary figures for 2021. Mr. Burnett Msika, a chief mining engineer at the Malawi Department of Mines, confirms the ASM and medium-scale operations' shares as listed in Table A3.1 in Annex A3. The weighted average of ASM productions and revenues suggests MWK4,378 million total revenue projections for the subsector. We consider this projection as the base-period formal ASM revenues.

GoM official reports do not contain any gold mining figures. This is due to the fact that the majority of the operations are artisanal and small-scale and conducted illegally. According to EITI (2019), on the one hand, Malawi's gold resources remain unexplored. The OEC data shows, on the other hand, that gold accounts for almost all of Malawi's precious metals, gems, and jewelry exports in 2019 (99.2%, $21,992,690). These observations highlight Malawi's significant potential to utilize its mineral prosperity and generate wealth for its nation. Given that no official gold statistics exist, we consider 100% of the export revenues as generated by the informal ASM operators.

In line with World Bank (2015), we assume that the intervention's successful implementation will gradually lead to an incremental increase in Malawi's ASM subsector's revenues by 35% in real terms. We also take in our analysis that the incremental increase in revenues would be net of the production costs, and the total impact's realization will be in 7 years. We consider the assumption on the revenue increases being net of the production cost reasonable for our analysis as the cost streams in the model account for almost all of the miners' operation expenses.

"Currently, Malawi is fighting to establish gemstone marketing centres to ease problems of lack of market access encountered by most of the artisanal and small-scale miners." Given that our intervention targets overcoming this essential deficiency and providing mechanization, exploration, value addition, training, and marketing support for ASM operators, we consider the assumptions on the intervention's incremental impacts to be conservative.

Table 3.2:

Timeframe(s)					
Benefits accrue year 2022-2041					
Inputs		**Dimensions**	**Estimate**	**Unit**	**Source of verification**
R^{eg}_{2021}	Mining revenues by ASM in 2021 excluding gold	-	4,378	MWK million	GoM (2020) & expert interviews
R^{g}_{2019}	Gold export revenues by ASM in 2019	-	22	USD million	OEC
g_t	Rate of incremental increase in real mining revenues	Time	5 to 35	%	World Bank (2015)
DEF_t	GDP price deflator index in year t	Time		#	World Bank WDI[20]
X_{2019}	Exchange rate of MWK per USD (2019 average)	-	734.25	MWK	ExchangeRates.org.uk
Calculation					
Benefit:	$$B1_t = (R^{eg}_{2021} + R^{g}_{2019} \times X_{2019} \times \frac{DEF_{2021}}{DEF_{2019}}) \times g_t$$				

C1 - Investment and infrastructure costs

Annex I of the CBA model presents the complete list of intervention cost estimates.

The capital expenditures (CAPEX) are categorized into 5 groups as:

1. Assets for the Core Landing Centers
2. Furniture and Office Hardware Supplies
3. Gemological Identification Equipment
4. Gold Panning and Related Machineries
5. Land Policy and Frame Construction of the International Marketing Center

Our analysis assumes that there will be 12 landing centers potentially located in the following districts from three regions of Malawi:

- Northern region
- Mzuzu, Mzimba, Rumphi, Karonga
- Central region
- Lilongwe, Kasungu, Salima, Dedza
- Southern region
- Blantyre, Mangochi, Balaka, Chikwa

We have considered the unit costs to be the same across the regions.

The intervention's total investment cost is estimated at US $7,537,827.

Table 3.3:

Timeframe(s)					
Costs accrue year 2021					
Inputs		**Dimensions**	**Estimate**	**Unit**	**Source of verification**
C_0	CAPEX for 12 landing centers in base period	-	7.5	USD million	Authors' calculation
X	Exchange rate of MWK per USD	-	745	MWK	CCC
Calculation					
Cost:	$$C1_t = C_o \times X_{\square}$$				

[20] World Development Indicators.

C2 - Operational and administrative costs

According to the cost estimates presented in Annex I of the CBA model, the project's annual operating expenses (OPEX) would include:

- National Office Wage Expenditures
- National Office Other Administrative Expenses
- Regional Expenses
- Capacity Building Expenditures
- Other Expenses

The aggregate annual OPEX is estimated at US $1,530,659 for the project's base year.

Table 3.4:

Timeframe(s)					
Costs accrue years 2022-2041					
Inputs		**Dimensions**	**Estimate**	**Unit**	**Source of verification**
O_0	OPEX in the base year	-	1.5	USD million	Authors' calculation
X	Exchange rate of MWK per USD	-	745	MWK	CCC
Calculation					
Cost:	$C2_t = O_o \times X \times (1+i)^{t-2021}$				

C3 - Mining sites rehabilitation costs

This cost item contains the expenses for the rehabilitation of land surrounding gemstone mining and gold panning fields. Following expert interviews, we consider 1-kilometer and 3-kilometer squares of restoration around the gemstone and gold mines, respectively. The research team makes the following assumptions for the number of gemstone and gold sites for the districts to contain the landing centers and the surrounding ones to be covered by the centers. Therefore, we determine the total area of restoration as 450-kilometer squares, equal to 45,000 hectares.

Table 3.5:

Major Districts	Minor Districts Covered	# of Gemstone Sites	# of Gold Sites
Mzuzu	Nkhata Bay, Mzimba North	20	5
Mzimba		50	4
Rumphi		20	5
Karonga		20	2
Kasungu	Ntchisi	15	5
Lilongwe	Dowa, Mchinji	20	10
Salima	Dwangwa, Nkhotakota	12	10
Dedza		20	1
Blantyre	Thyolo, Mulanje	10	1
Mangochi		15	10
Balaka	Ntcheu, Neno, Mwanza	30	8
Chikwawa	Nsanje	20	5
Totals		**252**	**66**

Malawi's National Forest Landscape Restoration Strategy, launched in 2017, contains the financial costs and sites areas of restoration activities for various land uses. To estimate the per hectare restoration cost for our intervention's gemstone and gold sites, we calculate the weighted average cost of restoration activities presented in the Strategy as MWK 61,925 per hectare.[21] We accumulate the 2017 figures to the intervention's base year and assume that the cost of restoration will be constant in the project lifetime. We also consider that all the mining sites will be rehabilitated once every ten years.

Table 3.6:

Timeframe(s)					
Costs accrue years 2031 & 2041					
Inputs		**Dimensions**	**Estimate**	**Unit**	**Source of verification**
R	Average cost of rehabilitation per hectare	-	61,925	MWK / hectare	Authors' calculation
A	Total area of mining sites to be restored	-	45,000	Hectares	Expert interviews
DEF_t	GDP price deflator index in year t	Time		#	World Bank WDI
Calculation					
Cost:	$C3_t = \frac{DEF_{2021}}{DEF_{2017}} \times R \times A$				

T1 - Increased royalties, licence processing and annual ground rent fees

GoM (2020, p. 69) shows that "Revenue generated by the Government through the Department of Mines only between the period July, 2019 to April 2020 amounted to about MK450 million in terms of royalties, licence processing and annual ground rent fees." The Annual Economic Report 2020 also presents the total mineral exports to be MWK2,390 million and MWK2,405 million in 2019 and 2020, respectively.

We, therefore, calculated the ratio of royalties and fees to the weighted average of 2019-2020 total exports with the weights of 0.6 and 0.4, respectively. We obtained 18.78% as the share of royalties, license processing, and annual ground rent fees in total mineral exports and applied it to the incremental revenues we expect the ASM operations generate throughout the project period.

Table 3.7:

Timeframe(s)					
Costs accrue year 2021					
Inputs		**Dimensions**	**Estimate**	**Unit**	**Source of verification**
r	CAPEX for 12 landing centers in base period	-	7.5	USD million	Authors' calculation
$B1_t$	Exchange rate of MWK per USD	-	745	MWK	CCC
Calculation					
Cost:	$T1_t = r \times B1_t$				

Mining - Timing

Timeframe (Flag)

The intervention is assumed to last the lifetime of the CBA, which is currently set to 20 years. The intervention is assumed to take effect in the first period.

[21] See Table 5 in GoM (2017, p. 27) for the disaggregated data.

Table 3.8:

Inputs		Dimensions	Unit
	Start year	2021	Year
	Intervention 1 implementation beginning year	2021	Year
	Intervention 1 implementation length	20	Years
Calculation			
Periods:	t is a time index corresponding to the number of complete years elapsed since the start year $Y_t = Y_0 + t$		
Flags:	$F1Imp_t = if(Y_t \geq Imp^B, if(Y_t < (Imp^B + Imp^L),1,0),0)$		

Intervention 2: Chipoka fisheries and aquaculture project

Fisheries - General summary

Malawi is home to plentiful water resources contributing to the country's wealth creation via fisheries, irrigation, electricity generation, and tourism. The fisheries and aquaculture sector plays a critical role in rural job creation, poverty reduction, and household food security. Lack of boat docking, fish storage, processing, packaging, and marketing facilities and access to quality fingerlings and floating feeds make Malawi dependent on Zambia imports.

The Chipoka fisheries and aquaculture development program targets providing the sector with the required infrastructure utilities and facilities of manufacturing, storage, distribution, commerce, and more. We expect the intervention to significantly contribute to formalizing and linking the industry to industrial, urban, and service sectors, especially tourism.

The primary beneficiaries of the intervention are the fisheries and aquaculture operators and the GoM.

The direct benefits include:

- Benefit 1: Increased fisheries and aquaculture revenues
- The main costs include:
- Cost 1: Investment and Implementation Costs
- Cost 2: Fisheries and Aquaculture Production and Processing Costs

The model calculates the benefit stream as incremental revenues from aquaculture and fish processing. It is essential to note that the analysis takes inland fisheries into account from a processing perspective only. Considering the problem of overharvesting and illegal fishing in Lake Malawi, we assume that the additional fisheries production due to the Chipoka project will be taken away from artisanal harvesting that would occur illegally in a without-project scenario. In other words, the revenues from fisheries landings to be generated due to the intervention would not be incremental welfare gains.

Fisheries - Benefits, costs, and stakeholders

Table 3.9:

		Stakeholders	
Intervention	**Impact**	**Fisheries Operators**	**GoM**
2. Chipoka Fisheries and Aquaculture Project	B1 - Increased Production and Revenues	X	
	C1 - Investment and Infrastructure Costs		X
	C2 - Fisheries and Aquaculture Production and Processing Costs	X	
	T1 - Increased Government License Fee Collections	X	X

Fisheries - Model specification

B1 - Increased fisheries and aquaculture value added

The research team prepared the input-output analysis of the Chipoka fisheries and aquaculture project. As we present in Annex 4, the analysis's key assumptions are;

- Number of vessels: 10
- Number of farms (pond farming): 10
- Number of farms (cage farming): 4
- Farmgate price per kg of caught fish: MWK 2,500
- Farmgate price per kg of pond/cage grown fish (tilapia) per kg: MWK 3,000
- Factory price industrial processed fish per kg: MWK 4,000

Based on these conservative assumptions, the team estimated the incremental annual fisheries and aquaculture revenues due to the Chipoka project as MWK 18,495 million (see Table A.4.3). Our analysis considers the real revenues to be constant as of 2026. The team also conducted a sensitivity analysis on the model's key assumptions and measured the main results' responsiveness.

Table 3.10:

Timeframe(s)					
Benefits accrue year 2026-2045					
Inputs		**Dimensions**	**Estimate**	**Unit**	**Source of verification**
R	Total annual incremental fisheries and aquaculture revenues	-	18,495	MWK million	Authors' calculation
Calculation					
Cost:	$B1_t = R$				

C1 - Investment and Implementation Costs

The research team also interviewed Mr. Maxwell J. Maida, senior development planner and specialist at NPC; and Mr. Kobi Ruthenberg, associate director at Org Permanent Modernity, and obtained a concept note on the Chipoka Port Fisheries and Aquaculture Infrastructure and Land Development Program together with the cost estimates on the project.

As we present with the cost estimates in Annex 4, the lakefront hubs and peripheral and localized farms and markets (spokes) contain the following elements:

Hubs

- Fishing Boat docking and repair shops
- Industrial processing + packaging + cold storage
- Cage farms + facilities
- Wholesale fish market
- Lakefront training and research facilities
- Aquarium
- Small aquaculture farming communities

Spokes

- Fish feed milling
- Fingerlings hatchery
- Commercial Aquaculture farming
- Small aquaculture farming communities
- Marine wildlife reserves including Lake Malawi National Park

The team based the investment and implementation cost estimates on the inputs and calculations below.

We converted the USD figures to MWK using 745 as the real exchange rate in the base period and assumed the rate to be constant in real terms during the project period.

Table 3.11:

Timeframe(s)					
Costs accrue years 2021-2033					
Inputs		**Dimensions**	**Estimate**	**Unit**	**Source of verification**
C^{p1}	Investment and implementation costs - phase 1	-	53,845,000	USD	Expert interviews
C^{p2}	Investment and implementation costs - phase 2	-	60,345,000	USD	
c^{pf}	Pre-feasibility study cost ratio to the total phase 1 costs	-	1.0	%	
c^{fs}	Feasibility study cost ratio to the total phase 1 costs		1.5	%	
c^{ps}	Project structuring cost ratio to the total phase 1 costs		2.5	%	
l^{p1}	Investment phase 1 length		5	Years	
l^{p2}	Investment phase 2 length		5	Years	
X	Exchange rate of MWK per USD	-	745	MWK	CCC
Calculation					
Cost:	$C1_t = C_t^{pi} + C_t^{p1} + C_t^{p2}$				
Where	$C_t^{pi} = (C^{p1} \times c^{pf} + C^{p1} \times c^{fs} + C^{p1} \times c^{ps}) \times X$				$t = 2021 - 2023$
	$C_t^{p1} = C^{p1} \times X / l^{p1}$				$t \geq 2024$
	$C_t^{p2} = C^{p2} \times X / l^{p2}$				$t \geq 2029$

C2 - Fisheries and Aquaculture Production and Processing Costs

The second cost stream of the CBA model contains the incremental expenses of fisheries processing and aquaculture production due to the intervention. As presented in Appendix 4, considering the assumptions used in the benefit stream, the aggregate production costs of fresh fish and industrial processing and aquaculture are estimated as MWK 2,716 million. Our model uses this estimation as a constant input to account for the incremental production costs due to the intervention.

Table 3.12:

Timeframe(s)					
Costs accrue years 2026-2045					
Inputs		**Dimensions**	**Estimate**	**Unit**	**Source of verification**
C	Total annual incremental fisheries and aquaculture production and processing costs	-	2,716	MWK million	Expert interviews
Calculation					
Cost:	$C2_t = C$				

T1 - Increased Government License Fee Collections

As mentioned in the benefit stream narrative above, we assumed that there would be ten incremental vessels being operational due to the intervention. Taking MWK1.2 million as the license fee per vessel per year, we expect the GoM to generate MWK12 million annually from license fee collections. We assume that the annual incremental revenues will be constant in real terms throughout the project period.

Table 3.13:

Timeframe(s)					
Costs accrue years 2021-2045					
Inputs		Dimensions	Estimate	Unit	Source of verification
L	License fee per vessel per year	-	1,200,000	MWK	Expert interviews
v	Number of vessels	-	10	#	
Calculation					
Cost:	$T1_t = L \times v$				

Fisheries - Timing

Timeframe (Flag)

The intervention is assumed to last the lifetime of the CBA, which is currently set to 24 years. The intervention is assumed to take effect in the first period.

Table 3.14:

Inputs	Dimensions	Unit
Start year	2021	Year
Intervention 2 implementation beginning year	2021	Year
Intervention 2 implementation length	24	Years
Calculation		
Periods:	t is a time index corresponding to the number of complete years elapsed since the start year $Y_t = Y_0 + t$	
Flags:	$F1Imp_t = if(Y_t \geq Imp^B, if(Y_t < (Imp^B + Imp^L),1,0),0)$	

Because the second intervention contains pre-investment pre-feasibility, feasibility, and structuring procedures, and investment periods before the benefits accrue in 2026, the implementation period is different from the first intervention. Both interventions have 20 years of benefits realization period.

4. Conclusion and Discussion

To address the research questions, "how can national resources best contribute to wealth creation?" and "what institutional structures best deliver the returns on investment in national resource management?", the team conducted a CBA to measure the potential impact of two possible interventions:

1. Formalization and Modernization of the ASM Sub-sector by District Landing Centers
2. Chipoka Port Fisheries and Aquaculture Infrastructure and Land Development Program

The primary beneficiaries of the interventions are the ASM and fisheries/aquaculture operators, respectively. The GoM is also among the beneficiaries of both interventions.

The interventions' direct benefits include:

- Intervention 1: B1 - Increased production and revenues by ASM operations
- Intervention 2: B1 - Increased fisheries and aquaculture revenues

The methodology for calculating the benefit stream of the first intervention follows the success stories of Chile, Ghana and Tanzania appraised by World Bank (2015) and assumes a 35% increase in incremental real revenues during the project's lifetime. The analysis takes a conservative view and considers that it will take the project seven years to reach maturity in revenue generations.

The Chipoka fisheries and aquaculture CBA model calculates the benefit stream as the incremental revenues from fish landings processing and aquaculture.

The results show that both interventions have BCRs above one. This suggests that both interventions are likely to generate positive results while remaining cost-effective, as shown in the following figure.

Figure 4.1: Interventions' Benefit-Cost Ratios at Alternative Discount Rates

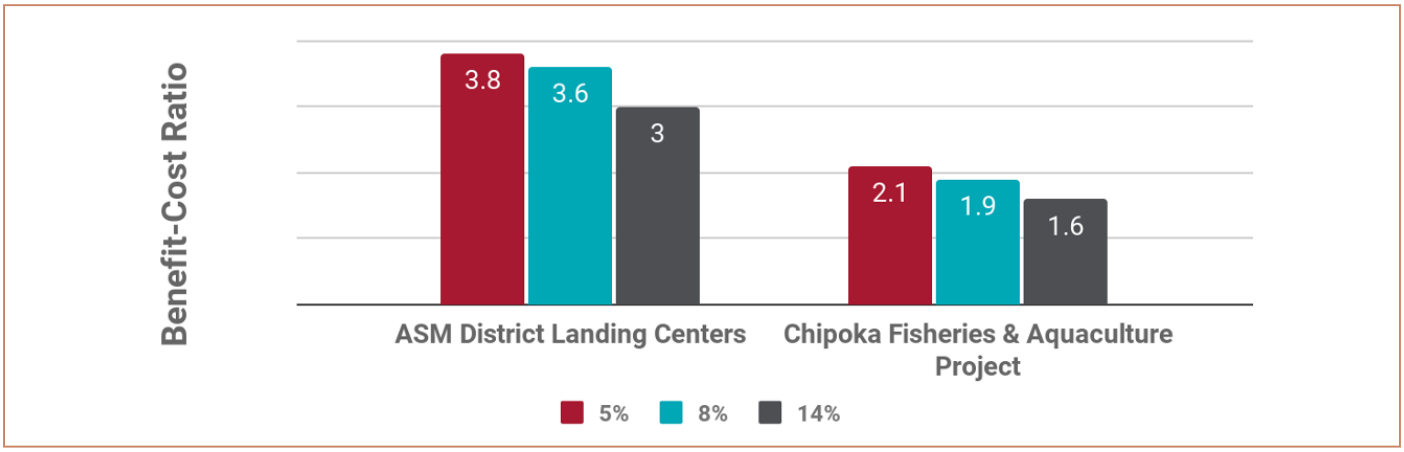


Figure 4.2: Mining CBA - Summary of the Benefit and Cost Streams

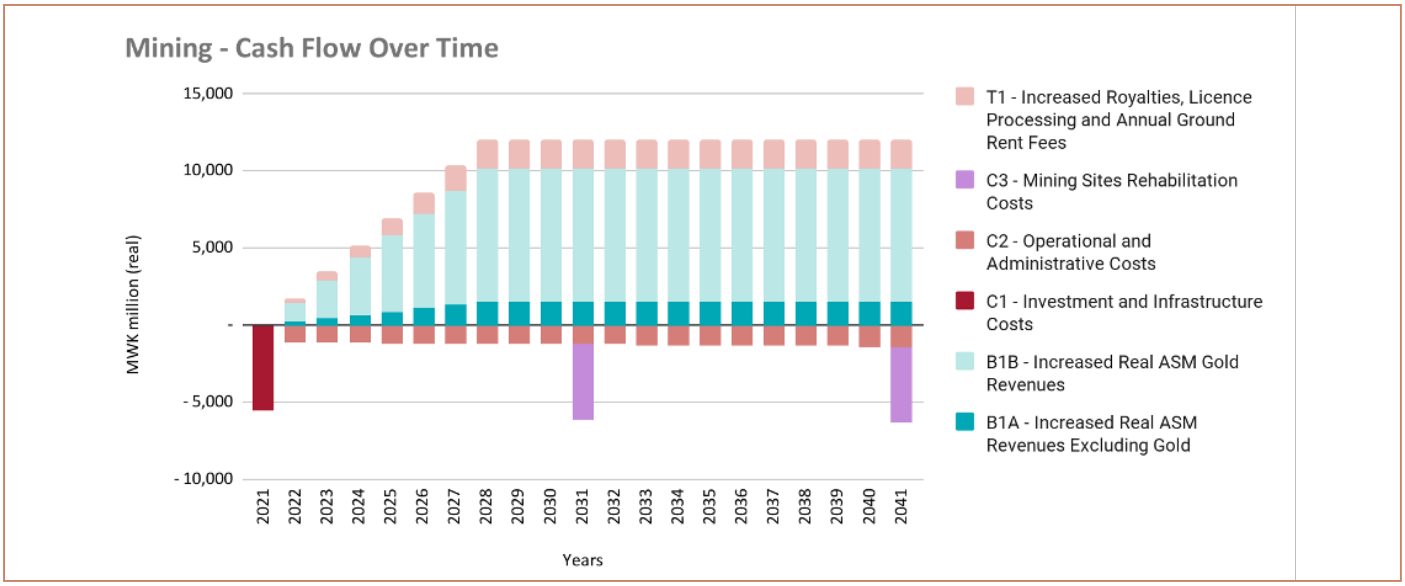
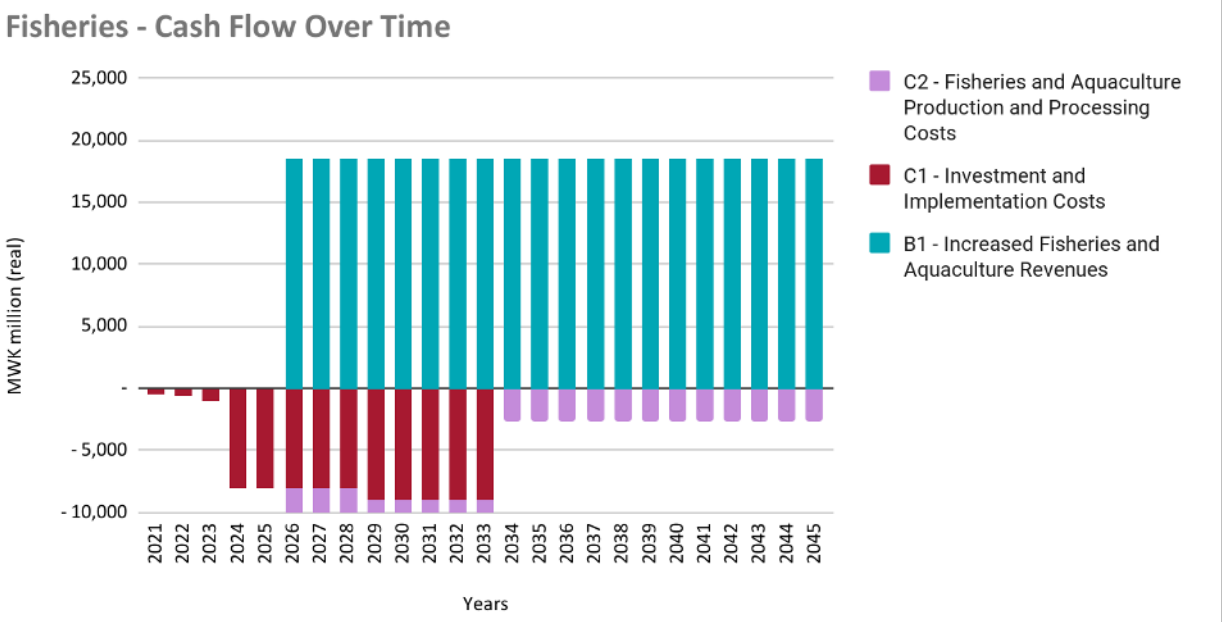


Figure 4.3: Fisheries CBA - Summary of the Benefit and Cost Streams



All of the interventions proposed have expected BCRs above one, even when the highest discount rate is used (14%). When the discount rate of 5% is used, BCRs are 3.8 for ASM district landing centers and 2.1 for the Chipoka fisheries and aquaculture project. This suggests that each of the two interventions could yield positive results on their own while being somewhat cost-effective. The BCR for both interventions are in the fair range of 1-5, meaning that the net benefits outweigh the net costs of each intervention.

It is important to note that the team has conducted the analyses with a conservative view on the assumptions about interventions' impact on the sectors. It is reasonable to assume that successful implementation of both interventions could generate significant benefits not only to the particular sectors of interest but also to subsidiary businesses.

Specifically speaking, on the one hand, ASM landing stations and the international marketing center present an outstanding potential for Malawi's mining sector. It is likely for the intervention to lead to the discovery, extraction, and marketing of a considerable amount of gold, gemstones, and other minerals. The Chipoka fisheries and aquaculture investment project, on the other hand, could turn into a national hub for industrial, commercial, and logistical activities and generate a significant multiplier effect on the key related sectors of agriculture, tourism, and transportation.

There is no doubt that the realization of these scenarios could present higher net revenues in the sectors than what the team has assumed in the analyses. It is also reasonable to consider the potential of the interventions in generating additional employment both in the industries of interest and the subsidiary businesses. Moreover, occupational health and safety, positive environmental externalities are among the interventions' possible benefits that the team couldn't account for in the analyses due to the unavailability of reliable data. In Annex 5, an approximate, imprecise estimate is made suggesting a plausible range that may increase benefits by 3-9%. This suggests the omitted benefits would not materially affect the calculations.

Sensitivity analysis

In order to identify which assumptions are the most critical to the success of each intervention, the team has conducted some basic sensitivity analyses. The following tables report the BCR when alternative input values are assumed for key parameters.

Mining - Rate of incremental increase in real mining revenues in period 1 and project maturity

We mentioned earlier that our analysis follows World Bank (2015) and assumes that the intervention's successful implementation will lead to an incremental increase in Malawi's ASM subsector's revenues by 35% in real terms. We also mentioned that the analysis takes a conservative view of the total impact's realization in seven years, i.e., gradually increases by 5% per annum. We, therefore, test the sensitivity of the BCR results to these two critical assumptions of the model.

The findings of the analysis highlight the BCR showing downward sensitivity to lower figures of the critical assumptions of the intervention. The tables below show that lower (higher) revenue-increase rates reduce (increase) the benefit stream and, thereby, the BCR of the model. The results suggest that the faster the intervention's successful implementation, the ASM subsector would yield higher returns.

Table 4.1: Sensitivity Analysis of the Mining Intervention

Scenario	Rate of Increase in Revenues	BCR @ 8%
Period 1		
Current	5%	3.6
Alternative 1	2%	2.2
Alternative 2	10%	4.2
Alternative 3	15%	4.4
Maturity		
Current	35%	3.6
Alternative 1	10%	1.3
Alternative 2	25%	2.8
Alternative 3	50%	4.4

Fisheries - Key assumptions on the value addition

We have based the fisheries landings, fish processing, and aquaculture value addition of the Chipoka project on the following key assumptions:

- Number of vessels: 10,
- Number of farms (pond farming): 10
- Number of farms (cage farming): 4
- Farmgate price per kg: MWK 2,500
- Factory price industrial processed fish per kg: MWK 4,000

The following tables present the effects of using alternative values for the assumptions on the model's BCR results.

Table 4.2: Sensitivity Analysis of the Fisheries Intervention

Scenario	Critical Item	BCR @ 8%
Number of Vessels		
Current	10	1.9
Alternative 1	5	1.6
Alternative 2	15	2.2
Alternative 3	20	2.4
Number of Farms (Pond Farming)		
Current	10	1.9
Alternative 1	5	1.91
Alternative 2	15	1.91
Alternative 3	20	1.92
Number of Farms (Cage Farming)		
Current	4	1.9
Alternative 1	2	1.5
Alternative 2	6	2.3
Alternative 3	8	2.6

Farmgate Price (MWK) per kg		
Current	2,500	1.9
Alternative 1	2,000	1.8
Alternative 2	3,000	2.1
Alternative 3	4,000	2.3
Factory Price (MWK) Industrial Processed Fish per kg Price per kg		
Current	4,000	1.9
Alternative 1	3,500	1.89
Alternative 2	4,500	1.93
Alternative 3	5,000	1.96

The analysis findings suggest that the model is sensitive to the assumptions on the number of vessels and that of cage farms. The results also show that as more vessels utilize the infrastructure created by the intervention and more cage farms get active, the higher BCRs the project would generate. However, even doubling the assumptions would still yield BCRs in the fair range of 1-5.

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6. Annexes

A1. Chipoka Port Fisheries and Aquaculture Infrastructure and Land Development Project Render and Scenarios

Figure A1.1: Chipoka fisheries and aquaculture project render

Figure A1.2: Chipoka fisheries and aquaculture project scenarios

A2. Land degradation and deforestation literature review and intervention options

Malawi's natural capital is under significant pressure on many fronts including population growth, agricultural expansion, and climate change (World Bank, 2019a). Land degradation is considered to be the main channel of this pressure. Following a Total Economic Value approach, Kirui (2016) finds that the annual cost of land degradation due to land use and land cover change during the 2001 – 2009 period is about $244 million in Malawi, expressed in constant 2007 $, and representing about 6.8% of GDP). Chemical land degradation, including soil pollution and salinization/alkalinisation, has led to 15 % loss in the arable land in Malawi in the last decade alone (Chabala et al., 2012).

The underlying drivers of land degradation in Malawi include; (1) growing demand for agricultural land and wood fuels associated with a growing population; (2) imperfect knowledge about sustainable farming practices; (3) insecure land tenure which reduces incentives to invest in soil and water conservation measures; and (4) limited access to markets and rural finance (World Bank, 2019b). Additionally, a wide range of biophysical factors such as topography, land cover, climate change and soil erodibility, and poor land management can also be considered as the proximate causes of land degradation (World Bank, 2020). World Bank (2020) considers the weak institutional capacity for natural resource management at both national and local levels and the severe lack of funding for these activities in local government budgets as the major challenge of the land degradation problem in Malawi. In this context, local governments' insufficient resources, weak capacity and lack of incentives make them unable to address land degradation effectively at the local level.

Almost all households in Malawi (i.e. more than 97%) rely on illegally-sourced biomass heating energy.[22] As noted in the Malawi National Charcoal Strategy 2017-2027 (Government of Malawi - GoM, 2017b), this illegal and unsustainable system results in high levels of deforestation and forest degradation throughout the country. It is also highlighted in the Strategy that, as a result, downstream negative impacts occur on water availability, hydropower-generating capacity, and more broadly, vulnerability of Malawians to climate change. According to current projections, by 2030 there will not be enough biomass in the country to meet demand for firewood and charcoal (GoM, 2017b). The destructive impact of illegal charcoal production on deforestation is also emphasized by Dr. Clement Chilima, the director of the Department of Forestry, in an email conversation with the team, who stated that the "illegal charcoal production and use is one of the key drivers of deforestation in Malawi, where more than 90% of the population relies on unsustainably produced and illegal charcoal for domestic cooking and heating needs."

World Bank (2019a) emphasizes weak land tenure security, unsustainable land management practices (driven in part by poorly designed and targeted agricultural subsidies), chronic shortages of public funding for environmental management, and weak institutions, particularly those at decentralized levels, as the proximate drivers of environmental degradation.

[22] "Inaccessible, unreliable, and unaffordable electricity supplies are the main reason for this high dependency on biomass fuels." (World Bank, 2019a, p. 8)

Further environmental vulnerabilities arise from unsustainable agriculture and land use practices. World Bank (2019a) highlights agricultural policies and accompanying state interventions contributing to land degradation and reducing resilience. These interventions are considered as having worked against crop diversification and sustainable agricultural development.

Malawi's institutions lack required capacity for natural resource management. This weak institutional capacity is particularly observed at district or local levels. World Bank (2019a) points out two related reasons for this weak capacity:

> First, the slow pace of implementation of the government's decentralization policies constrains the extent to which district councils and extension services can support farmers to adopt Sustainable Land Management (SLM) practices or Village Natural Resources Management Committees to protect and restore forest resources. Second, severe under resourcing constrains the effective functioning of institutions at district and local levels, limiting their ability to implement policy. (p. 6)

In light of their study of land and water management in sub-Saharan Africa including Malawi, Winterbottom et al. (2013, p. 2) also highlights that "[i]n many cases, national policies and legislation do not provide sufficient incentives— such as secure land tenure and property rights—to stimulate farmers to invest in improved land and water management."

According to Nkonya et al. (2016), the major factors affecting land degradation at the global level include land tenure security, population density, market access and rule of law. The authors list the following drivers of land degradation and policies for improvement:

- Better rule of law was found to positively influence SLM in most cases, especially in sub-Saharan Africa.
- The areas with high population densities were found to manage their land resources more sustainably when they have a dynamic non-farm sector which facilitates cross-sector labor, technological and capital spillovers.
- Secure land tenure may provide additional benefits and opportunities for SLM.
- With relatively well-functioning markets, including output, input and financial markets, land degradation also declines.
- Where markets do not function well or are very thin, secure land tenure may have much less effect on SLM.
- The findings further illustrate the key role played by governance and incentives for wider adoption of SLM practices.

Winterbottom et al. (2013, p. 2) examines the following four improved land and water management practices particularly relevant to sub-Saharan Africa;

- Agroforestry—the deliberate integration of woody perennial plants —trees and shrubs—with crops or livestock on the same tract of land.
- Conservation agriculture—a combination of reduced tillage, retention of crop residues or maintenance of cover crops, and crop rotation or diversification.
- Rainwater harvesting—low-cost practices—such as planting pits, stone bunds, and earthen trenches along slopes—that capture and collect rainfall before it runs off farm fields.
- Integrated soil fertility management[23]—the combined use of judicious amounts of mineral fertilizers and soil amendments such as manure, crop residues, compost, leaf litter, lime, or phosphate rock.

Winterbottom et al. (2013, p.34) states that "[e]xperience shows that improving land and water management can enhance food security and reduce poverty while helping to adapt to and mitigate climate change." The authors explain a wide range of practices which can restore the productivity of degraded agricultural land and boost crop yields. They also highlight the role of governments in the creation of enabling conditions for the private sectors to market-based approaches to strengthening agroforestry value chains.

Baumgartner and Cherlet (2015) reviews examples of land degradation in different contexts to reveal the multiple driving forces and contextual factors. The examples and adopted interventions include:

- Application of the combination of organic and chemical fertilisers to the severe problem of soil salinity in China. The applications are found to reduce the negative impact of saline soils on crop land's productivity in a cost-efficient way.
- Certification of sustainable production practices and international marketing of the produced products led to significant decrease in deforestation in Brazil. Producers of soy bean and beef received special certifications and economic incentives if they signed and adhered to moratoriums on deforestation.

Pistorius et al. (2017) analyzes the voluntary commitment of Ethiopia to implement Forest Landscape Restoration (FLR) on 15 million hectares in the context of the Bonn Challenge. Specifically, the paper applies a CBA to the case study of FLR opportunities in the Amhara National Regional State, following the ROAM. Five most significant opportunities analyzed are:

- medium to large-scale afforestation and reforestation activities on deforested or degraded marginal land not suitable for agriculture,
- the introduction of participatory forest management,
- sustainable woodland management combined with value chain investments,
- restoration of afro-alpine and sub-afro-alpine areas, and
- the establishment of woodlots.[24]

[23] i.e. "the combined use of judicious amounts of mineral fertilizers and soil amendments such as manure, crop residues, compost, leaf litter, lime, or phosphate rock" Winterbottom et al. (2013, p. 2).
[24] CBA of all interventions except the fourth one presents positive NPV per hectare. According to Pistorius et al. (2017, p. 16), " [w]ith less than 50,000 hectares, the area potential is relatively smaller, but key ecosystem services benefits are highly significant for this FLR option, such as biodiversity protection, watershed and soil protection, and cultural preservation."

According to GoM (2017, p. 26), the financial and economic CBA of the implementation of the identified restoration intervention types in the national FLR assessment suggests the following findings in regards to land degradation and deforestation:

- Agricultural technology,[25] when adopted by smallholder farmers, makes them likely to be better off in the long run than their peers who did not adopt it. Farmer-managed natural regeneration was identified as the most cost-effective and least labor-intensive strategy.
- Community forests and woodlots generate additional benefits to smallholder farmers of 5.7 million MWK over a 20-year period compared to degraded forest and woodlands with light agriculture.
- Natural forest management is most beneficial when it is done on landscapes with low agricultural and forestry opportunity costs or in areas where the public benefits of natural forest management are high.

Implementation of these restorations under Malawi's commitment to the Bonn Challenge is considered by AFR100[26] to be aligned with Malawi's domestic targets, and, therefore, to:

- support Growth and Development Strategies;
- raise adoption rates of improved land and water management practices (including climate smart agriculture[27] and watershed management);
- improve food and water security;
- reinforce and scale up ongoing efforts to promote reforestation of denuded forest land;
- protect and manage forest regeneration and trees and shrubs on cropland to increase the supply of fuelwood and other forest products;
- enhance carbon storage; and
- improve rural livelihoods.

United Nations Development Program (UNDP, 2016) co-financed the "Private Public Sector Partnership on Capacity Building for Sustainable Land Management in the Shire River Basin" project which aimed at reducing land degradation in the Shire River Basin through improved institutional, policy and Payment for Ecosystem Services arrangements and improved food security. The basin is of great importance for Malawi not only due to covering over 3.1 million hectares of land and influencing the livelihoods of over 5.5 million people in the southern region of Malawi, but also as it provides over 98% of the country's electricity. The project, implemented with the Environmental Affairs Department in the Ministry of Natural Resource, Energy and Mines in Malawi, identified the following barriers impeding the wide scale adoption of SLM in the Shire River Basin (p. 21):

- Weaknesses in the policy, planning and institutional environment that influence SLM;
- Weak incentives for adoption of SLM;
- Weak capacities and inadequate skills at all levels required for promoting and/or adopting SLM.

According to UNDP (2016, p. 7), the important achievements of the Shire River Basin project include;

- Promotion of a multi-sector approach and partnerships in natural resources management;
- Promotion of integrated river basin management;
- Promotion of SLM at community and farm level;
- Promotion of innovative approaches on the policy agendas such as Green Water Credits, sustainable charcoal and weather information based crop insurance;
- Change of mind set with regard to sustainable charcoal;
- Provide important inputs in policy and legal frameworks;
- Reduction of environmental degradation in a number of pilot sites.[28]

Kirui (2016) highlights secure land tenure, access to markets and extension services as the major factors incentivizing SLM adoption, and states the following interventions for Malawi and Tanzania:

- Local institutions providing credit services, inputs such as seed and fertilizers, and extension services must be included in the development policies.
- Some of the actions taken by communities to address the loss of ecosystem services or enhance or maintain ecosystem services improvement include afforestation programs, enacting of bylaws to protect existing forests, area closures and controlled grazing, community sanctions for overgrazing, and integrated soil fertility management in croplands.

As part of the National Commitment to Achieve Land Degradation Neutrality in 2017, GoM lists specific targets for avoiding, minimizing and reversing land degradation as follow:

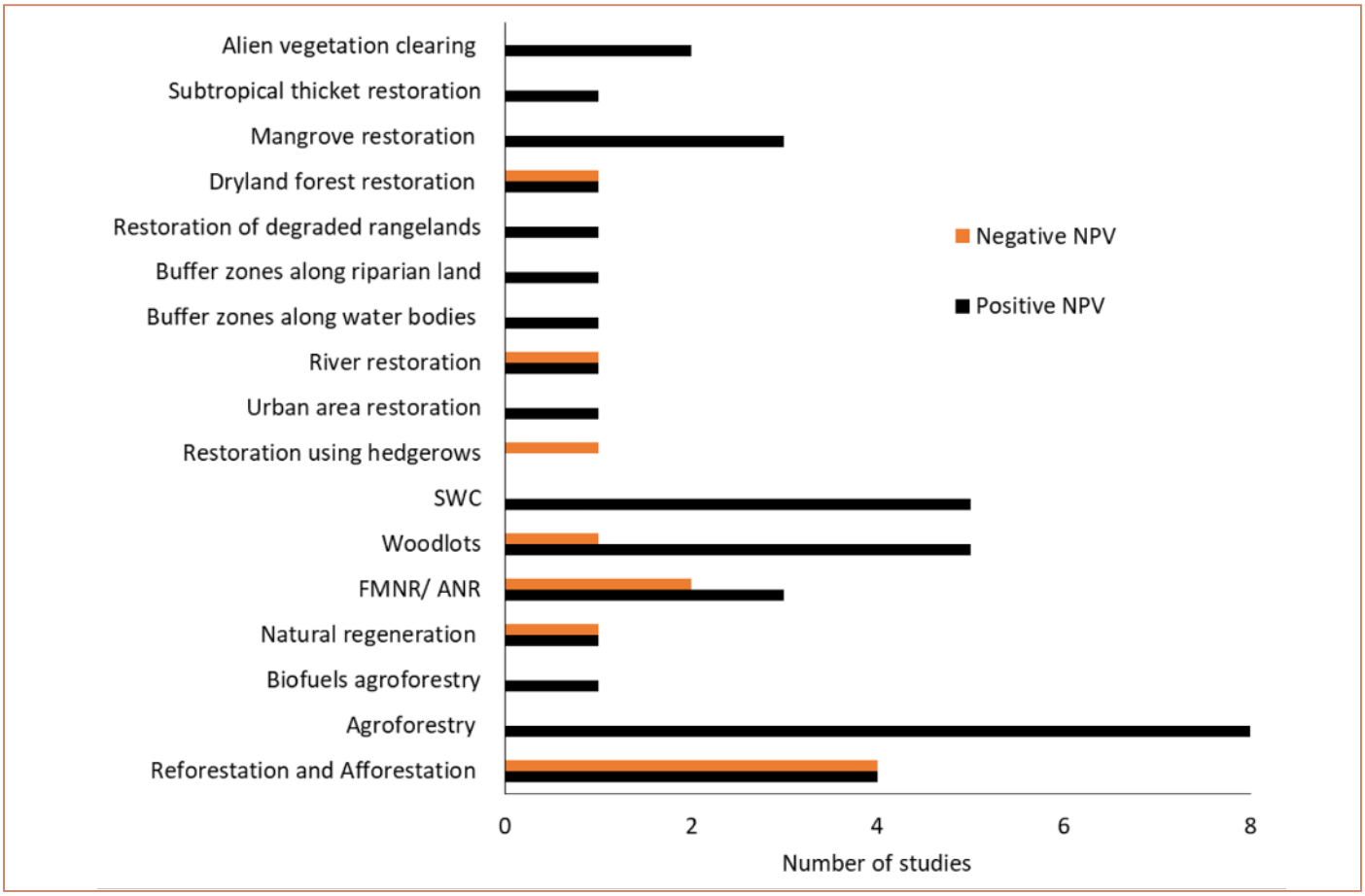
[25] Agricultural technologies refer to any type of intercropping of trees with crops and include conservation agriculture, farmer-managed natural regeneration, and agroforestry." (GoM, 2016, p. 10)
[26] https://afr100.org/content/malawi
[27] "Overall, the results show that packages that contain all three CSA strategies (improved maize varieties, soil and water conservation and cereal-legume diversification) generate positive economic benefits in terms of NPV, IRR and payback period for heterogeneous smallholder farming systems." (Mutenje et al., 2019, p. 135)
[28] See UNDP (2016, pp. 84-92) for a detailed list of objectives together with their target level at the end of the project and their status at terminal evaluation.

- Improve productivity of 754320 hectares cropland by 2030
- Improve Soil Organic Carbon stocks on cropland to 55 ton/ha by 2025 as compared to 44.7 ton/ha estimated in 2015
- Rehabilitate one million hectares of degraded land for crop production by 2030
- Halt the conversion of forests and wetlands to other land cover classes by 2020
- Improve forest (plantation & indigenous) cover by 33750 hectares by 2030 as compared to 2015
- Reduce the rate of top soil loss (soil erosion) to 20 tons per hectare per year by 2030 from the 2015 estimated rated of 29 tons/ha/year
- Increase forest cover by 2% from 2015 baseline by 2022
- Restore 820,000 hectares of degraded indigenous forest by 2030
- Sustainably manage 138,000 hectares of plantation forest by 2025
- Restore 36000 hectares of degraded stream banks by 2030
- Protect 2.4 million hectares of natural forest by 2035

FLR is an ongoing process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes. Colomer et al. (2018) specifies climate change mitigation and adaptation, better land productivity, rural job creation, and improvements in the availability and quality of water as some of the most tangible benefits of FLR, besides the main target of land degradation and deforestation.

Wainaina et al. (2020) presents a literature review of studies on landscape restoration which conducted economic CBA of the interventions analyzed. The authors filtered 31 studies out of 2,056 by the selection criterion of conducting an economic CBA on at least one landscape restoration strategy. Figure A2.1 below presents reported Net Present Value (NPV, positive or negative) by the studies reviewed by Wainaina et al. (2020, p. 10).

Figure A2.1: NPVs of Landscape Restoration Projects



We see from the figure that the majority of the studies reviewed by Wainaina et al. (2020) reported positive NPVs for most of the restoration strategies.

A2.1 BCRs of relevant interventions

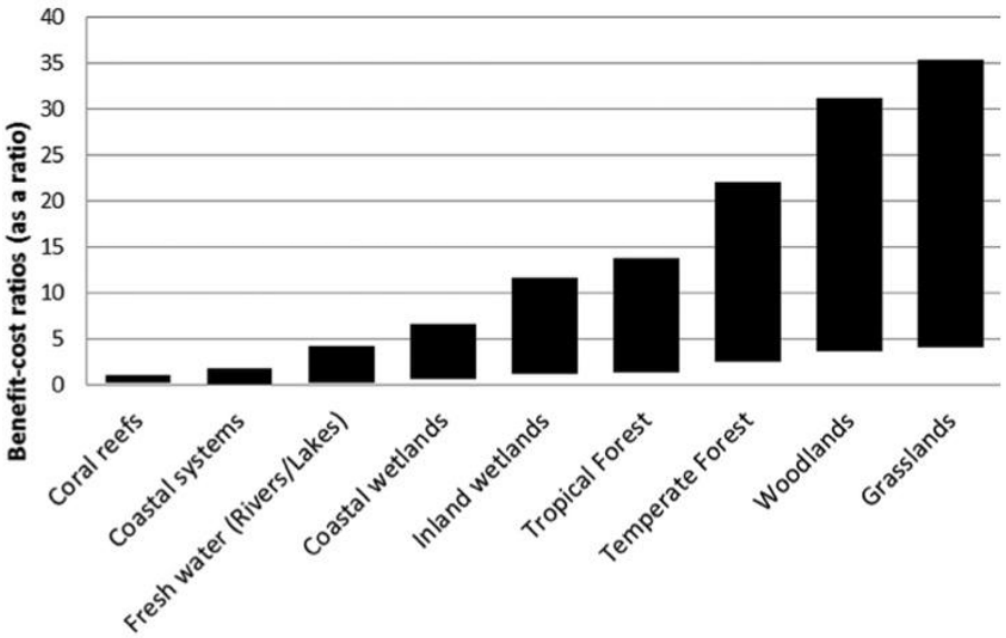
De Groot et al. (2013) reviews over 200 peer-reviewed scientific papers applying CBA to ecosystem restoration projects worldwide, and identifies 94 restoration case studies with meaningful cost data. Figure A2.2 below shows the range of BCRs of the analyzes, where;

- bars represent the range of values,

- the bottom of the bars represent the worst-case scenario in which the analysis is conducted at 100% of highest restoration cost reported, 30% of benefits, and social discount rate 8%,
- the top of the bars represent the best-case scenario in which the analysis is conducted at 75% of highest restoration cost reported, 75% of benefits, and social discount rate of 2%.

Figure A2.2 below shows that the CBA analyzes of the ecosystem restoration projects suggest BCRs ranging from about 0.05 (coral reefs and coastal systems, worst-case scenario) to as much as 35 (grasslands, best-case scenario), with the majority of ratios being between 5 and 20.

Figure A2.2: Benefit-Cost Ratios of Ecosystem Restoration Projects

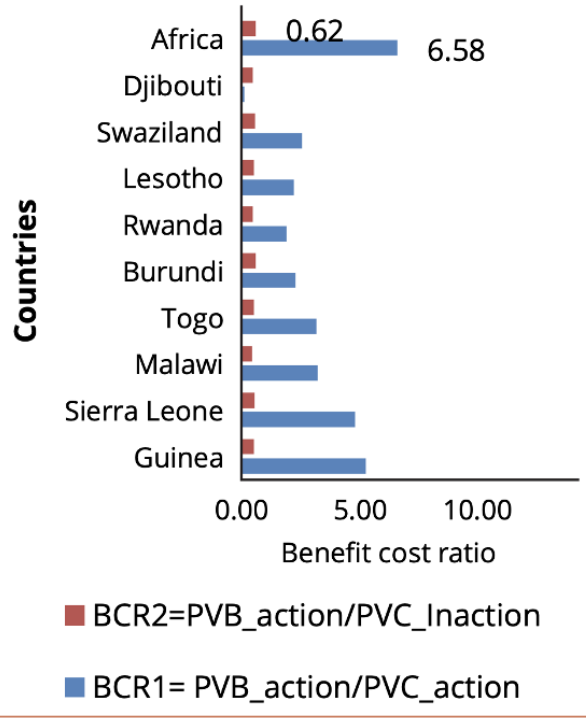


Source: *De Groot et al. (2013, p. 1290)*

The United Nations Environment Program (UNEP) and the Economics of Land Degradation (ELD) Initiative focus on soil erosion and crop productivity on over 100 million hectares of crop lands across 42 African countries,[29] and analyze the interventions using a CBA approach. ELD and UNEP (2015) analyzes the SLM practices, such as different soil and water conservation technologies, and finds out that the mean BCR of the interventions on erosion induced nutrient depletion in croplands is 6.58. The study also shows that the BCRs are higher on average for countries with current high rates of soil erosion.

As shown in Figure A2.3 below, the BCR of action for Malawi is around 3.

Figure A2.3: Benefit-Cost Ratios of Countries with Soil Erosion Rate < 950 ton/ha/year



Source: *ELD and UNEP (2015, p. 87)*

[29] Listed in the previous footnote above.

Verdone and Seidl (2017) investigates the critics on the Bonn Challenge that 'restoration takes too long, costs too much, and produces too few benefits to justify public or private expenditures'. The estimations of the baseline scenario[30] suggest the BCR of 7.54 for restoring 350 million hectares of degraded forest. The results also show that the net benefit of meeting the Bonn Challenge target would be $2.25 trillion.

GoM (2017c, p. xiii) highlights the lack of "a strong and well-understood legal framework with sufficient economic incentives supporting restoration" as the main barrier to implementation. GoM (2017c, pp. xiv-xv) lists the recommendations based on the CBA conducted as part of the national FLR assessment as follow:

- Prioritize the implementation of restoration interventions with relatively lower costs and higher benefits such as agricultural technologies including conservation agriculture, farmer managed natural regeneration, and other forms of agroforestry.[31]
- Prioritize the implementation of forestry-based restoration like natural forest management in gazetted forest reserves with steep slopes and near important water resources like the Shire River.
- Provide support for improved data collection, analysis, and monitoring of costs and benefits from a variety of proven restoration interventions as they are implemented at scale.
- Shift domestic government budget allocations from subsidies for mineral fertilizers to support for increased extension services, training and outreach programs.
- Create and support institutions to extend farm credit to smallholders.
- Support active research to improve the monitoring of significant outcomes and impacts of investments in restoration.
- Focus the government public works programme (cash-for-work) scheme on restoration activities.
- Build restoration-focused financial infrastructure at district and community levels.

FAO (2017) focuses on the potential contributions of a green charcoal value chain to climate-change mitigation and improved livelihoods. The paper proposes technical interventions for cleaner and most efficient charcoal production and use for the stages of the value chain such as sourcing of wood/charcoal, carbonization, transportation and distribution, and end use. These interventions are as follow:

- Sourcing of wood/charcoal
- Sustainably manage source (e.g. natural forests, planted forests and community forests)
- Switch to alternative sources, such as agricultural waste, wood residues and wood outside forests, including agroforestry
- Process charcoal dust into briquettes
- Carbonization
- Better manage traditional kilns to increase efficiency and use improved kilns with higher efficiencies
- Cogenerate charcoal and electricity (in the case of industrial-scale production)
- Transportation and distribution
- Reduce fossil-fuel consumption in transportation
- End use
- Use improved cook stoves

FAO (2017) states that the undervaluation of resources and inefficiencies in carbonization and end use often causes sustainable charcoal production to be economically unviable. The report also highlights that "[t]he informality and lack of enforcement in the charcoal value chain mean that governments forego millions of dollars in taxes and licensing fees and incur costs due to environmental and health externalities" (p. 81). FAO (2017) cites Minten, Sander and Stifel (2010) and Macqueen and Korhaliller (2011) where the forgone annual tax revenues from charcoal licensing and taxation for Malawi are estimated as US$7 million and US$5–8 million, respectively.

FAO (2017) also shows the overview of the costs and benefits of the following efficiency improvements in forest subsectors in Kenya,[32] from which we calculate the particular BCRs:

Table:

Intervention	BCR
Charcoal production	9.3
Forestry operations (harvesting)	3.1
Timber processing (briquette production)	2.3
Fuelwood/charcoal consumption at household level	2.1
Fuelwood/charcoal consumption at industrial level	1.6

[30] "Costs and benefits are discounted at a social discount rate of 4.3% following Nordhaus (2014), and the NPV per hectare of degraded and restored forests include both private and public benefits." Verdone and Seidl (2017, p. 906).

[31] "The NPV of agricultural-based restoration technologies ranges from 3.6 million MWK for farmer managed natural regeneration to 3.0 million MWK for conservation agriculture and intensive agroforestry when only private benefits are accounted for." (GoM, 2017c, p. 12)

[32] Assuming a certain amount of upfront investment and a carbon price of US$5.6 per tonne of CO_2e.

Cheboiwo et al. (2019) investigates seven broad categories of forest landscape restoration opportunities identified by the Kenyan government in the context of its commitment to restoration and reforestation of 5.1 million hectares by 2030 under the Bonn Challenge. The categories are (i) afforestation or reforestation of degraded natural forests, (ii) rehabilitation of degraded natural forests, (iii) agroforestry in cropland, (iv) commercial tree and bamboo growing on potentially marginal cropland and unstocked forest plantation forests, (v) tree-based buffer zones along water bodies and wetlands, (vi) tree-based buffer zones along roads and restoration of degraded rangelands.

Cheboiwo et al. (2019) applies economic and financial CBA on the following twelve specific interventions based on the broad categories of restoration opportunities:

- Degraded natural forest to improved natural forest through enrichment planting,
- Degraded forest to Improved Natural regeneration with protection,
- Traditional Agriculture (Maize farming) to Intensive Agroforestry Maize, Grevillea, Avocado Fruit,
- Traditional Agriculture (Cowpeas Farming) to Intensive Agroforestry with Melia,
- Poorly managed woodlots to improved and well-managed Eucalyptus woodlots,
- Degraded woodlands to commercial Gmelina arborea plantations,
- Degraded planted forests to commercial bamboo plantations,
- Un-stocked plantations to fully stocked cypress plantations,
- Degraded riparian zones to bamboo and grass strip buffer,
- Degraded grasslands to grass reseeding, and
- Degraded grassland to Silvo-pastoral system grass reseeding and acacia woodlands.

The economic CBA of the interventions show that the BCR of the restoration transition ranged from as low as 2.35 (degraded riparian zones to bamboo and grass strip grass buffer) to highest of 29.2 (transition from degraded grasslands to reseeded grassland). Financial analysis of the study also shows commercial viability of the interventions.

Adjasi and Adiaba (2020) presents the land titling program of Ghana which involves surveying and documentation of 170,657 square kilometers of land representing the parcel of customary lands in Ghana and building a comprehensive and automated national base land map. The intervention of the program contains the following segments:

- Updating and modernizing the national base map
- Rehabilitating the Continuously Operating Referencing Station (CORS) network
- Mapping, survey and demarcation of customary land ownership
- Digitization of documents, and automation of the registration process
- Sensitization
- Legal framework for adjudication

The results of the CBA approach conducted by Adjasi and Adiaba (2020) suggest a substantial BCR of around 100 under plausible parameters including a 25% probability of success. The authors highlight that the land titling program in Ghana is therefore likely to be welfare enhancing for the country. The key policy recommendation raised by Adjasi and Adiaba (2020, p. 14) is that "land reform has the potential to generate impressive impacts relative to costs, if sufficient political will is devoted to increasing the probability of successful implementation."

Akpalu and Wong (2020a) points out Rwanda and Democratic Republic of Congo, where mining cooperatives improved efficiency, reduced negative environmental externalities, and minimized social conflicts. The authors conduct a CBA on the intervention of forming mining cooperatives within all mining communities in Ghana. The analysis assumes that the formation of mining cooperatives would lead to improved revenue, safer production processes, and fewer environmental externalities in the sector. The findings suggest that the intervention would have a BCR around 1.2.

Akpalu and Wong (2020b) applies a CBA to the artisanal fishery sector in Ghana in order to investigate three proposed interventions of (i) replacement of illegal/destructive fishing nets, (ii) training and subsidizing feed for aquaculture, and (iii) installation of video devices on trawl vessels. The analysis suggests that planting video devices on each vessel generates the highest social net returns, i.e. BCR, followed by the replacement of nets with illegal mesh sizes. Using a central discount rate of 8%, the paper finds that installing video devices on trawl vessels generates the BCR of 21.1,[33] i.e. the benefit accruing to planting a video device could be more than 20 times the associated cost, all else equal. The benefits of the interventions are found to be (i) increased revenue from selling mature and valuable fish, (2) stock build up and the corresponding increase in rents in the captured fisheries sector, and (3) rise in artisanal profits by almost three-quarters, respectively.

[33] That of intervention (i) and (ii) are 5.1 and 1.2, respectively.

A2.2 Summary of Impact Evaluation Evidence - Land and Forests

Table A2.1: Summary of Impact Evaluation Evidence - Land and Forests

Intervention	Location	Impact
Enhancing government effectiveness and rule of law **Improving access to markets and extension (rural) services** **Improving land tenure security, livestock ownership among smallholder crop producers** **Nkonya et al. (2016)**	Global & sub-Saharan Africa	• Enhance the adoption of SLM practices (e.g. Nigeria, Ethiopia, Malawi, Senegal, Tanzania and Uzbekistan) • Works especially well when it gives local communities the mandate to manage their natural resources • Enabling communities to independently manage their natural resources and accrue direct benefits from their investments • Reduce the costs of land degradation • Improves tree planting (Bhutan) and adoption of SLM in general (Bhutan, Ethiopia, Kenya, Ethiopia, Malawi) • Access to credit also increases the adoption SLM practices (Ethiopia, Malawi) • More opportunities for addressing land degradation • Create alternative non-farm employment that could reduce pressure on land resources • Land markets improve women's access to land
Improving land and water management practices by **agroforestry, conservation agriculture, rainwater harvesting, integrated soil fertility management** **Winterbottom et al. (2013)**	Malawi Zambia Burkina Faso West Africa (Mali, Burkina Faso, and Niger)	• Help smallholders boost crop yields • Help to alleviate poverty and provide gender benefits while reducing pressures on ecosystems, climate, and water. • Increase soil organic matter, soil moisture content, fertilizer-use efficiency, viability of improved seed varieties, and provide other benefits that boost yields and incomes directly for farmers • Some improved practices such as integrating perennial tree crops into farms and expanding dry season gardens—can diversify and increase farmer income streams • Diversify and increase women's income streams. Improved access to fuelwood, fodder and water can also reduce women's workload. • Restores and boosts the productivity of existing agricultural land, thereby reducing the need to expand cropland area • Can sequester carbon on cropland by increasing levels of soil organic matter and density of trees and shrubs on farms • Reduce farmer vulnerability to increased climate variability by increasing soil moisture retention • Reduce rainfall runoff, increase infiltration of water into soils, recharge aquifers, and contribute to improved local water supplies
Agricultural technologies **Community forests and woodlots** **Soil and water conservation** **River- and stream-bank restoration** **GoM (2017)**	Malawi	• Increased crop yields with reduced dependence on inorganic inputs, reduced soil/nutrient loss, increased resilience to drought and other climate shocks • Locally managed, more sustainable sources of fuelwood; increased access to forest products for subsistence and sale; reduced burden on women in collecting fuelwood • Decreased sedimentation in catchments of hydropower infrastructure, protection of source water, increased access to forest products for subsistence and sale, conservation of biodiversity • Protection of croplands and water sources from rainfall runoff and erosion; reduced landslide risk during high rainfall events • Protection of source water and decreased sedimentation in catchments of hydropower infrastructure, reduced impacts of flood events
Land titling program **Adjasi and Adiaba (2020**	Ghana	• Update and modernization of the national base map • Rehabilitation of the Continuously Operating Referencing Station (CORS) network • Mapping, survey and demarcation of customary land ownership • Digitization of documents, and automation of the registration process • Better legal framework for adjudication • Significant welfare enhancement opportunities

Forest landscape restoration **Colomer et al. (2018)** **Pistorius et al. (2017)**	Guatemala Ethiopia	• Climate change mitigation and adaptation • Better land productivity • Rural job creation • Improvements in the availability and quality of water
Application of the combination of organic and chemical fertilisers **Certification of sustainable production practices** **Baumgartner and Cherlet (2015)**	China Brazil	• Reduce the negative impact of saline soils on crop land's productivity in a cost-efficient way • Increased international marketing of agricultural products • Significant decrease in deforestation as certificates and economic incentives led producers to adhere to moratoriums on deforestation
Capacity building for SLM **UNDP (2016)**	Malawi	• Promotion of a multi-sector approach and partnerships in natural resources management • Promotion of integrated river basin management • Promotion of SLM at community and farm level • Promotion of innovative approaches on the policy agendas such as Green Water Credits, sustainable charcoal and weather information based crop insurance • Change of mind set with regard to sustainable charcoal • Provide important inputs in policy and legal frameworks • Reduction of environmental degradation in a number of pilot sites

A3. Mining - 2021 production and revenue projections

Table A3.1: ASM and Medium-scale Production and Revenue Projections

	ASM Scale	Medium Scale	2021 (Projection)	
	%	%	Quantity (tonnes)	Value (MWK million)
Coal	0	100	40,052	590
Cement	0	100	262,521	162
Agricultural and Hydrated Lime	70	30	96,770	1,264
Rock Phosphate	0	100	1,628	29
Rock Aggregate	10	90	19,032,340	31,647
Gemstones	100	0	790	326
Iron ore	70	30	1,220	3
Total ASM[34]			1,972,617	4,378
Total MSM[33]			17,462,704	29,644
Grand Total			**19,435,321**	**34,022**

Source: *GoM (2020)*

[34] Authors' calculation as the weighted average of the total figures.

A4. Fisheries - overall budget and revenue estimate

Table A4.1: Budget for Total Development Hubs

#	Program	Site area (ha)	Element	Cost Estimate	Unit Cost	Amount	Unit
1	Fishing Boat docking and repair shops	2	Boat docks	$2,500,000	$10,000	250	Linear Meter
			Repair shop	$12,500,000	$1,250	10,000	Square Meter
2	Industrial processing + packaging + cold storage	6	Industrial buildings	$52,500,000	$1,750	30,000	Square Meter
3	Cage farms + facilities	3	Warehouses	$2,500,000	$1,250	2,000	Square Meter
			Lake Cages	$1,000,000	$20,000	50	Cages
4	Wholesale fish market	2	Buildings	$14,000,000	$1,750	8,000	Market Buildings
5	Lakefront training and research facilities	0.5	Buildings	$5,250,000	$1,750	3,000	Research Buildings
6	Aquarium	1	Buildings	$17,500,000	$2,500	7,000	Aquarium Building
7	Small aquaculture farming communities	100	Co-op Village	$720,000	$3,000	240	1 acre farms
	Subtotal	**19.5**		**$108,470,000**			

Table A4.2: Budget for Total Development Spoke

#	Program	Site area (ha)	Element	Cost Estimate	Unit Cost	Amount	Unit
1	Fish feed milling	7.8	Buildings	$1,000,000	$1,000,000	1	Milling facility
2	Fingerlings hatchery		Buildings	$1,000,000	$1,000,000	1	Hatchery facility
3	Commercial Aquaculture farming	200ha	Large ponds	$2,500,000	$50,000	50	10 acres ponds
4	Small aquaculture farming communities	100ha	Co-op Village	$720,000	$3,000	240	1 acre farms
5	Marine wildlife reserves		Waterbodies	$500,000	$500	1,000	Hectare
	Subtotal			**$5,720,000**			

Table A4.3: Revenue and Operating Costs from intervention

#	Type	Quantity of Fish (metric tonnes p.a.)	Revenue (MWK per kg)	Revenue (million MWK)	Production and processing cost (MWK per kg)	Production and processing cost (million MWK)
1	Fish processed	2,790	2,500	6,975	400	1,116
2	Industrial process	450	4,000	1,800	800	360
3	Cage farming	3,200	3,000	9,600	375	1.200
4	Pond farming	40	3,000	120	1,000	40
	Total			**18,495**		**2,716**

A5. Approximate estimates of omitted benefits from ASM landing centers intervention

Due to the unavailability of data, the research team was unable to precisely quantify certain benefits from ASM landing centers such as avoided injury, improved sanitation and avoided child labor. Additionally, it remains an open question whether the intervention would lead to increased or decreased environmental impacts. In this section we provide approximate order-of-magnitude estimates of the omitted benefits and show that a plausible range is 3-9% of the total benefits. We also discuss the likely environmental impacts from ASM, which suggests that the direction of net impact on the environment is unclear, with potentially positive and negative externalities relative to a situation of unregulated ASM.

Accidental injury – ASM operations are characterized by poor occupational, health and safety standards. The ASM landing centers should be able to partially mitigate these injuries through improved training and technical support. The Global Burden of Disease notes that in 2019, 888 deaths and 433,188 incidents attributable to unintentional injuries occurred in Malawi for the 15-49 age group (IHME, 2019). This is for the entire country, not just for ASM. Unfortunately, there is scant data on the extent of accidental injuries and deaths occurring in the ASM sector. The National Compensation Committee notes that from 2000-2011, 1.9% of all injuries brought to the Committee related to ASM. Assuming some level of under-reporting, a plausible figure may be 4% of all injuries in Malawi are attributable to ASM. Given that the 30,000 ASM contribute around 0.3-0.5% to Malawi's total workforce, a 4% estimate for the sector's contribution to injuries does not appear too low. At this level, ASM should contribute 36 deaths and 17,300 injuries per year to Malawi's overall tally. Assuming a cost of injury equivalent to 15% of GDP per capita (in line with typical experience in LMICs as per Wesson et al. (2014)) and standard valuation of mortality avoided under Malawi Priorities protocol (0.6x GDP per capita for each life year gained), the size of the injury negative externality is estimated MWK 1.1 billion per year.

Poor sanitation – Maloya and Banda (2021) note that gold mining sites in Malawi often suffer from poor sanitation, with no access to improved toilets or handwashing facilities. ASM landing centers may be able to mitigate some of the expected mortality and morbidity from exposure to poor sanitation. The Global Burden of Disease notes that per 100,000 people in the 15-49 age group, there are 16 deaths and 100,081 cases attributable to diarrhea annually. Given a reduction of 16% in diarrheal disease from improved sanitation this implies that (Wolf et al. 2018), for the estimated 30,000 ASM miners, poor sanitation should contribute to 6 deaths and 36,000 cases of diarrhea each year. Using figures for the cost of illness associated with diarrheal disease from Hendrix et al. (2017) and standard valuation of mortality avoided under Malawi Priorities protocol (0.6x GDP per capita for each life year gained), the size of the sanitation negative externality is estimated at MWK 0.3 billion per year.

Child labor – UNHCR (2017) estimates that 1,965,690 children aged 5-14 are engaged in some form of employment in Malawi. There is imprecise evidence regarding how many of these are working in ASM. UNHCR suggests 1.4% of child laborers work in 'industry', a category that includes ASM and also 7 other sectors. In the absence of more data, a plausible estimate is that 1/8th of the children employed in industry are working in ASM. This implies 3,440 children work in ASM, roughly 10% of the total ASM workforce. Child labor is correlated to the incidence of poverty. ASM centers, through increasing ASM revenues may offset some of the economic incentives that compel families to put children to work. The cost of these children working in ASM, instead of going to school is estimated by the reduction in lifetime earnings they experience as an adult. Turkson, Wong and Dubosse (2020) note that the wage of a person without education is 60% of average income in Malawi. This differential, 40% of average wage, is considered the wage premium from 8 years of education and equals MWK 1.6 million at an 8% discount rate over a presumed working life of 15 to 60 years of age. Every year in ASM instead of school a child would lose 1/8th of this premium. Therefore, for the estimated 3,440 children in school, the child labor negative externality is estimated at MWK 0.7 billion per year.

Overall impact of ASM landing centers – Summing up the negative externalities noted above, the total social costs of ASM roughly equal MWK 2.1 billion annually. ASM landing centers are unlikely to eliminate all of these externalities. There will still be some injury, poor sanitation and child labor even with the intervention. The evidence of the impact of interventions like the one envisaged in this report on such externalities is scant. Zolkinov and Ortiz (2018) note that mining training reduced negative externalities from gold processing by 30%. We use this as the central estimate and also test 15%, and 45% reduction in negative externalities. The results indicate that at a 15%, 30% and 45% reduction in these externalities, the BCR would increase by 3%, 6% and 9% respectively. In other words, instead of a BCR of 3.6 as reported in this document, the BCR may be 3.7, 3.8 or 3.9 under these scenarios. Overall, this suggests the omitted benefits are not material.

The environmental impact of the intervention is less clear. There is general consensus that unregulated ASM has detrimental impacts on the environment, both in Malawi and across Africa (Maloya and Banda, 2021; Haundi et al. 2021). The main environmental challenge observed in other countries with respect to gold – mercury emissions – is generally absent in Malawi due to the fact that gold mining is predominantly alluvial in nature (Maloya and Banda, 2021; Haundi et al. 2021). Instead, the main impacts are de-vegetation, erosion and loss of arable land due to lack of rehabilitation of unfilled pits (Maloya and Banda, 2021). The presence of the ASM centers will likely lead to environmental benefits on land that would have been mined in an unregulated manner, due to training provided by the centers, and the fact that there is a dedicated rehabilitation process once mines are no longer operational. However, the presence of the ASM landing centers, particularly the introduction of mechanized technology may accelerate the discovery of additional mineral reserves, causing the area under ASM to expand. Those areas that would have remained unmined would experience negative environmental externalities relative to the status quo. There is insufficient data to estimate the timing, magnitude and welfare effects of these countervailing impacts. Since we are unable to assess even the direction of impact, we do not include it in the cost-benefit analysis, though we account for at least the costs of rehabilitation. We leave this as an avenue for future research.

The Malawi Priorities Project

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